Conquering the third ventricular chamber

Historical vignette

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Surgery within the third ventricle was a special challenge early in the conception of the discipline of neurosurgery due to a lack of diagnostic methods and difficulty in reaching and removing lesions affecting this vital region. Walter Dandy and Harvey Cushing performed pioneering approaches of the third ventricular region. The authors have reviewed the previously undisclosed efforts of Cushing to approach the third ventricle through a direct review of his available patient records at the Cushing Brain Tumor Registry. The authors compare these efforts to those of Dandy published in Dandy’s pioneering work Benign Tumors in the Third Ventricle of the Brain: Diagnosis and Treatment. Based on the review of these records, the authors attempt to examine the foundations of surgery within the third ventricle. (DOI: 10.3171/2008.9.17664)

KEY WORDS • Harvey Cushing • Walter Dandy • third ventricle • history of neurosurgery

This was a highly disappointing procedure thrown in on us when we were just beginning to be confident of exposing third ventricle tumors. Pride goeth before a fall.

HARVEY W. CUSHING

The earliest references to the cerebral ventricular system can be found in the writings of the ancients, such as Erasistratus, the Hippocratic writers, and Aristotle—this last having written of a “cavity inside the brain.” Galen’s accounts established a system whereby the ventricles were “a storage space for the spirit or soul, which gave rise to motor and sensory function.” This view persisted into the 17th century when the ventricles were considered the seat of “psychological function.” It was not until Magendie’s classic accounts in the early 19th century that the modern understanding of the ventricular system and CSF circulation were established.1

By the early 20th century, despite the development of early surgical and diagnostic techniques, lesions in the vicinity of the third ventricle remained out of reach due to the lack of diagnostic methods and techniques capable of exposing and removing such lesions without endangering adjacent vital structures.1 Procedures such as cannulation of the aqueduct of Sylvius or excision of the choroid plexus were in the former case ineffective and in the latter case too risky to promulgate. Even for procedures with some chance of success, there was no consensus on the preferred operative approach. Although Victor Horsley pioneered the direct removal of pineal tumors in 1905, his infratentorial approach proved unsatisfactory due to poor results.2 By 1911, Fedor Krause3 continued to advocate an infratentorial approach. Dandy’s 1921 publication3 of the posterior transcortical approach to the third ventricle and pineal tumors was a pioneering effort. It also heralded the controversies regarding the application of transcortical versus transcortical approaches to the anterior third ventricle that persist to this day.

Walter Dandy’s contributions to third ventricular surgery included his 1933 Benign Tumors in the Third Ventricle of the Brain: Diagnosis and Treatment.4 In this monograph, he reported on 21 patients who constitute the substance for the foundation of surgery in the third ventricle. A review of the Cushing Brain Tumor Registry proves that Harvey Cushing had a similar number of cases (22) over a comparable period; however, he did not report his series for unknown reasons. Both Dandy and Cushing took advantage of ventriculography, introduced by Dandy in 1918, without which the precise localization of tumors in the third ventricle would have been virtually impossible.

In this paper we present a historical analysis of 22
Conquering the third ventricle

consecutive patients of Cushing who underwent surgery at the Peter Bent Brigham Hospital for lesions within the third ventricle between 1924 and 1931. These patients’ records are maintained at the Cushing Brain Tumor Registry housed at Yale Department of Neurosurgery.

We also examine and compare the surgical techniques developed presumably independently by Cushing and Dandy. Both surgeons were excellent students of experience, leading them to improve their techniques for operating in the third ventricular space. Undoubtedly, other surgeons have been instrumental along the way in conquering the formidable territory of the third ventricle, often referred to as the “seat of the soul.”

Cushing’s and Dandy’s Backgrounds

Cushing was born in Cleveland, Ohio, coming from a long line of physicians. He was brought up in a strong traditional Puritan family, a background that may explain his steadfastly conservative surgical style in his career, although he was not a religious man. This philosophy was shared and reinforced during his residency by his surgical chief, William Halsted.

Walter Dandy, 17 years younger than Cushing, was the son of John Dandy, a railroad engineer who had emigrated from England. Dandy’s parents were part of a fundamentalist Puritan sect who called themselves the Plymouth Brethren. Dandy did not share his parents’ beliefs. This rejection of a conservative mindset, as opposed to Cushing’s acceptance of it, may help explain Dandy’s nontraditional innovative spirit in his career.

Surgical Techniques—Cushing

We extracted the following data based on a complete review of the Cushing Brain Tumor Registry looking for any diagnosis of third ventricular tumor. Among the 1870 patients for whom records are available in the collection today, 22 (1.2%) harbored such a diagnosis. We reviewed these patients’ records as summarized in Table 1. All the patients suffered from papilledema or optic atrophy based on their tumor was correctly localized. Of the 22 patients, 13 (59%) were women and 9 (41%) were men. The mean number of hospitalization days was 39 (range 11–84 days). Pathological findings are listed in Table 1. The overall mortality rate from such operations was 27% (6 patients).

Cushing considered ventriculography essential in the diagnosis of such tumors as only 4 of the 22 patients did not undergo at least one evaluation by means of ventriculography. In fact, in one operative note (Patient 4, Table 1) Cushing claimed: “This is another excellent example of the desirability . . . . of taking a preliminary ventriculography before wasting time in making a suboccipital exposure unnecessarily.”

Based on his training under his chief, William Halsted, Cushing followed his belief of respecting normal cerebral tissue during surgery. Consequently, early on in his series (Patients 1–4, Table 1), he employed the transcallosal rather than the transcortical route to reach the third ventricle. The limited space provided by the transcallosal route and the initial poor results from such an approach most likely drove him to adopt the transcortical approach. Indeed, after his initial experience with the above 4 patients, he almost exclusively employed the transcortical route.

Cushing recognized the importance of a dilated lateral ventricle for exposure of the deeper third ventricle and therefore designed a somewhat alternative strategy. The operative note for his first transcortical approach (Patient 6, Table 1) describes his strategy:

I had an inspiration as to how we might attack this lesion, and I think it may conceivably be the solution of the difficulty . . . . namely to operate directly though the greatly dilated ventricle . . . in the case of a third ventricular tumor if a generous frontal or lateral flap [is] made permitting the hydrocephalus to bulge out easily and to thin the cortex.

In other words, he designed a 2-stage operation. The first stage of the operation completed a frontal or temporal decompression. A frontal craniotomy and temporal craniectomy would be performed and the frontal bone flap replaced without any fixation. This osseous decompression would allow disproportional dilation of the ipsilateral lateral ventricle, providing maximal space to work through for the second (resection) stage of the operation. The first operation would also address raised intracranial pressure, alleviating papilledema, and allow delaying the second stage of the operation safely for several months, further increasing the size of the ipsilateral ventricular system.

Patients would undergo another ventriculography prior to their second surgery to confirm significant dilation of the ipsilateral frontal horn of the lateral ventricle. Cushing carefully followed this 2-stage operation paradigm following the operation for Patient 6 (Table 1).

Cushing reached the tumor through a frontal cortical incision. He often transected the fornix “at its base” and widened the foramen, disclosing the tumor in the third ventricle. Following routine lesional decompression using drainage of cysts or enucleation of solid tumors with Bovie electrocautery, he at least attempted to strip away cyst wall or tumor capsule from the surrounding brain. Most tumors were resected subtotally with the goal of allowing for reinstitution of CSF pathways and preventing injury to the ventricular wall. Postoperatively, Cushing often tapped the ventricle repeatedly through a bur hole until the skin flap over the decompression site was flattened.

Cushing and Eisenhardt did not identify colloid cyst as a pathological entity, and a diagnosis of colloid cyst is not included among the cases in Table 1. Therefore, the difference in terminology may account for the difference in pathological diagnosis in the two surgeons’ series. Undoubtedly, some of the lesions resected in Cushing’s series, especially the ones referred to as “epithelial tumor,” are consistent with a colloid cyst.

Surgical Techniques—Dandy

Dandy who trained under Cushing at Johns Hopkins, was a skillful progressive surgeon who believed operative intervention for deep lesions could become a reality in the near future (Cushing warned other neurosurgeons
**TABLE 1: Clinical characteristics of patients who were treated surgically for a third ventricular lesion by Cushing**

<table>
<thead>
<tr>
<th>Pt No.</th>
<th>Age (yrs), Sex</th>
<th>Date of Op</th>
<th>Presenting Sx</th>
<th>Phys Exam Findings†</th>
<th>Imaging Findings</th>
<th>Surgical Approach</th>
<th>Op Findings</th>
<th>Path Finding</th>
<th>Immediate Outcome</th>
<th>Long-Term Outcome</th>
<th>Last FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20, F</td>
<td>3/13/1924</td>
<td>stupor &amp; urinary incontinence</td>
<td>rt central facial paralysis &amp; rt-sided weakness</td>
<td>skull radiographs: spongy suprasellar calc of considerable extent</td>
<td>subfr, then rt fr transcallosal craniotomy</td>
<td>&quot;small granules of typical of craniopharyngeal pouch cyst&quot;</td>
<td>craniopharyngioma</td>
<td>never regained consciousness, died 11 days postop</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>20, M</td>
<td>6/18/1926</td>
<td>rt foot weakness &amp; &quot;sluggish&quot; behavior</td>
<td>rt-sided hypotension &amp; weakness</td>
<td>ventriculogr: rt midline shift, bilat enlargement of ventr</td>
<td>neg post loss explor, then rt fr transcallosal craniotomy</td>
<td>&quot;unduly vascular&quot; 3rd ventricle</td>
<td>autopsy: glioma</td>
<td>death</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>7, M</td>
<td>6/23/1926</td>
<td>precocious puberty &amp; diplopia</td>
<td>precocious puberty &amp; rt &quot;internal strabismus&quot;</td>
<td>skull radiographs: suprasellar calcaceous shadow well above pituitary fossa</td>
<td>rt fr transcallosal craniotomy</td>
<td>calcified tumor occluding foramen of Monro</td>
<td>autopsy: &quot;ganglieneuroma&quot;</td>
<td>died 1st postop night</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>6, F</td>
<td>12/28/1927</td>
<td>headaches &amp; &quot;weakness of the legs&quot;</td>
<td>retarded mental dev cerebellar signs</td>
<td>ventriculogr: bilat ventriculomeg &amp; incompl filling of 3rd ventr</td>
<td>rt fr transcallosal craniotomy</td>
<td>large &quot;fat&quot; optic nerves/chiasm &amp; soft tumor in 3rd ventr</td>
<td>ependymoma</td>
<td>improved</td>
<td>death from &quot;other causes&quot;</td>
<td>2/6/1928</td>
</tr>
<tr>
<td>5</td>
<td>15, M</td>
<td>5/31/1928</td>
<td>weight gain &amp; decr vis acuity</td>
<td>obesity, rt ptosis, &amp; lt homonymous hemianopsia</td>
<td>skull radiogr: sellar enlargement</td>
<td>rt subfr craniotomy</td>
<td>chiasmal tumor extending into 3rd ventr</td>
<td>&quot;glioma&quot;</td>
<td>unchanged</td>
<td>&quot;sight not improved&quot;</td>
<td>11/18/1928</td>
</tr>
<tr>
<td>6‡</td>
<td>16, F</td>
<td>3/7/1930</td>
<td>headache, vomiting, &amp; diplopia</td>
<td>rt exophthalmos &amp; bitemp vis field defects</td>
<td>ventriculogr: &quot;markedly dilated&quot; rt ventr, &quot;greatly enlarged&quot; rt fr horn</td>
<td>prev rt subfr explor × 2, then rt fr transcort craniotomy</td>
<td>&quot;large irregular tumor of third ventr&quot;</td>
<td>ependymoma</td>
<td>unchanged</td>
<td>&quot;condition at dischg excellent&quot;</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>40, M</td>
<td>4/5/1930</td>
<td>somnolence &amp; vis diff</td>
<td>decr lt vis acuity &amp; temp field defect</td>
<td>ventriculogr: ventriculomeg &amp; filling defect in 3rd ventr</td>
<td>rt fr transcort craniotomy</td>
<td>enlarged foramen of Monro occluded by cystic tumor</td>
<td>&quot;fibrillary astrocytoma&quot;</td>
<td>&quot;good condition&quot;</td>
<td>&quot;general condition excellent&quot;</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>16, M</td>
<td>6/6/1930</td>
<td>headache, diplopia, &amp; loss of vis acuity</td>
<td>rt-sided hemiparesis &amp; rt homonymous hemianopsia</td>
<td>ventriculogr: enlarged lt ventr</td>
<td>lt temp transcort craniotomy</td>
<td>&quot;gliomas&quot; cyst extending between 3rd ventr &amp; both Monro foramina</td>
<td>oligodendroglia</td>
<td>compl rt hemiplegia</td>
<td>&quot;doing well&quot;</td>
<td>8/6/1930</td>
</tr>
<tr>
<td>9</td>
<td>24, M</td>
<td>3/2/1931; 4/11/1931</td>
<td>blindness &amp; gen convulsions</td>
<td>compl blindness</td>
<td>ventriculogr: lt ventriculomeg skull radiogr: midline calc 4 cm above ant clinoids</td>
<td>subfr, then rt fr transcort craniotomy</td>
<td>1st op: &quot;no evidence of tumor,&quot; 2nd op: tumor occluding foramen of Monro</td>
<td>&quot;atypical glioma&quot;</td>
<td>regained some sl vis light sensitivity</td>
<td>&quot;general health is fine&quot;</td>
<td>4/13/1933</td>
</tr>
</tbody>
</table>

(continued)
TABLE 1: Clinical characteristics of patients who were treated surgically for a third ventricular lesion by Cushing\(^*\) (continued)

<table>
<thead>
<tr>
<th>Pt No.</th>
<th>Age (yrs), Sex</th>
<th>Date of Op</th>
<th>Presenting Sx</th>
<th>Phys Exam Findings†</th>
<th>Imaging Findings</th>
<th>Surgical Approach</th>
<th>Op Findings</th>
<th>Path Finding</th>
<th>Immediate Outcome</th>
<th>Long-Term Outcome</th>
<th>Last FU</th>
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</thead>
<tbody>
<tr>
<td>10  □ 5, F</td>
<td>3/24/1931</td>
<td>irritability &amp; staggering gait</td>
<td>mental retardation &amp; ataxia</td>
<td>“huge&quot; bilat venters &amp; 3rd ventr defect</td>
<td>neg pst fossa explor, then rt fr transcort craniotomy</td>
<td>ball of soft tumor occluding foramen of Monro</td>
<td>“fibrillary astrocytoma”</td>
<td>“condition excellent”</td>
<td>improved</td>
<td>12/26/1934</td>
<td></td>
</tr>
<tr>
<td>11  □ 23, F</td>
<td>5/7/1931</td>
<td>fr headaches, failing vision, obesity, convulsions &amp; amenorrhea</td>
<td>“marked drowsiness”</td>
<td>skull radiogr: irreg calcified suprasellar mass; ventriculogr: bilat ventriculomeg</td>
<td>rt fr transcort craniotomy</td>
<td>cystic mass occluding dilated Monro foramen</td>
<td>“craniopharyngioma”</td>
<td>died 10th postop day</td>
<td>NA</td>
<td>NA</td>
<td></td>
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<tr>
<td>12  □ 36, F</td>
<td>6/26/1931</td>
<td>visual deterioration, amenorrhea &amp; drowsiness</td>
<td>bilat optic disc atrophy &amp; constr of rt nasal field</td>
<td>ventriculogr: enlarged rt ventr &amp; lt ventr filling defect</td>
<td>rt fr transcort craniotomy</td>
<td>“centrally placed vascular tumor”</td>
<td>meningioma</td>
<td>died 1st postop day</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>13  □ 28, F</td>
<td>7/20/1931</td>
<td>failing vision, diplopia &amp; severe headaches</td>
<td>bitemp hemianopsia &amp; dim vis acuity</td>
<td>radiogr: suprasellar calc; ventriculogr: filling defect in bilat fr horns, displaced 3rd ventr</td>
<td>rt fr transcort craniotomy</td>
<td>“intraventricular tumor of outer wall of ventricle compressing rt foramen of Monro”</td>
<td>“oligodendroglioma”</td>
<td>“general condition excellent”</td>
<td>NA</td>
<td>at dischg</td>
<td></td>
</tr>
<tr>
<td>14  □ 21, M</td>
<td>5/7/1931; 12/7/1931</td>
<td>headache &amp; blurry vision</td>
<td>cerebellar ataxia &amp; bilat chronic papillledema</td>
<td>ventriculogr: filling defects in ant portions of both lat ventrs</td>
<td>neg pst fossa explor, then rt fr transcort craniotomy</td>
<td>“blush bulging cyst” in lt lat &amp; 3rd ventricles</td>
<td>“cheesy contents,” poss craniopharyngioma</td>
<td>“general condition fair”</td>
<td>“patient is perfectly well”</td>
<td>1/22/1934</td>
<td></td>
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<tr>
<td>15  □ 43, F</td>
<td>10/14/1931</td>
<td>fr headaches &amp; failing vision</td>
<td>bilat exophthalmos, rt facial weakness &amp; bitemp hemianopsia</td>
<td>ventriculogr: ventriculomeg &amp; filling defect in 3rd ventr; radiogr: bilat enlarged optic foramen</td>
<td>rt fr transcort craniotomy</td>
<td>small dermoid cyst “acting as a ball valve obstructing both foramen”</td>
<td>cysticercus cyst “quite psychotic”</td>
<td>sudden sz &amp; death</td>
<td>10/3/1932</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16  □ 38, F</td>
<td>10/15/1931</td>
<td>headaches, vomiting, diplopia, staggering gait, s/p pituitary adenoma resection 1 yr prior</td>
<td>disorientation, lt facial weakness, bilat CN VI palsies &amp; gen hyperreflexia</td>
<td>radiogr: bilat enlarged pit fossa; ventriculogr: upward displ of rt ant horn, filling defect in lt ventr</td>
<td>rt fr transcort craniotomy</td>
<td>“bulging, cystic tumor” extending across both hemispheres &amp; into base of 3rd ventricle</td>
<td>“epithelial tumor”</td>
<td>unchanged</td>
<td>“markedly improved”</td>
<td>11/6/1931</td>
<td></td>
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<tr>
<td>Pt No.</td>
<td>Age (yrs), Sex</td>
<td>Date of Op</td>
<td>Presenting Sx</td>
<td>Phys Exam Findings†</td>
<td>Imaging Findings</td>
<td>Surgical Approach Op Findings</td>
<td>Path Finding</td>
<td>Immediate Outcome</td>
<td>Long-Term Outcome</td>
<td>Last FU</td>
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<tr>
<td>17</td>
<td>7, F</td>
<td>11/2/1931</td>
<td>failing vision</td>
<td>bilat nystagmus, rt blindness, rt hemiplegia, rt intention tremor &amp; rt hyperreflexia</td>
<td>ventriculogr: &quot;small, rounded mass above the sella &amp; just to lt of 3rd ventr&quot;</td>
<td>lt fr transcort craniotomy</td>
<td>cystic mass occluding lt Monro foramen</td>
<td>&quot;fibrillary astrocytoma&quot;</td>
<td>&quot;doing very well&quot;</td>
<td>NA at dischg</td>
<td></td>
</tr>
<tr>
<td>18‡</td>
<td>40, M</td>
<td>2/3/1932</td>
<td>bilat fr headaches &amp; drowsiness</td>
<td>bilat blurring of optic discs, spastic gait &amp; pos Romberg</td>
<td>ventriculogr: bilat ventriculomeg (rt &gt; lt)</td>
<td>rt fr transcort craniotomy</td>
<td>cystic mass in 3rd ventr</td>
<td>cysticercus cyst died 4th postop day</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>14, F</td>
<td>3/12/1932</td>
<td>headache, nausea &amp; vomiting</td>
<td>horiz nystagmus &amp; hypotonia of upper extremities</td>
<td>ventriculogr: lt ventriculomeg, absence of 3rd ventr filling defect</td>
<td>rt fr transcort craniotomy</td>
<td>&quot;grayish-yellow, tough tumor&quot; occluding Monro foramen</td>
<td>&quot;fibrillary astrocytoma&quot;</td>
<td>&quot;excellent progress&quot;</td>
<td>NA at dischg</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>38, M</td>
<td>4/4/1932</td>
<td>headaches &amp; poor memory</td>
<td>impaired memory, hyperaemia of optic discs &amp; unsteady gait</td>
<td>ventriculogr: bilat ventriculomeg &amp; 3rd ventr filling defect</td>
<td>rt fr transcort craniotomy</td>
<td>cystic tumor bulging through rt Monro foramen</td>
<td>craniopharyngioma</td>
<td>&quot;general condition very good&quot;</td>
<td>NA at dischg</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>39, F</td>
<td>4/21/1932</td>
<td>&quot;fainting spells,&quot; headaches &amp; lt-sided clonic szs</td>
<td>anisocoria rt &gt; lt &amp; lt lower facial weakness</td>
<td>ventriculogr: sl lt ventriculomeg &amp; poor comm w/ rt ventr</td>
<td>lt fr transcort craniotomy</td>
<td>bulging mass through dilated rt Monro foramen</td>
<td>&quot;glioma&quot;</td>
<td>&quot;condition very good&quot;</td>
<td>deterioration &amp; death 2 yrs later 7/26/1934</td>
<td></td>
</tr>
<tr>
<td>22**</td>
<td>18, F</td>
<td>5/6/1932</td>
<td>headaches, convulsions &amp; lethargy</td>
<td>bilat horiz nystagmus &amp; rt facial weakness</td>
<td>ventriculogr: lt ventriculomeg w/ ant filling defect</td>
<td>lt fr transcort craniotomy</td>
<td>&quot;grayish suckable tumor&quot; at 3rd ventr</td>
<td>&quot;astroblastoma&quot;</td>
<td>&quot;condition excellent&quot;</td>
<td>NA at dischg</td>
<td></td>
</tr>
</tbody>
</table>

* ant = anterior; diff = difficulty; dim = diminished; bitemp = bitemporal; calc = calcification; CN = cranial nerve; compl = complete; CN = cranial nerve; comm = communication; decr = decreased; dev = development; dischg = discharge; displ = displacement; explor = exploration; fr = frontal; FU = follow-up; horiz = horizontal; gen = generalized; incompl = incomplete; irreg = irregular; NA = data not available; neg = negative; path = pathological; phys = physical; pit = pituitary; pos = positive; poss = possible; pst = posterior; radiogr = radiographs (skull); sl = slight; s/p = status post; subfr = subfrontal; sz = seizure; temp = temporal; transcort = transcortical; ventr = ventricle or ventricular; ventriculogr = ventriculogram; ventriculomeg = ventriculomegaly; vis = visual.

† All patients suffered from papilledema or optic atrophy on presentation.

‡ Patient 6 is important because her management paradigm signifies the first case during which Cushing attempted a 2-stage operation (Stage I: frontal decompression to allow for ipsilateral ventricular dilation; Stage II: transcortical tumor resection through the dilated ventricle). All patients treated after Patient 6 underwent the 2-stage approach except Patients 10, 15, and 18.

§ Patient 15 had significant herniation of the frontal cortex during the first stage necessitating removal of a portion of the frontal lobe and therefore the resection procedure was conducted in the same stage.

¶ Patients 10 and 18 had "huge" ventricles and Cushing did not believe additional efforts for expanding the ventricle would be necessary.

** Patient 22 is of special importance because she underwent surgery during the first meeting of the Harvey Cushing Society in 1932, witnessed by other members.
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that deeper lesions should be approached with caution until diagnostic and surgical techniques were further developed.) Third ventricular tumors often presented with non- or false-localizing signs and therefore their adequate diagnosis and planned surgical approach was difficult before ventriculography was available and during Cushing’s early career. Before 1918 and the introduction of ventriculography, some patients with third ventricular lesions underwent posterior fossa exploration with negative findings. In fact, in Dandy’s 21 reported cases involving patients who underwent third ventricular surgery, 4 (19%) of the patients had undergone negative posterior fossa explorations beforehand despite Dandy’s expert use of ventriculography.

In his book, Dandy noted that all other cases with third ventricular lesions known to date were assembled from autopsy material. He inadvertently (since Cushing did not report on his patients with similar lesions) did not mention Cushing’s efforts as noted above. In the same book, Dandy described mainly 2 approaches to the third ventricle: 1) a posterior transcallosal (pineal) approach and 2) an anterior frontal transcortical (hypophyseal) approach with resection of a portion of the frontal lobe. He also mentioned the “midsagittal” transcallosal approach (used for cysts of the septum pellucidum). His approach was based on preoperative ventriculographic findings. If the tumor filled the majority of the third ventricular space, he would proceed with a posterior transcallosal “pineal” approach. If the tumor filled the anterior part of the ventricle and if there was air present in the posterior portion of the third ventricle on ventriculography, he would perform a frontal transcortical “hypophyseal” approach (this includes his 5 patients who harbored colloid cysts). He did not use an anterior transcallosal approach for colloid cysts most likely due to the limited space provided by this approach as he wrote: “There is little to lose and everything to gain in safety of life and function by providing an adequate exposure through the preliminary removal of cerebral tissue.”

Among his 21 patients, he had 14 recoveries and 7 deaths—a mortality rate of 33.3%. Later in his career, his mortality rate for this operation decreased to 14.3%.

Comparisons in Technique

Cushing firmly believed in minimal violation of normal cerebral tissue. He used the anterior transcallosal approach at the beginning of his career but abandoned it shortly thereafter. He then developed an alternative strategy by allowing the ventricle to enlarge in a 2-staged operation, which allowed him to work through a large ventricle but using a small cortical incision. On the other hand, Dandy was more inclined to remove a small conical shaped wedge of nondominant frontal cortex to increase his working space to maximize resection. Dandy may have also followed up his patients until the ventricles had adequately enlarged (personal information from Dandy’s trainees), although this strategy may have placed patients at an increased risk of neurological injury due to hydrocephalus such as visual loss. Both surgeons suffered from a lack of magnification and good visualization of neural and vascular structures due to the unavailability of operating room microscopes. The goal of both surgeons was to reconstitute CSF pathways through the ventricles and thereby alleviate hydrocephalus since shunting systems were not available during their day.

Dandy was more radical in his tumor resection than was Cushing. Dandy’s development of the posterior transcallosal (pineal) approach increased the exposure and allowed him a more complete resection of the lesions which filled the majority of the space in the third ventricle. Cushing’s mortality rate (27%) was essentially similar to Dandy’s (33%), although Dandy used the posterior transcallosal approach, which was more technically challenging with increased associated risks.

Of the 19 patients mentioned in Dandy’s book who underwent surgery for colloid cysts or tumors, 12 patients underwent the posterior transcallosal (pineal) approach and 7 underwent the frontal transcallosal (hypophyseal) approach. On the other hand, Cushing advocated exclusively the transcallosal approach although his first 5 patients underwent transcallosal or subfrontal approaches. Cushing most likely avoided transsection of the normal corpus callosum to any significant extent and therefore did not explore the posterior transcallosal approach.

It is remarkable that, by the time of his death in 1946, Dandy had operated on 79 pineal area lesions. His legacy and experience became the benchmark for the next generation of neurological surgeons.

Illustrative Cases—Cushing

We present 3 of Cushing’s cases in further detail to illustrate his approach to these lesions.

Case 1

This patient (“A.M.,” Patient 1, Table 1, Fig. 1) was a 20-year-old woman who was admitted to Peter Bent Brigham Hospital on February 1924 for complaints of headaches, impaired vision, and amenorrhea. Skull radiographs demonstrated a calcified mass in the suprasellar region. The diagnosis of a “craniopharyngeal pouch cyst” was suspected. Cushing performed a subfrontal approach, but he was unable to get adequate exposure of the mass located behind the optic chiasm. Although Cushing was tempted to transect the chiasm to access the lesion, the fear of resultant bitemporal hemianopsia prevented him from doing so. A biopsy of the lesion confirmed the diagnosis of what is today known as a craniopharyngioma. The patient returned to the hospital 9 months later with worsened preoperative symptoms as well as fecal and urinary incontinence, decreased mental status, and right-sided hemiparesis. Physical examination also revealed significant impairment in vision with optic atrophy. Cushing decided to operate a second time. He described the patient case as a “humiliating story” since he did not get the job done the first time. This time, he tried to approach the lesion by transecting the chiasm but was unable to reach the optic chiasm due to significant “adhesions.” Cushing then attempted to reach the lesion through the anterior transcallosal approach and wrote:

This is the first time I have attacked one of these lesions in
this way though there are 2–3 earlier cases in which I transected the frontal lobe, all of them have had disastrous results.

He identified 2 cysts in the third ventricle, and after draining their yellowish fluid and cholesterol crystals, he resected their walls using blunt dissection methods. The patient never regained consciousness and died the next day. Cushing described his resection as “too radical.”

Case 2

This patient (“E.A.,” Patient 4, Table 1, Fig. 2) was a 6-year-old girl who was admitted to Peter Bent Brigham Hospital in December 1927 for headaches and “weakness of the legs” and was found to have cerebellar signs. Ventriculograms demonstrated a “definite” filling defect in the third ventricle associated with significant hydrocephalus. Cushing suspected a primary tumor of the chiasm due to the “typical pear-shaped sella” evident on skull radiograph plates (Fig. 2, Inset II).

Through a subfrontal approach, Cushing found “two extraordinarily fat large optic nerves” and a “large soft tumor, possibly an ependymoma” protruding through the lamina terminalis. It is interesting that Cushing felt free to discuss his feelings without any reservation:

it may have been very foolish to have proceeded to look

into the ventricle to determine the nature of this intra-ventricular portion of the tumor but I was nevertheless tempted to do so, partly because of the failure to locate the lesion in the recent case of [another patient’s name].

In this case, Cushing did indeed locate the lesion through an anterior interhemispheric transcallosal approach and completed a subtotal resection of “a glioma.” The patient was discharged after 24 days in the hospital in “good condition.”

Case 3

This 18-year-old female (Patient 22, Table 1) presented with a history of generalized seizures, vomiting, and lethargy. Physical examination demonstrated a right-sided facial weakness, bilateral horizontal nystagmus, and papilledema. Skull radiographs revealed a calcified mass in the right frontal lobe. Ventriculography disclosed an anterior third ventricular mass.

Cushing carried out his usual 2-stage operation: first a left “fronto-central” osteoplastic flap with subtemporal decompression, followed by a second ventriculography 2 weeks later revealing a more dilated left ventricle. After the ventriculography, he performed the second stage of
the operation, which coincided with the first meeting of the Harvey Cushing Society in 1932 and was witnessed by other members. Following reflection of the left frontal osteoplastic flap, Cushing accessed the ventricle through a left frontal cortical incision and exposed and removed an “astroblastoma” protruding through the foramen of Monro. The patient did well after surgery. Other operative sketches by Cushing (Figs. 3–5) illustrate the intraoperative findings in Patients 10, 11, and 19 (Table 1), respectively.

Illustrative Cases—Dandy

Case 1

This 12-year-old girl presented in 1931 complaining of bifrontal headaches accompanied by vomiting for 2 months. A school nurse reported her deteriorating vision. Physical examination revealed a sensory loss in the distribution of the right V1. A tumor was suspected near the superior orbital fissure. Ventriculography demonstrated a dilated right ventricle. The third ventricle was effaced anteriorly and displaced posteriorly. Dandy suspected a lesion in the anterior part of the third ventricle. Using a frontal transcortical approach a U-shaped area of frontal lobe was then removed in order to expose the anterior part of the lateral ventricle. This exposure proved inadequate, and the remainder of this part of the frontal lobe, which was alongside the falx was additionally resected … There was now ample exposure to permit extirpation of the tumor.

The tumor itself was difficult to remove due to its strong attachment, and the dissection required the sacrifice of the right anterior cerebral artery. However, Dandy was successful in excising the entire tumor (Fig. 6). The roof of the third ventricle remained intact. The patient’s condition was stable for the first several days after her operation, but her course suddenly turned for the worse on the 10th day, with a sharp rise in temperature and increasing lethargy. She died 22 days after the operation.

Case 2

This 10-year-old boy presented in 1931 with headaches, vomiting, and gait imbalance. The pertinent findings on neurological examination included bilateral sixth cranial nerve palsies and bilateral papilledema. Radiographs of the skull demonstrated a calcified mass in the pineal region. Ventriculography disclosed enlarged ventricles. Due to the history of staggering gait, Dandy performed a posterior fossa exploration, but the findings were negative. After closure of the suboccipital wound, Dandy conducted a posterior transcallosal (pineal approach) following a ventricular tap. He split the corpus callosum along three-fourths of its extent. He then identified an encapsulated tumor to the left of the vein of Galen and removed it in its entirety. After he removed the tumor...
mass, the third ventricle was exposed, and a large amount of fluid and air escaped.

The patient was discharged from the hospital 19 days later with improvement in his preoperative symptoms. The histopathology of the tumor was consistent with “combined ependymal and pineal tumor.”

Despite these advances, the problems of third ventricular surgery remained so great that as late as 1948, Torkildsen wrote: “attempts at the removal of neoplasms in regions of the pineal gland and third ventricle of the brain are associated with such a grave mortality that, if possible, such operations should be avoided.” It was not until the introduction of microneurosurgery that such lesions were treated with low morbidity.

**Conclusions**

Dandy and Cushing provided pioneering contributions to the surgery of the third ventricle. Cushing advocated minimal removal of normal cerebral tissue and a conservative approach to resection. Dandy used wider corridors to these deep tumors and was able to achieve more complete resections.

**Disclaimer**

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Conquering the third ventricle

References

2. Dandy W: Benign Tumors in the Third Ventricle of the Brain: Diagnosis and Treatment. Springfield, IL: Charles C. Thomas, 1933

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