The Transcallosal Anterior Interfoniceal Approach: A Microsurgical Anatomy Study

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Abstract

Objectives A plethora of surgical strategies have been described to reach deep-seated lesions situated within the third ventricle including the Rosenfeld, or transcallosal anterior interfoniceal (TAIF), approach. First introduced in 2001, it consists of a small callosotomy followed by the midline transeptal dissection of fornices to enter the roof of the third ventricle. The aim of this microsurgical anatomy study is to describe and show each stage of the surgical procedure, focusing on the possible trajectories to anatomical landmarks.

Participants A total of 20 adult cadaveric specimens were used in this study. Using $\times 3$ to $\times 40$ magnifications, the surgical dissection was performed in a stepwise fashion, and the transcallosal anterior interfoniceal approach was performed, analyzed, and described.

Results In 5 specimens of 10, a cavum septum pellucidum was depicted. In 5 cases of 20 after the callosotomy, the lateral ventricular cavities were reached. Different orientation of the microscope allowed us to define three surgical trajectories to visualize the region of interest without exposing important functional areas.

Conclusion The TAIF represents a minimally invasive approach to the third ventricle; its tricky surgical steps make appropriate anatomical dissection training essential to become confident and skilled in performing this approach.

Keywords

- ▶ microsurgical anatomy
- ▶ third ventricle
- ▶ transcallosal anterior interfoniceal approach

Introduction

A variety of lesions can occur in the third ventricle. Whereas colloid cyst, hypothalamic hamartomas, astrocytoma, germinoma, metastatic disease, craniopharyngiomas, meningioma, ependymoma, or choroid plexus papilloma are among the most common lesions harboring in the anterior part of the third ventricle, the posterior third ventricle, in contrast, is mainly affected by pineal region tumors such as germinoma, tectal glioma, epidermoid, or meningioma. Clinical presentation varies not only according to the specific anatomical siege but also to the histotype. For instance, hypothalamic

hamartomas, which are frequently seen in pediatric patients, typically cause gelastic seizures, premature puberty, behavior disturbances, and cognitive impairment.^{1–7} Different surgical approaches are currently used to treat intraventricular lesions or to reach others surrounding deep structures.^{1–4,8–12} The “open” approaches such as temporobasal, supratentorial or infratentorial, and frontobasal (translamina terminalis), could be used to reach different deep-located structures; however, it is necessary to pass through numerous functional areas or structures, with possibly serious complications of neurologic deficits.¹³ The endoscopic approach may be also performed, but small ventricles may sometimes limit its use.^{2,4}

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In 2001 Rosenfeld et al first reported their experience using an anterior transcallosal interforaminal (TAIF) approach to remove hypothalamic hamartomas of the third ventricle.^{1,3,5,6,9,10,14} The approach consists of a small callosotomy followed by a midline transtentorial dissection of fornices to enter the roof of the third ventricle. It is a minimally invasive approach and allows an adequate debulking of hypothalamic hamartomas, reducing the risk of damaging the surrounding nervous structures such as mammillary bodies, pituitary stalk, and optic chiasm. Furthermore, as an entirely anterior approach, it avoids the necessity to manipulate the neurovascular structures in the suprasellar cistern and interpeduncular fossa, lowering the incidence of cerebral infarction and oculomotor nerve palsy and reducing the risk of memory disturbance by using a trajectory between the columns and thus avoiding damage to the body of the fornices.^{10,11,14}

Materials and Methods

A total of 20 adult cadaveric specimens whose arteries and veins were infused with colored silicone were used in this study. Using $\times 3$ to $\times 40$ magnifications, the surgical dissection was performed by the first author (F.G.) in a stepwise fashion, and the TAIF approach was performed. No relevant brain

abnormalities were known before the dissection. Each stage of the surgical dissection procedure was analyzed, and pictures of each step were taken and described (**→ Figs. 1, 2, and 3**).

Results

No brain abnormalities were found in the 20 adult cadaveric heads. In 5 of 10, a cavum septum pellucidum was depicted. In 15 of 20, the TAIF approach was performed correctly, and in 5 cases, after the callosotomy, the lateral ventricular cavities were reached instead of the third ventricle, leading to difficulties in addressing the correct route. Next the surgical steps are shown and described.

TAIF Surgical Approach

Step 1: Head Positioning and Opening

Specimens were positioned in a manner that simulates a neutral position with the vertex slightly elevated to achieve a good anatomical orientation of the principal nervous structures. A bicoronal skin incision was performed centered along the coronal suture. After the soft tissues were opened and retracted, a right frontoparietal craniotomy was performed: it was centered 1 cm laterally to the sagittal sinus, 4 cm anteriorly, and 2 cm posteriorly to the coronal suture to avoid

Fig. 1 (A–F) Key steps of the anatomical exposition of interhemispheric sulcus and corpus callosum. (A) The cadaveric head is placed in a neutral position on the dissecting table. The sagittal line and the coronal suture are depicted. (B, C) After the soft tissues of the scalp are retracted, the craniotomy is performed, localized right to the sagittal line, two-thirds anterior and one-thirds posterior to the coronal suture. (D) The dura mater is exposed; the underlying brain parenchyma and superficial vascular structures can be seen in transparency. (E) A meningeal flap is cut and bent medially, to expose the brain cortex. (F) The interhemispheric fissure is gently dissected, exposing the callosomarginal branches from anterior cerebral arteries.

Fig. 2 (A–E) The transcallosal anterior interforaminal approach. (A) Axial section of the adult cadaveric brain at the level of the lateral ventricle: The laminae of septum pellucidum are going to be separated. Note the cavum septum pellucidum as a vacuum space depicted by the red arrow. (B–E) The two laminae are gently separated, and the main structures of the third ventricle's cavity are progressively encountered. From anterior to posterior, the following structures are depicted: the anterior commissure and anterior recess, the columns of fornix, the mammillary bodies, the choroid plexus, and the posterior recess.

the major venous tributaries to the superior sagittal sinus (SSS). The dura mater was cut in a curvilinear fashion and retracted medially, covering the SSS (►Fig. 1).

Step 2: Intradural Dissection and Intraventricular Exploration

The interhemispheric fissure was dissected. The callosomarginal branches of the anterior cerebral arteries and the pericallosal arteries were progressively encountered: the correct identification of these vascular structures is the key passage to achieve a median approach to the corpus callosum, avoiding entering the lateral ventricle. A small callosotomy posterior to the genu (~20 mm in length) was performed to reach the underlying median structures. The two layers of the septum pellucidum were gently dissected through the raphe portion to separate the two laminae (►Fig. 2). Five of 20 cadaveric heads presented a cavum septum pellucidum that facilitated the dissection of the two laminae; in the other cases, the absence of such anatomical evidence led to a more difficult dissection of the two laminae of septum pellucidum, and in few cases the lateral ventricle was entered instead of the third ventricle. Upon detachment of the septum pellucidum laminae, the third ventricle cavity was visible (►Figs. 1 and 2).

Step 3: Third Ventricle Exploration and Surgical Trajectories

Once splitting the two laminae of the septum, the third ventricle was exposed. From anterior to posterior, the following structures were visible: the anterior recess, the anterior commissure, the columns of fornix, the mammillary bodies, the choroid plexus of third ventricle, and the posterior

recess with its vascular structures (median posterior choroid artery and internal cerebral vein) (►Fig. 3).

Moreover, by orientating the microscope optic system with a tilt angle of 45 degrees, multiple trajectories with different angles of view were obtained (►Fig. 3). In particular, we identified three different surgical trajectories.

1. Anterior trajectory: The anterior trajectory was obtained by slightly reclining the microscope backward to expose the infundibular recess, anterior commissure, median eminence, tuber cinereum, and mammillary bodies.
2. Posterior trajectory: The posterior trajectory was obtained by reclining the microscope optic slightly forward to reach the posterior perforate substance and the posterior vascular structures (median posterior choroid artery and internal cerebral vein).
3. Midline trajectory: An intermediate trajectory, obtained by reclining the microscope optic between the two previously mentioned positions, allowed us to explore the central part of the third ventricle floor and to visualize the basilar artery tip region.

Discussion

Different surgical approaches may be used to reach brain ventricles and deeply located structures.^{4,9,13,15–17} Due to its familiarity among neurosurgeons, the pterional approach has been widely used for microsurgical resection of hypothalamic lesions; however, the narrow surgical space obtained by this approach could lead to serious complications and neurologic dysfunctions because of the close proximity to important

Fig. 3 (A–D) Anatomical intradural dissection and surgical operative exposure. (A) The superior part of the corpus callosum, body of fornix, septum pellucidum, basal frontal gyri, and the temporal lobe have been removed. The main structures of the third and lateral ventricles are depicted from anterior to posterior and from cranial to caudal orientation: corpus callosum (resected), lateral wall of lateral ventricle (the thalamus and the choroid plexus are depicted), body of fornix (resected), anterior cerebral arteries and anterior communicating artery, anterior commissure, (resected), optic chiasm and optic tracts (partially resected), choroid plexus of third ventricle, posterior recess and posterior vascular structures. (B) Anatomical picture through a medial sagittal section, showing the small callosal incision region used in the transcallosal anterior interfontal approach and the different surgical trajectories. The colored triangles indicate the different structures of the third ventricle that could be observed by each trajectory. Red triangle, anterior trajectory: infundibular recess, anterior commissure, median eminence, tuber cinereum, mammillary bodies. Yellow triangle: medial trajectory: central part of the third ventricle floor; this trajectory could also be used to approach the basilar artery tip region. Blue triangle: posterior trajectory: posterior recess, choroid plexus, posterior median vascular structures (median posterior choroid artery and internal cerebral vein). (C, D) A different orientation of the microscope allows the exposure of the different structures of the floor of the third ventricle.

structures such as the internal carotid artery, the optic nerves and chiasm, and the third cranial nerve pair.¹⁸ The orbitozygomatic approach, alone or combined with a transventricular endoscopic resection, is often used for pedunculated lesions. Mini-invasive techniques include the endoscopic transventricular approach for small lesions or the combined open and endoscopic approach, which requires normal size ventricles to reduce the risk of damaging surrounding structures.^{2,8,19} Stereotactic radiosurgery and deep brain stimulation allow the functional disconnection of deep intraventricular lesions by radiofrequency ablation and high-frequency stimulation of the mammillothalamic tract. However, in cases of incomplete resection, the epilepsy control may be inadequate.^{1,12,20}

The transcallosal anterior interforaminal approach, introduced by Rosenfeld et al in 2001, provides lesion debulking with a reduced risk of injury to the pituitary stalk, the optic chiasm, and the mammillary bodies.^{3,10,11} The TAIF approach allows a meticulous dissection of important anatomical structures, reducing the risk of short-term memory disturbances.²¹ The interforaminal approach can also be used to expose lesions located below the roof of the third ventricle and posterior to the foramen of Monro. The interforaminal incision extends posteriorly in the midline along the body of the fornix. Thus it carries the potential risk for bilateral damage to the fornix; the memory deficits resulting from use of this approach are usually transient. The main advantage of the open transcallosal approach compared with the skull base and endoscopic techniques is the direct visualization of the lesion, of the mammillary bodies, and the surrounding anatomical structures with a wider angle of view.^{9,11} The anterior callosotomy favors reaching the area anterior to the fornix columns where the septum pellucidum laminae are more easily dissected, especially in children and young adults. Some authors consider the TAIF approach more affordable in children than in older adolescents and adults, within acceptable ranges of safety. However, other authors believe that the risk of short-term memory impairment could be worse in children and young adolescents with no preoperative evidence of memory disturbances than in adults with no or mild memory impairment.^{10,11,15}

In our microsurgical anatomy study, the TAIF approach was performed in 20 cadaveric heads. In 5 of 20 specimens, the lateral ventricles were entered. However, it is important to emphasize that even though the lateral ventricle is entered, it is still possible to reach the septum pellucidum and pass in the midline between the leaves of the septum pellucidum. In all the other cases, by going medially between the two septum pellucidum laminae, the proper route was reached. The correct median dissection is a challenging step in the TAIF approach, leading to an unnecessary and inconvenient waste of time and the potential risk of neurologic dysfunction. Once entered the third ventricle, just by slightly changing the orientation of the microscope, it was possible to visualize the entire floor of the third ventricle. In particular, we identified three different trajectories: anterior, posterior, and medial. The TAIF approach may be customized for different pathologies; indeed, the trajectories favor the

precise visualization of the anatomical region of interest, avoiding the potential damage of important functional areas not required for the surgical approach. In our study, we pointed out the importance of the meticulous identification of the anatomical structures, which is essential in performing the TAIF approach correctly and successfully. Although not yet widely diffused within the major neurosurgical centers, we believe this approach could be an important and useful goal for the surgical training of the skilled neurosurgeon and should be counted among the neurosurgery armamentarium. It has to be acknowledged that being a “new approach,” it is mandatory to have surgical confidence in the other common approaches to the third ventricle before using the Rosenfeld route.

Clinical studies and review of the literature by Rosenfeld and colleagues have demonstrated that the TAIF approach could represent a useful and reliable technique in patients with large lesions that present medications-refractive seizures and cognitive and behavioral impairment. Large clinical studies have demonstrated that this approach allows the reduction, if not the withdrawal, of medication-refractive gelastic seizures in patients with hypothalamic hamartomas and improvements in behavioral attitude and in general cognition.²⁰ Some patients showed a short-term memory loss in the immediate postoperative period; however, after a short time, most of them either recovered completely or improved significantly.^{1,10,22}

Conclusion

The TAIF approach represents a challenging and suitable achievement among recent neurosurgery procedures. The main advantage of the TAIF consists principally in its limited invasiveness. However, because of its tricky surgical steps, appropriate anatomical dissection training is essential to become confident and skilled in performing the approach. For all these, surgical anatomy dissection in the laboratory remains the mainstay whether for learning the basic surgical approaches or for developing safer and less demanding procedures.

Conflict of Interest

The authors report no conflict of interest concerning the materials or methods used in this study.

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