Frontobasal Interhemispheric Trans-Lamina Terminalis Approach for Suprasellar Lesions

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Received, April 15, 2004.
Accepted, October 25, 2004.

ONLINE DIGITAL VIDEO

THE FRONTOBASAL INTERHEMISPHERIC APPROACH for suprasellar tumors currently incorporates technological advancements and refinements in patient selection, operative technique, and postoperative care. This technique is a valid choice for the removal of suprasellar lesions with extension into the third ventricle without major sequelae related to the surgical approach. The method described here reflects the combination of the frontal interhemispheric and trans-lamina terminalis approaches.

KEY WORDS: Craniopharyngioma, Interhemispheric, Lamina terminalis, Suprasellar tumors, Third ventricle

Neurosurgery 56[ONS Suppl 2]:ONS-418–ONS-424, 2005 DOI: 10.1227/01.NEU.0000157027.80293.C7

Frontal craniotomy, isolating an osseous flap only from the anterior wall of the frontal sinus, was initially used only to approach the frontal sinus (5). It was used by Dandy (1) as a craniotomy to expose and cure cerebrospinal fluid fistulae through the posterior wall of the frontal sinus. It was then developed and adapted to the different pathological conditions of the base. The microsurgical technique aimed at preserving olfaction during a subfrontal approach of the anterior cranial fossa was described for the first time by Suzuki (14) in the treatment of aneurysms of the anterior communicating artery (AComA).

The approach to the anterior cranial fossa for intracranial lesions can be performed by a frontal transsinusal approach (if the frontal sinuses are sufficiently large), a suprasinus transfrontal approach, or a frontobasal or pterional approach. Suprasellar lesions are potential challenges for surgical treatment. Intrasellar or intracisternal tumors located in the subdiaphragmatic portion can be treated via a transsphenoidal approach. Tumors extending to or located in the third ventricle can be treated via the transcallosal approach. For sellar and suprasellar tumors with extension into the third ventricle, a subfrontal or pterional approach can be used (2, 8).

Tumors protruding from the sellar-suprasellar region to the third or lateral ventricle or septum pellucidum present a particular difficulty, with a risk of producing damage to the optic pathways and the hypothalamus. Fahlbusch et al. (2), Oi et al. (8), and Suzuki et al. (15) have previously described an interhemispheric approach for the treatment of such lesions. The advantage of this approach lies in its limited brain retraction. In addition, the arteries and veins coursing along the exposed dorsal and medial surfaces of the frontal lobe and over the corpus callosum can always be saved. Nevertheless, this surgical approach is reported to be complex, and postoperative psychological problems and olfactory tract damage are other inherent disadvantages. This article describes a modified version of the traditional frontal interhemispheric approach and basal interhemispheric approach combined with the trans-lamina terminalis approach, which is a frontobasal interhemispheric approach for lesions protruding from the sellar-suprasellar region to the third ventricle or septum pellucidum. This approach provides a good view of the structures of the infundibulohypophyseal axis and tends not to require strong retraction of the frontal lobes, thus preserving olfactory tracts (3, 6, 7, 11, 13). Among the lesions that grow primarily within the third ventricle are optic gliomas, pituitary adenomas, craniopharyngiomas, meningiomas, cavernous angiomas, and rarely, arteriovenous malformations (AVMs). In cases of suprasellar lesions that displace the third ventricle inferoposteriorly, however, this approach provides a wide operative field and consequently good operative results without significant damage to brain tissue itself. Once again, if the frontal sinuses are sufficiently large, a transsinusal craniotomy can provide the same access.

CONCEPTUAL NUANCES

The frontobasal interhemispheric trans-lamina terminalis approach is suitable for lesions located in the anterior part of the third ventricle, especially for those that develop anteriorly from the line joining the anterior ridge of the foramen of Monro and the cerebral aqueduct. For lesions of the pineal region, complete excision is not possible by opening only the lamina terminalis. Moreover, this approach is facilitated when optic nerves are short.

CLINICAL PRESENTATIONS

The common clinical manifestations of suprasellar lesions are increased intracranial pressure, endocrine system dysfunction, visual field defects, and hemorrhage in cases of AVM.

PREOPERATIVE WORKUP

Endocrine evaluation and neuropsychological examination are routinely performed before admission. Replacement of hormones can be done before operation if needed. Computed tomography and magnetic resonance imaging (MRI) are both essential for identifying the tumor margin and the surgical plan.

OPERATIVE TECHNIQUE (FOR SUPRASELLAR TUMORS) (*see video at web site*)

Positioning

The patient is supine after induction of general anesthesia and intubation. The patient's head is fixed in a four-point headrest centrally. The vertex is rotated approximately 15 degrees toward the floor, placing the head in slight extension. Lumbar drainage of cerebrospinal fluid and mannitol (0.5 g/kg) allows the brain to relax and minimizes the need for retraction.

Incision

The scalp is incised through the galea, beginning 1 cm anterior to the tragus and staying within the hairline, following a bicoronal incision. The galea is elevated from the pericranium by use of sharp dissection. At the superior temporal line on each side, the connective tissue layer over the temporal fascia contiguous medially with the pericranium is elevated with the galeal layer. Elevation of the scalp flap is continued forward, preserving the bilateral supraorbital nerves adherent to the galea. The galeal layer is separated from the pericranium until it reaches the supraorbital rim. The pericranium is incised separately and is elevated along the vertical line up to the supraorbital nerve bilaterally. The periosteum is elevated along the midline to the nasofrontal suture, and finally, a large pericranial flap is elevated and held anteriorly.

Craniotomy

A bifrontal craniotomy is performed under the incised area of the pericranium. First, a burr hole is placed on each side at the junction of the orbital ridge, the zygomatic process of the frontal bone, and the linea temporalis (the pterional keyhole). The third burr hole is placed on the midline 4 cm away from the nasofrontal suture. Using the craniotome, a craniotomy is performed as low as possible on the orbital roofs. The base of the craniotomy is drilled with a high-speed drill or an oscillating saw (*Fig. 1*). After release of all dural attachments, the bifrontal bone flap is cut in one piece. The frontal sinus has been opened, the mucous membrane is removed, and the internal bone lamina of the sinus is rongeured away to decrease the dead space. The residual bone is removed with a high-speed drill. The frontonasal canal is plugged with temporal muscle.

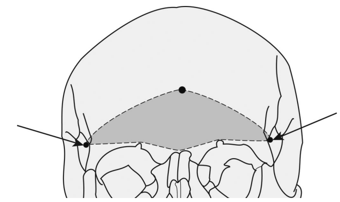

FIGURE 1. *Illustration showing the site of the craniotomy. As noted in the text, a craniotomy can also be performed in smaller format and even limited to the extension of the frontal sinus.*

Dural Incision

With the aid of the microscope, the dura is opened transversely along the anterior orbital bone edge as far forward as possible to minimize damage to the frontal bridging veins. Then the dura is elevated in a U-shape posteriorly, and the anterior sagittal sinus is sectioned and ligated in its most anterior portion. The falx cerebri is also cut.

Intradural Dissection

The constant existence of an arachnoidal cistern surrounding all the olfactory structures on the inferior face of the frontal lobes gives a microsurgical plane of cleavage. The arachnoid is sharply divided, and dissection of the olfactory tracts, alternating between the left and the right, is performed. If a unilateral olfactory tract is completely dissected before the start of the dissection of the other side, there is the danger of avulsion of the contralateral olfactory tract. It is important to sharply dissect the olfactory tracts in parallel, proceeding by alternating between the left and the right sides. In the dissection of these tracts, pressure should not be applied inferiorly but rather in a superior direction. Inadvertent traction during the operation can lead to the complete avulsion of the olfactory tract or bulb and loss of olfaction. The olfactory bulb can be reinforced with fibrin glue, fixing it to the cribriform plate. The olfactory tract should not be allowed to become dry during the operation. The olfactory bulb, together with the olfactory tract, is separated from the orbital surface of the frontal lobe bilaterally as far as the olfactory trigonal region. At the completion of dissection of the olfactory tracts, a small portion of both optic nerves should be visible beneath the arachnoid (*Fig. 2*).

Respect for olfactory function is respect for the olfactory artery. The vascular supply of the olfactory bulb is from the lateral side of the anterior cerebral artery, distal to the AComA, in 53% of patients (10). In 47% of patients, the olfactory artery arises from a collateral branch of the medial frontobasal or orbitofrontal artery. It gives off terminal branches in the direction of the olfactory tract in its first centimeter. It is possible to free the bulb and tract from the inferior face of the frontal lobes, because they have their own independent vascularization.

The entry to the basal interhemispheric fissure should be down forward in an overhanging position such that the distal A2 segments of the anterior cerebral arteries will appear. With a sharp basal interhemispheric dissection, the chiasmatic cistern and the lamina terminalis cistern are extensively exposed. After exposure of the lamina terminalis and chiasmatic cisterns, the AComA comes into view.

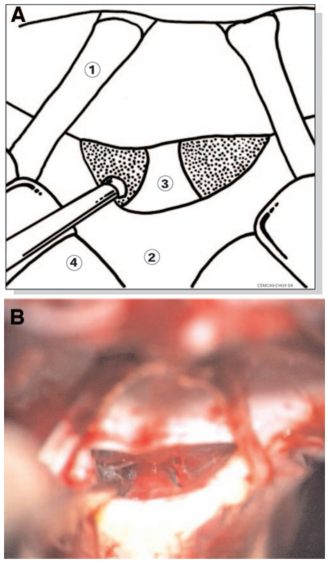

FIGURE 2. *Schematic drawing* (A) *and intraoperative photograph* (B) *showing the surgical view of the interhemispheric approach to the lamina terminalis.* 1, *olfactory nerve;* 2, *optic chiasm;* 3, *pituitary stalk;* 4, *frontal lobe.*

Tumor Removal

A survey of the entire exposure is made, including the anterior and lateral parts of the optic chiasm, the AComA, both A2 and both A1 segments, the organum vasculosum of the lamina terminalis located between the optic chiasm and the AComA, and the posterior part of the lamina terminalis. The lamina terminalis is a soft, thin, white matter structure located in the inferior part of the anterior ventricular wall, between the optic tracts, proceeding from the anterior commissure to the posterior limit of the chiasm. It is important to distinguish the lamina terminalis from the thinned-out medial border of the optic tract and from the posterior part of the chiasm. The supraoptic nuclei of the hypothalamus and the columns of the fornix lie in the anterior wall of the hypothalamus just dorsal to the optic chiasm and just lateral to the lamina terminalis. The lamina terminalis is punctured by microscissors, and removal of a small amount of liquid produces enough space for dissection to render the procedure easier. Aspiration of the contents of any cysts will facilitate the dissection of adjacent arteries from the anterior wall of the third ventricle, and separation of perforating arteries to the left and right will allow visualization of the tumor beneath the lamina terminalis. Incising the lamina terminalis allows dissection while directly observing the retrochiasmal portion of the tumor from the hypothalamus. In cases of craniopharyngioma, the tumor elevates the floor of the third ventricle, reducing the ventricular space and allowing the flattened walls of the third ventricle to lie against one another. Consequently, the incision in the lamina terminalis will sever both the superior and the inferior walls.

If the tumor contains solid portions and is covered by the stretched floor of the third ventricle, intracapsular decompression is performed first. Coagulation by bipolar forceps is avoided as much as possible to prevent damage to the hypothalamus (9). The worst possible circumstance is damage to arterial vessels during the operation, so great care should be taken to identify and dissect the surrounding blood vessels from the chiasm and optic nerves, and simply pressing with a cottonoid controls small amounts of bleeding. When the roof of the capsule is decompressed, the perforating vessels become visible. Under the chiasm, the arachnoid layer allows dissection of the tumor from the internal carotid artery and posterior communicating arteries and the perforators of the thalami. The tumor can be firmly adherent to the posterior part of the optic chiasm. It is possible to free the tumor by a very sharp dissection from the posterior aspect of the chiasm. The tumor can then be removed gradually either through the lamina terminalis or through the prechiasmatic or postchiasmatic space above or below the AComA, in a piecemeal fashion. A large part of the tumor located in the anteroinferior portion of the third ventricle is usually the enhanced portion of the tumor on MRI. Some thin cotton pledgets should be inserted between the internal wall of the third ventricle and the tumor. This procedure allows the tumor to rise gradually toward the lamina terminalis. Then, piecemeal excision of the tumor is performed.

As the tumor is gradually pulled upward toward the surgeon, the prepontine cistern becomes visible, enabling the surgeon to identify the basilar artery and sometimes the superior cerebellar artery, the posterior cerebral artery, and the perforating arteries associated with these vessels. If detaching these perforators from the tumor or the hypothalamus proves difficult, a small part of the tumor can be left. Damage to these perforating arteries can be associated with inadequate postoperative arousal of the patient. The use of the endoscope within the third ventricle can maximize the visibility and improve the quality of tumor resection.

The continuity between the median eminence and the pituitary stalk should be preserved whenever possible on both sides to maintain pituitary function. The stalk is identified when dissecting the wall of the tumor from the floor of the third ventricle. Once the stalk is identified, it can be followed to the hypothalamus. Because it was subjected to compression from a mass, the hypothalamus does not contain planes. Even the pia mater seems to be missing, especially in most cases of craniopharyngioma. This observation indicates the impact that the suction tube can inflict on the hypothalamus by just slight contact with it. Caution should be exercised at this point. If the mamillary bodies are injured, the patient can go into prolonged coma and will experience short-term memory disturbances.

One should avoid a vigorous retraction of the tumor capsule in cases with significant adherence to the floor of the third ventricle, because this maneuver could result in a bitemporal hemianopsia or hypothalamic dysfunction. The capsule can be removed if it is adequately debulked, with gentle retraction. Only after the tumor capsule has been dissected and carefully delimited and it has been determined that damage to brain tissue will not be incurred should excision of the tumor and the capsule itself be performed (*Fig. 3*). The tumor capsule is usually separated by a surrounding barrier of glial cells from the normal brain, facilitating dissection; however, in cases of craniopharyngioma, it is hard to perform complete excision without damaging neural tissue, because fingers of tumor invade the surroundings (4, 12). Densely calcified tumor may be adherent to the medial aspect of the carotid artery. If difficulty is encountered to separate a calcified tumor from the wall of the carotid, a subtotal resection is preferred, combined with adjunctive radiotherapy.

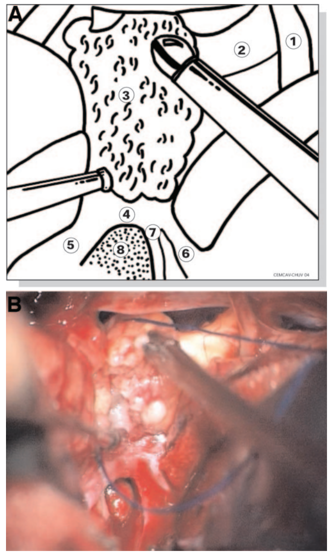

FIGURE 3. *Schematic drawing* (A) *and intraoperative photograph* (B) *showing tumor removal.* 1, *olfactory nerve;* 2, *optic chiasm;* 3, *tumor;* 4, *AComA;* 5, *left A2;* 6, *right A2;* 7, *precocious right callosomarginal artery;* 8, *third ventricle.*

In achieving complete hemostasis, one should rinse the operative field repeatedly with normal saline. The formation of hematoma around the vessels is likely to cause vasospasm, and therefore, the importance of complete hemostasis must be kept in mind (*Fig. 4*).

Closure

The dura is closed in a watertight manner. The frontonasal ducts are covered by muscle, bone, fibrin glue, and a pedicled periosteal layer. Fibrin glue is used to seal all of the gaps around it. The bone flap is fixed with round maxillofacial microplates to cover the frontal burr holes, and the skin is closed in two layers. A subgaleal drain is left for 24 hours.

POSTOPERATIVE COURSE

An incision in the flattened anterior wall of the third ventricle has been made, and considerable trauma to the third ventricle has been incurred. Therefore, corticosteroids should be continued and tapered over several days, and water and electrolyte balance should be checked at hourly intervals during the first 72 hours. The body weight should be checked twice daily during the hospital stay. A control MRI scan is performed routinely within 48 hours after surgery to confirm the complete removal of the tumor or to show the residual part. A postoperative endocrine workup is essential to evaluate the need for hormone replacement.

We have performed this approach in 14 operations during the past 5 years. Eight of these cases were for suprasellar craniopharyngiomas, three for meningiomas, two for subcallosal AVMs, and one for a cavernoma. Postoperatively, a transient diabetes insipidus was observed in three patients, hormonal disturbances were noted in four (which remained permanent in two), and obesity was present in two patients. There was no additional visual deficit and no mortality at 6-month follow-up.

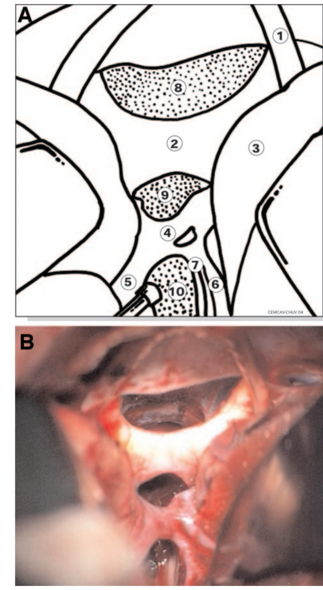

FIGURE 4. *Schematic drawing* (A) *and intraoperative photograph* (B) *showing final inspection before closure. Note the three surgical windows to the third ventricle established during surgery: the prechiasmatic window* (8), *the postchiasmatic window under the AComA* (9), *and the postchiasmatic window above the AComA* (10). 1, *olfactory nerve;* 2, *optic chiasm;* 3, *frontal lobe;* 4, *AComA;* 5, *left A2;* 6, *right A2;* 7, *precocious right callosomarginal artery.*

Illustrative Cases

The following are brief descriptions of two patients in whom this approach was used.

Patient 1

The patient was a 44-year-old woman with a third ventricular craniopharyngioma who presented with amenorrhea, polydipsia, and bitemporal superior hemianopsia. The endocrine workup showed panhypopituitarism. A computed tomographic scan showed calcifications in the floor of the third ventricle (*Fig. 5A*). MRI showed the solid, contrast-enhancing part of the tumor involving the floor of the third ventricle and a cystic part occupying the anterior third ventricle (*Fig. 5, B* and *C*). With the frontobasal trans-lamina terminalis approach, the tumor was totally resected and the pituitary stalk, which was involved by the tumor, also had to be excised. Postoperative MRI confirmed complete resection, and the patient showed no new neurological deficits but continued experiencing panhypopituitarism (*Fig. 5D*). The visual field defect improved.

Patient 2

The patient was a 26-year-old man who bled from a subcallosal AVM extending along the anterior wall of the third ventricle and along the medial wall of the frontal horns of the lateral ventricles (*Fig. 6, A* and *B*). With the same approach, the feeding vessels from the AComA and both A2 segments could be controlled (*Fig. 6C*). The

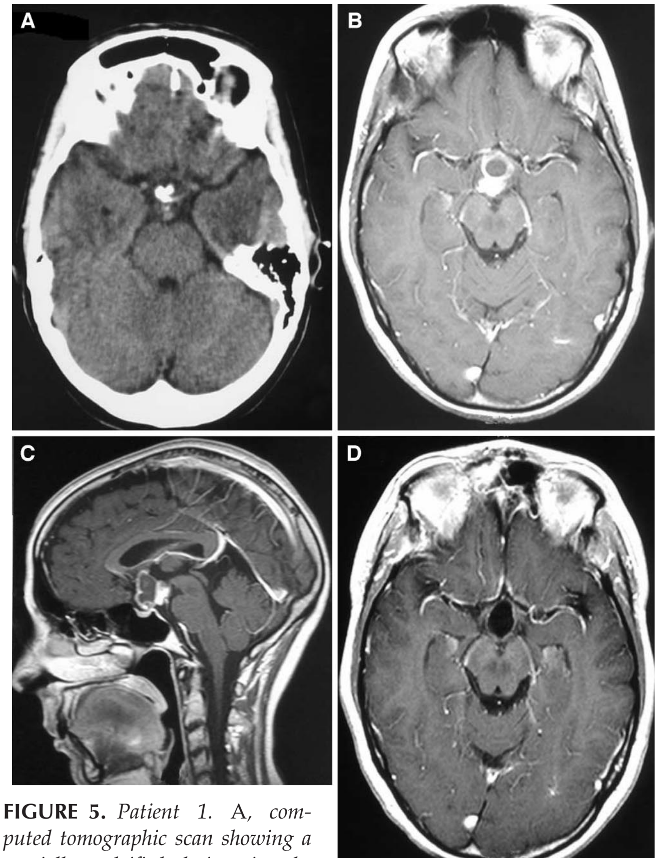

FIGURE 5. *Patient 1.* A, *computed tomographic scan showing a partially calcified lesion in the floor of the third ventricle.* B *and* C, *axial* (B) *and sagittal* (C) *MRI scans showing a partially cystic suprasellar lesion; the enhancing part of the tumor is located in the anteroinferior part of the third ventricle.* D, *postoperative MRI scan confirming complete resection of the tumor, diagnosed as a craniopharyngioma.*

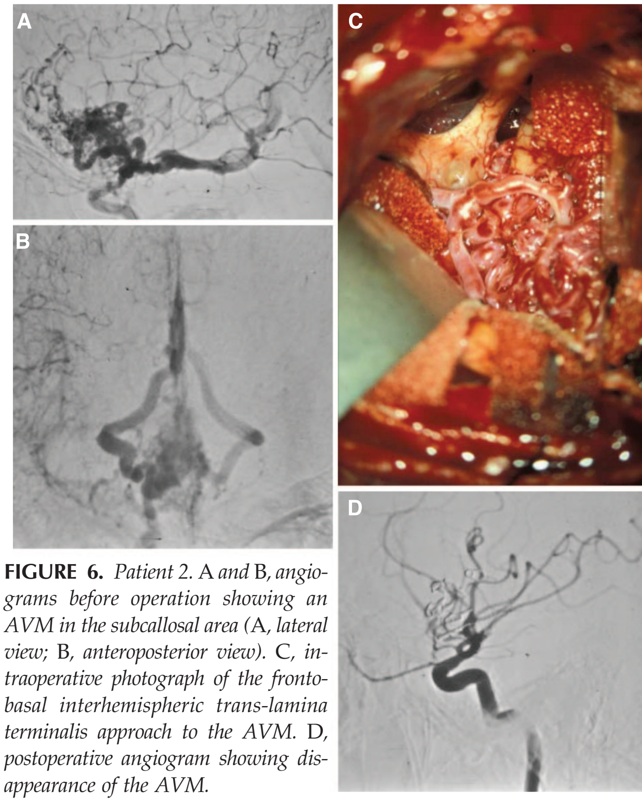

FIGURE 6. *Patient 2.* A *and* B, *angiograms before operation showing an AVM in the subcallosal area (*A, *lateral view;* B, *anteroposterior view).* C, *intraoperative photograph of the frontobasal interhemispheric trans-lamina terminalis approach to the AVM.* D, *postoperative angiogram showing disappearance of the AVM.*

venous drainage was into both basilar veins of Rosenthal. Complete resection of the AVM was confirmed on a postoperative angiogram (*Fig. 6D*). The patient had recovered fully from the hemorrhagic insult and the surgery at 6-month follow-up.

ADVANTAGES

1. The operative field is wide, allowing visualization of both optic nerves as well as the chiasm and, behind or above it, the AComA, the lamina terminalis, and both A2 segments, and below the chiasm, both internal carotid arteries, the posterior communicating arteries, their perforating branches, and the pituitary stalk.
2. No damage is done to the brain tissue except to the lamina terminalis itself, which, depending on the nature of the lesion, is often widened and thinned.
3. This approach is also suitable for lesions located on the midline of the anterior fossa.

DISADVANTAGES

1. The frontal sinus must be opened, so treatment of the frontal sinus must be performed with extreme caution to prevent infection.
2. Additional care is needed when the superior sagittal sinus is divided. The ligation of the severed end of the sinus may become loosened during operation or after closure of the dura, and hemorrhage from the venous sinus may occur.

COMPLICATIONS

1. Diabetes insipidus should be considered a virtual inevitability. It is consequently essential to measure urine output at 1-hour intervals during and after operation and to check the water and electrolyte balance, serum and urine osmolality, and natrium.
2. Hormone disturbance may occur if the pituitary stalk is sectioned.
3. Hypothalamic dysfunction may occur if the vascular supply of the hypothalamus is damaged. Lesioning of the ventromedial part of the hypothalamus causes hyperphagia, lesioning of the lateral part causes aphagia and loss of weight, and lesioning of the anterior hypothalamus causes hyperthermia, obesity, somnolence, fits of rage, and precocious puberty.

CONCLUSION

The frontobasal interhemispheric approach offers safe access to suprasellar tumors, including craniopharyngiomas. Anatomic preservation of the pituitary stalk, hypothalamic structure, perforating vessels, anterior communicating complex, the visual pathway, and the olfactory nerves is often possible. However, accurate neuroendocrine, electrolyte, and neuropsychological control is critical even years after surgery.

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COMMENTS

At this time, when minimally invasive surgery has become trendy, as if it were a status symbol for some modern neurosurgeons, the proposal of a large approach introduced more than two decades ago and not used very frequently seems to be out of order. Therefore, if only for this reason, we should be grateful for this nice, elegant, and clear presentation of the frontobasal interhemispheric trans-lamina terminalis approach. This very welcome contribution demonstrates how approaches considered to be complex and risky are in reality simple and safe even for the ordinary surgeon, as he or she gains experience. I truly hope that even the most reluctant surgeons become convinced that this approach can offer the exposure they need to deal with midline large suprasellar lesions. Since 1992 (1), we systematically started to use this approach for larger craniopharyngiomas to obtain radical removal of the tumors associated, when possible, with the preservation of the pituitary stalk. Since then, we have treated 162 patients, with more than satisfactory results. In brief, we achieved total removal in 81% of our patients, with complete preservation of the pituitary stalk in 67%. Because craniopharyngiomas are extra-axial midline lesions and they grow displacing structures from the midline in any direction, we believe it is opportune to approach the tumor at the midline, and the approach presented here allows preservation of the olfactory nerves and exposure and removal of the tumor better than any other approach, if I may say so. One should be extremely grateful to the authors for knowing how to clearly demonstrate to the neurosurgical community the great potentiality of this approach, which I have worked with many times with great satisfaction.

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1. Bricolo A, Turazzi S, Talacchi A: Bilateral subfrontal (trans-lamina-terminalis) approach for radical resection of craniopharyngiomas with preservation of pituitary stalk. Presented at the 6th Asian-Oceanic International Congress on Skull Base Surgery, Makuhari, Japan, November 12–15, 2001 (abstr).

Retrochiasmatic tumors and other lesions that insinuate themselves into the floor of the third ventricle or present in the anterior third ventricle itself are probably among the most technically challenging intracranial lesions. The authors describe an interhemispheric trans-lamina terminalis approach for removal of these lesions. The description of their technique is clear, concise, and easy to follow, especially by those who have at least some experience with anterior third ventricle surgery. They describe the advantages and disadvantages of their approach. Among the main advantages is a lesser need for frontal lobe retraction compared with other approaches, a greater ability to preserve olfaction, and perhaps a better visualization of the lamina terminalis and the surrounding neurovascular structures. There is a point of caution, however, that is worth remembering. Just as watching Ernie Elis swing a golf club may give the impression that a golf swing is essentially easy and simple to execute, which it probably is for professionals but not for amateurs, so does the description of the authors' technique appear simple and straightforward and, in their hands, also safe. However, we should not forget that these authors are true masters of third ventricle surgery, which should not be construed as a simple, straightforward, and safe operation when performed by those less experienced with or even uninitiated in this procedure.

The relative simplicity and straightforwardness of exposing the lamina terminalis and the surrounding neurovascular structures by use of the authors' approach may sway those of us who are at present still prone to expose the retrochiasmatic lesions using the pterional orbital-clinoidal cranial base dissection technique toward using the outer hemispheric approach. Clearly, neurosurgeons endeavoring to remove retrochiasmatic lesions would be well served to master the authors' technique. However, the real danger of the procedure, which requires considerable experience, starts with the exposure and removal of the lesion situated behind the lamina terminalis. The immediate proximity of the hypothalamus and the potential adherence of the tumor to the lateral hypothalamic walls can prove treacherous to the outcome regardless of how the lamina terminalis is approached.

In short, I applaud the authors for offering us their contribution in exposing the lamina terminalis. However, neurosurgeons should be aware of the danger zone behind the lamina terminalis and of the potentially serious complications, such as a hypothalamic injury, when deciding to proceed with this operation. There are not enough of these tumors facing neurosurgeons (fortunately or unfortunately) to make the average neurosurgeon an expert with this operation. Consequently, patients harboring such tumors are probably safer in the hands of a surgeon experienced with third ventricle tumors and in an institution in which such operations are performed on a programmatic basis.

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In this well-written report, Dehdashti and de Tribolet present the technical aspects of the frontobasal interhemispheric trans-lamina terminalis approach for suprasellar lesions. We believe that there are a number of microsurgical technical limitations to the described approach. By definition, the trajectory entails bilateral mesial frontal lobe retraction. The working corridor is narrow and deep. Tumors that extend laterally into the carotid cistern would not be easily accessible. Using the frontal sinus as the main port of entry does theoretically raise the risk of the introduction of infection.

On the other hand, the pterional transsylvian approach for lesions involving the suprasellar cistern provides a number of advantages. Early release of cerebrospinal fluid from the basal cisterns allows for brain relaxation and minimizes brain retraction; early identification of the internal carotid artery and its branches protects these vessels; early exposure of the optic nerves and chiasm provides protection of the visual system; and the ability to dissect the anterior cerebral artery and its branches from a lateral approach allows maximal protection of these crucial vessels (1). For craniopharyngiomas that also extend superiorly into the foramen of Monro, the senior commentator (MGY) has advocated the addition, in the same setting using a separate bone flap, of the interhemispheric transcallosal trajectory to the pterional transsylvian approach to achieve maximal resection (2).

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