Tumors of the Lateral Ventricles of the Brain

Report of Eight Cases, with Suggestions for Clinical Management*

Ernesto de la Torre, M.D.,† Eben Alexander, Jr., M.D., Courtland H. Davis, Jr., M.D., and D. Leroy Chandell, M.D.

Department of Surgery, Section on Neurosurgery and Section on Anesthesiology, Bowman Gray School of Medicine of Wake Forest College, Winston-Salem, North Carolina

In spite of differences in their histologic appearance, tumors of the lateral ventricle of the brain were presented by Dandy as a well defined clinical entity, requiring similar diagnostic and surgical management. Of his 13 cases, he described 2 fibromas, 1 adenoma of the choroid plexus, 1 venous aneurysm, and 9 ependymal gliomas. In his experience, tumors in this region constituted 0.75 per cent of all intracranial tumors.

Most reports on tumors of the lateral ventricle have dealt with specific histologic types, papers on isolated cases with a review of the literature predominating. Tumors reported most often in this location have been ependymomas, papillomas of the choroid plexus, papillomas of the choroid plexus, fibroblastic tumors or meningiomas, and angiommas. In addition, epidermoids, chondromas, and endotheliomas have been described.

In Cuneo and Rand's series of 83 intracranial tumors of childhood, 2 ependymomas and 3 papillomas of the choroid plexus were found in the lateral ventricle. French's series of 92 papillomas included 9 in this location. Papillomas of the choroid plexus were reviewed recently by Matson and Crofton, who collected 14 verified cases from the literature. In their own series, there were 14 patients operated upon of 408 with intracranial tumors in childhood. Cushing's series of 2,000 brain tumors included only 3 papillomas and possibly 6 ependymomas of the lateral ventricle.

Fibroblastic tumors and meningiomas arising from the stroma of the choroid plexus occur next in frequency. Only 3 of Cushing's cases of 313 meningiomas were contained within the lateral ventricle. Many other papers have dealt with this tumor.

The present report was prompted, first, by the high rates of morbidity and mortality in these cases of so-called benign tumors of the lateral ventricle, particularly in infants and children, and, second, by the familial occurrence in 3 siblings of tumors of the nervous system, 2 of them harboring neoplasms within the lateral ventricle of the brain.

Material and Analysis of Data

This report is based on 8 patients treated at the North Carolina Baptist Hospital from 1956 to 1960. The tumors were contained within the cavity of the ventricle without infiltration beyond the ependymal covering. There were 5 children, ranging from 3 months to 4 years of age, and 3 adults, 19, 29 and 35 years old respectively. These protocols are summarized in Table 1.

Symptoms and Signs. Headaches, nausea, vomiting and papilledema were found frequently in both groups. Irritability (3 cases) and ataxia (3 cases) were present in the majority of the children, but absent in the adults. Enlargement of the head with separation of cranial sutures and a “cracked-pot” sound on percussion, of course, were present only in the children.

Cerebrospinal Fluid. Four children had increased pressure of the cerebrospinal fluid, ranging from 400 to 550 mm. of water. The protein contained in the fluid was elevated in 3 cases, ranging from 140 to 189 mg. per 100 cc. The only patient (Case 2) who did not have elevated pressure and protein of the

Received for publication November 9, 1962.

* Presented at meeting of the Society of Neurological Surgeons, Boston, Massachusetts, May 6, 1961.
† Special Fellow (BT 685) from the National Institutes of Health, Public Health Service.
cerebrospinal fluid had a cyst of the choroid plexus.

Two adult patients (Cases 6 and 8) had increased intracranial pressure; in the other patient (Case 7), the pressure of cerebrospinal fluid was normal with normal content of protein.

Air Studies. Dilatation of the ventricular system was present in all the children, severe dilatation was seen in 4 cases (Fig. 1) and moderate dilatation was seen in 1 case (Case 2). Multiple loculations of air over the parietotemporal region were present in Cases 1 and 4, both harboring an ependymoma. No dilatation of the ventricles was seen in any of the adult patients.

Angiography. Angiography was performed in 3 patients (Cases 1, 6 and 7). In Cases 1 and 6, there was a shift of the anterior cerebral artery away from the side of the tumor, with displacement upward of the middle cerebral artery (Fig. 2). All angiograms revealed either a large anterior or posterior choroidal artery leading to the tumor in the region of the glomus of the choroid plexus. This feature was not always evident to us

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex &amp; Age</th>
<th>Symptoms</th>
<th>Signs</th>
<th>CSF</th>
<th>Roentgenograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M 31 yr.</td>
<td>Headaches, nausea, vomiting for 4 mo., decrease in visual acuity, slight difficulty in speech</td>
<td>Enlarged head with &quot;cracked-pot&quot; sound, papilledema, poor vision, sluggish pupils</td>
<td>550</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>F 4 yr.</td>
<td>L- and R-sided convulsions, weakness L. side of body</td>
<td>Equivocal Babinski on L.; slight ataxia</td>
<td>Normal at ventriculography</td>
<td>Normal</td>
</tr>
<tr>
<td>3*</td>
<td>F 9 mo.</td>
<td>Generalized weakness and irritability, failure to gain weight, enlargement of head</td>
<td>Suture lines open, ataxia, papilledema, areflexia, generalized weakness</td>
<td>450</td>
<td>108</td>
</tr>
<tr>
<td>4</td>
<td>F 2 yr.</td>
<td>Irritability, clumsiness, headaches, nausea, and vomiting</td>
<td>Ataxia, papilledema with &quot;cracked-pot&quot; sound, tremulousness of extremities</td>
<td>400</td>
<td>—</td>
</tr>
<tr>
<td>5*</td>
<td>M 31 yr.</td>
<td>Irritability, decrease in appetite, progressive enlargement of head</td>
<td>Enlarged head, with bulging fontanels, papilledema, divergent strabismus, sluggish pupils</td>
<td>420</td>
<td>157</td>
</tr>
<tr>
<td>6</td>
<td>F 10</td>
<td>Headaches, nausea, vomiting for 2 wk., blurring of vision</td>
<td>Papilledema</td>
<td>Increased at operation</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>M 29 yr.</td>
<td>First seen after severe head injury with R. parietal compound fracture and brain contusion; 5 mo. after discharge onset of nervousness and paranoid thoughts with abnormal behavior</td>
<td>Slight L. hemiparesis</td>
<td>Normal at PEG</td>
<td>Normal</td>
</tr>
<tr>
<td>8</td>
<td>F 55 yr.</td>
<td>Frequent headaches, nausea, vomiting for 6 mo., occasional diplopia in last 3 mo.</td>
<td>Papilledema, diplopia, nystagmus, unequal pupils, divergent strabismus.</td>
<td>Increased at PtG</td>
<td>—</td>
</tr>
</tbody>
</table>

* Cases 3 and 5 were siblings.

TABLE 1

de la Torre, Alexander, Davis and Crandell
Tumors of the Lateral Ventricles of the Brain

### TABLE 1—(Continued)

<table>
<thead>
<tr>
<th>Air Studies</th>
<th>Carotid Angiography</th>
<th>Operation</th>
<th>Histology</th>
<th>Operative Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilatation of L. lat. ventr., with shift to L. of ventr. system; peculiar loculations of air over R. parietal area in region of R. lat. ventr.</td>
<td>Shift to L. of ant. cer. art. with displacement upward of R. mid, cer. art.; large ant. or post. choroidal art. leading to tumor</td>
<td>R. parietotemporal craniotomy and piecemeal total excision</td>
<td>Ependymoma</td>
<td>Cardiac arrest. Died on table</td>
</tr>
<tr>
<td>Dilatation of both lat. ventr., more on R.; filling defect of R. lat. ventr. in region of trigonum</td>
<td>Not done</td>
<td>Excision of cyst. Bypass of choroid plexus</td>
<td>Cyst of choroid plexus</td>
<td>Recovery</td>
</tr>
<tr>
<td>Dilatation of R. lat. ventr., with shift to L.; loculations of air over R. parietal area</td>
<td>Not done</td>
<td>R. parietotemporal craniotomy and total piecemeal excision</td>
<td>Ependymoma</td>
<td>Cardiac arrest. Died on table</td>
</tr>
<tr>
<td>Dilatation of both lat. ventr., filling defect L. lat. ventr., with shift to R.</td>
<td>Not done</td>
<td>L. parietotemporal craniotomy and partial piecemeal excision</td>
<td>Ependymoma</td>
<td>Cardiac arrest. Died on table</td>
</tr>
<tr>
<td>Not done</td>
<td>Ant. cer. art. shifted to R.; mid. cer. art. shifted upward; post. choroidal art. leading to tumor. Routine abdominal film after aning, showed slight hydronephrosis and hydropnietra on R., with possible associated pyelonephritis</td>
<td>L. parietotemporal craniotomy and total excision</td>
<td>Papilloma choroid plexus</td>
<td>Recovery after stormy postop. period</td>
</tr>
<tr>
<td>Normal except for calcified density inside R. lat. ventr.</td>
<td>Normal ant. and mid. cer. vessels; large post. choroidal art. seen distributing in ant. portion of tumor; carotico-basilar anastomosis an incidental finding</td>
<td>R. parietal craniotomy and total excision</td>
<td>Meningioma</td>
<td>Recovery</td>
</tr>
<tr>
<td>Filling defect within post. portion of L. lat. ventr. Shift of entire ventr. system to R.</td>
<td>Not done</td>
<td>L. parietotemporal craniotomy and total excision</td>
<td>Meningioma</td>
<td>Recovery</td>
</tr>
</tbody>
</table>

preoperatively, and it was not evaluated until later. An incidental finding on the carotid angiogram in Case 7 was that of a carotico-basilar anastomosis, with partial filling of the basilar artery (Fig. 3).  

**Operative Procedure.** In children, the approach to the tumor was made through a posterior temporoparietal craniotomy and the cortex was transected in the posterior parietal region with a vertical or oblique incision. The tumors occupied and blocked the entire posterior portion of the lateral ventricle and they were in close contact with the ventricular walls, despite the existing hydrocephalus. All tumors formed a single mass and were attached intimately to the glomus of the choroid plexus. It usually was not possible to ligate the vascular pedicle of the tumor as the initial step in removal, consequently loss of blood during piecemeal removal was great; massive transfusion was necessary in most of the children.

The tumors in adult patients were smaller than those in the children, and dilatation of the ventricular system was less marked. Approach to these tumors was accomplished.
in 2 patients through a transverse horizontal incision along the middle temporal gyrus (Cases 6 and 8), and the vascular pedicle was clipped before total block-removal of the tumor. In Case 7, a vertical incision was made in the right posterior parietal cortex and the vascular pedicle was clipped before removal of a small meningioma.

**Histologic Findings.** The tumors were classified histologically as ependymoma (3), papilloma of the choroid plexus (2), meningioma (2), and cyst of the choroid plexus (1). The 2 meningiomas were found in adults.

**Clinical Course and Complications.** Four patients, all children, died of cardiac arrest. Three patients died on the operating table.

---

**Fig. 1. (A) Case 3.** Right lateral ventriculogram showing intraventricular papilloma of choroid plexus and severe hydrocephalus. (B) Case 5. Left lateral ventriculogram showing intraventricular ependymoma and hydrocephalus. These 2 patients were siblings.

---

**Fig. 2. (a) Case 1.** Right carotid angiogram showing increased arching of anterior cerebral artery caused by hydrocephalus and displacement of middle cerebral vessels upward. A large branch from internal carotid artery, probably anterior choroidal artery, is seen feeding the tumor in region of glomus of choroid plexus. Some loculations of air are still visible over the region of the tumor from the preceding ventriculography. (b) Case 6. Left carotid angiogram showing bowing of anterior cerebral artery, with displacement upward of middle cerebral vessels. A large choroidal artery is seen. Tumor stain was visible in the capillary phase of this angiogram.
lojugular shunt (Holter valve) was established. Although his recovery from the craniotomy was complete, previous paranoid behavior recurred 3 years later, requiring hospitalization in a mental institution. He died 13 days after this admission, following several generalized convulsive seizures. Postmortem examination revealed pulmonary edema and congestion and acute degeneration of the right parietal and occipital lobes of the brain. No residual tumor was found.

In Case 8, after an apparently good recovery from resection of meningioma, the patient became ill and stuporous 1 day after discharge (10 days postoperatively) and died in another hospital. Necropsy was not performed.

**Unusual Familial Occurrence of Tumors.** Cases 3 and 5 were siblings, having a papilloma of the choroid plexus and an ependymoma respectively. Their clinical picture and surgical outcome were similar in many respects. Postmortem examination in Case 3 disclosed a neuroblastoma in the left paravertebral region and another in the left adrenal gland; a pheochromocytoma was found in the right adrenal gland. Necropsy was not performed in Case 5. A third sibling of these children had been seen at the North Carolina Baptist Hospital 2 years before the admission of Case 3. At that time, an undifferentiated tumor, compatible with the histologic diagnosis of neuroblastoma, was present in the deep portion of the pterygomaxillary fossa. The child died at another hospital and permission for necropsy was not granted.

**Discussion**

Surgical removal of benign tumors within the lateral ventricles has carried a high mortality in most reported series. There have been reports of successful removal of papillomas of the choroid plexus.\(^{42,43,52}\) Van Wagenen\(^{51}\) presented 2 patients, 1 surviving after excision of the tumor in 2 stages. Kahn and Luos\(^{32}\) described 2 cases: 1 of successful removal of a small tumor in a 20-year-old girl, and the other, that of a 2-year-old girl, who died after several partial excisions. Ernsting\(^{46}\) reported the successful removal of
a papilloma of the choroid plexus, causing subarachnoid hemorrhage, in a 26-year-old patient. Abbott et al.\(^1\) published a similar case of a 15-year-old girl who died after excision of the tumor. Bohm and Strang\(^4\) reported a mortality rate of 62.5 per cent for papillomas of the lateral ventricle.

Matson and Crofton's\(^5\) review of papillomas of the choroid plexus in children under 15 years of age cited 14 well-documented cases found in the literature. One half of these patients survived the operation. They also reported 14 patients in their own series, 10 of whom survived the operation. These are the most successful results published in any series.

Sudden death has been reported in infants and young children with large tumors, either during diagnostic studies or immediately following operative procedures.\(^25,35,36,45,48\)

Ependymomas of the lateral ventricle also have been reported with a high rate of death.\(^19,24,36,29,50\)

Surgical treatment of fibroblastic tumors of the choroid plexus and meningiomas has been reported more favorably. Like the tumors in Cases 7 and 8 of this series, they generally are smaller, occur in older patients, and cause less severe hydrocephalus and increased intracranial pressure than do papillomas or ependymomas in infants and young children.

Cushing and Eisenhardt\(^13\) reported 19 cases of meningioma of the lateral ventricle collected from the literature, all removed successfully. The youngest patient in their series was 7 years old. Gardner and Turner\(^22\) reported 3 fibroblastic tumors of the choroid plexus; 2 patients died postoperatively and 1 survived. Other reports of this tumor relate variable results.\(^2,18,20\) Three of Dandy's\(^13\) 13 patients died as a result of the operative procedure. His patients ranged in age from 12 to 40 years.

An analysis of the series reported here is not unique in its high mortality. Study of the diagnostic and operative procedures in our patients disclosed pertinent information for the management of tumors in this location and for possible avoidance of certain factors contributing to high mortality.

I. Advantage of Angiography.

Carotid angiography performed in 3 patients having tumors attached to the glomus of the choroid plexus showed either a large anterior or posterior choroidal artery feeding these tumors. These arteries normally supply the choroid plexus, and it is probable that most tumors arising from the region of the glomus receive most of their arterial supply from these vessels. A better estimate of the vascularization of the tumors can be made by angiography, facilitating ligation of the vascular pedicle at the time of operation. Carotid and vertebral angiography were reported by Gassel and Davies,\(^23\) and by Wall,\(^53\) to be successful in demonstrating large anterior or posterior choroidal arteries leading to meningiomas of the lateral ventricle. Ernsting\(^24\) and Sears and Burnett\(^47\) had similar experiences with papillomas of the choroid plexus.

II. Method of Approach.

The surgical approach in the children usually was carried out by a vertical incision and transection of the cortex in the posterior parietal region to avoid damaging functioning cortex. This placed the surgeon lateral, posterior and superior to the tumor, making exposure of the main vascular pedicle of the tumor difficult as an initial step.

The choroidal arteries, usually coming from the internal carotid and posterior cerebral arteries, enter the lateral ventricle through its mesial and lowermost portion (Fig. 4). A horizontal transcortical incision along the posterior portion of the middle temporal gyrus would permit the surgeon to elevate the tumor and to clip the feeding vessels before removal. The remaining and least important mesial attachment of the tumor would be at the insertion of the choroid plexus of the lateral ventricle to the tela choroidea of the third ventricle.

Surgical approach through the middle temporal gyrus of the brain was carried out in 2 adult patients (Cases 6 and 8), simplifying removal of the tumor, although admittedly these tumors were smaller than those in children.

Permanent dysphasia has been reported as a postoperative complication in excision of lateral ventricular tumors on the dominant
Fro. 4. Diagram representing the arterial supply to choroid plexus. The anterior and posterior choroidal arteries are seen coming into the inferior horn of the lateral ventricle. The proposed line of incision is indicated for transcortical approach to tumors of the choroid plexus in the region of the glomus.

In Wall's report, severe dysphasia was present postoperatively in all patients in whom vertical incision and transection of the posterior parietal cortex was done. Only 1 patient in whom an oblique incision, "downward and forward," was carried out had no disturbance of speech, and in the same patient, only a slight hemianopsia remained. Wall recommended making the cortical incision "as far posteriorly and inferiorly as possible." Cramer suggested a "posterior linear incision in the occipitoparietal cortex." Cases 6 and 8 of the present series had tumors of the dominant side of the brain. Case 8 showed only transient dysphasia postoperatively, which cleared in 4 days; Case 6 had no dysphasia following operation.

III. Control of Hemorrhage; Special Precautions in Transfusion.

Four children died on the operating table with cardiac arrest; cardiac massage and other resuscitative measures failed. This occurred in spite of numerous precautions, including constant monitoring of electroencephalogram and electrocardiogram and the administration of adequate calcium gluconate to prevent citrate intoxication. Cardiac arrest was considered at first to be the consequence of a series of reflex phenomena occurring because of the large size of the tumors and the sudden decompression. A closer and more detailed analysis showed that all 4 of these children, ranging from 3½ to 5½ years in age, had received from 750 to 1,500 ml. of blood from the blood bank during the excision of the tumor. Massive transfusions of blood have been associated with a high incidence of ventricular fibrillation and cardiac asystole in infants and children.27 The factors believed to be responsible for these derangements in cardiac function are hyperkalemia, hypothermia, acidosis and citrate intoxication.

A. Hyperkalemia. When blood is stored, potassium passes outward from the cells. The potassium in the serum increases and reaches
toxic levels by the 10th day. Retrospective evaluation of the content of potassium in these samples of blood revealed that they contained from 15 to 23 mEq. per l. This amount is 3 to 5 times higher than the normal content of potassium in blood, and it is likely that the hyperkalemia produced by the transfusion of bank blood to the patients played an important role in the production of cardiac arrhythmia and arrest. The blood administered to these children was 8 to 20 days old.

B. Hypothermia. Inactivation of the thermoregulatory mechanism will result from the effect of premedicants and anesthetic agents. Exposure to an air-conditioned operating room may produce hypothermia by surface cooling, especially in infants. Bank blood is stored at a temperature of 4°C. and its rapid transfusion will produce a further decrease in body temperature. The heart is the first organ exposed to the rapid transfusion of cold blood. Electrocardiographic manifestations of disturbances in cardiac function can be correlated with the reduction in esophageal temperature.

C. Acidosis. The compensatory vasoconstriction from loss of blood and the additional vasoconstriction from hypothermia will produce inadequate perfusion of tissue with anaerobic metabolism and subsequent acidosis. Bank blood stored in citrate solution becomes acid, having a pH of 6.6 to 6.8. This enhances further the acidosis during massive transfusion of blood. There is evidence that acidosis depresses the myocardium and reduces myocardial and vascular reactivity to circulating catecholamines.

D. Citrate Intoxication. Metabolism of citrate is reduced during hypothermia, producing an elevation of the citrate of serum in the rapid transfusion of citrated blood. The harmful effects of an elevated level of citrate in serum are the result of binding of ionized calcium with resultant hypocalcemia. This elevates further the K⁺/Ca²⁺ ratio produced by the hyperkalemia of bank blood. Intoxication by citrate is manifested by circulatory depression and electrocardiographic evidence of hypocalcemia.

All these biochemical alterations produced by the massive transfusion of cold citrated bank blood may be the factors responsible for circulatory disaster during anesthesia and surgery. In Case 3, the increased level of catecholamine associated with a pheochromocytoma would be an additional factor in producing ventricular fibrillation and cardiac asystole.

Prevention of Cardiac Complications

Prophylaxis of these biochemical changes should be accomplished by:

1. The use of a surgical approach that will prevent excessive bleeding; block-removal is preferable, if possible, to piecemeal excision, as Matson has pointed out.

2. Careful control of body temperature during induction of anesthesia and surgery, thus enabling the liver to metabolize excess citrate and the patient’s buffering system to counteract the increased hydrogen-ion concentration of the blood-bank blood.

3. The use of fresh blood rewarmed to normal body temperature. This allows potassium to re-enter red blood cells in the course of 2 to 3 hours.

4. Administration of 1 cc. of 10 per cent calcium gluconate per 200 cc. of whole blood to assist in maintaining the normal potassium/calcium ratio.

5. Electrocardiographic monitoring to allow more early detection of imbalance of electrolytes, especially that of potassium.

Summary and Conclusions

1. Eight cases of benign tumors within the lateral ventricle are presented. These tumors were attached to the glomus of the choroid plexus.

2. Despite the variable histologic types, these tumors present similar diagnostic and surgical problems. Mortality has been high in the removal of these tumors, especially in infants.

3. Angiography may provide valuable information concerning supply of blood to tumors in the region of the glomus of the choroid plexus, which may aid in planning the surgical approach.
4. A transverse incision at the most posterior portion of the middle temporal gyrus facilitates access to the vascular pedicles of the large tumors, permitting clipping of the feeding arteries before block-excision. This also might prevent the frequently reported dysphasia after these procedures in the dominant hemisphere.

5. Prevention of catastrophic complications during surgery of intraventricular tumors in infants and children has been discussed in detail. It includes:

Ligation of the vascular pedicle initially, if possible, to minimize loss of blood.

Rewarming of blood before administration to reduce levels of potassium in the serum.

Use of fresh blood, not over 3 days old.

Prevention of hypothermia to reduce excitability of myocardium.

Administration of adequate amounts of calcium gluconate in event that large amounts of blood are given.

References


31. Ingram, P. D., and Matson, D. D. Neuro-