Third Ventricle - Anterior Approach

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ABSTRACT

OBJECTIVE: We explored relevant regional microanatomy as it relates to the challenging anterior interorniceal (AIF) approach for removing hypothalamic hamartomas.

METHODS: Five silicone-injected cadaveric heads were dissected by use of frameless stereotactic navigation to reveal microanatomy and extent of exposure through the transcallosal AIF approach. Distances between trajectories to the coronal suture and the genu of the corpus callosum (CC) and between the posterior border of the anterior commissure to the lower end of the rostrum of the CC and posterior border of the foramen of Monro were measured.

RESULTS: The AIF approach provided adequate access to the anterior third ventricle and related structures (i.e., hypothalamus, infundibular recess, and mamillary bodies) through the corridor bounded by the anterior commissure anteriorly and the choroid plexus at the foramen of Monro posteriorly. The mean distances from the posterior trajectory to the coronal suture and the genu of the CC were 44.8 mm (range, 43.8–46.2 mm) and 14.88 mm (14.1–15.7 mm), respectively. The mean distance from the anterior trajectory
posterior to the coronal suture was 4.66 mm (0–8.9 mm), and 32.6 mm (30.5–33.9 mm) to the genu of the CC. The mean length of callosotomy was 17.52 mm (16.2–19.1 mm). The mean distance between the posterior border of the anterior commissure and the lower end of the rostrum of the CC was 5.22 mm (4.6–5.6 mm), and 10.52 mm (9.7–11.5 mm) to the posterior border of the foramen of Monro.

**CONCLUSION:** The technically safe AIF approach permitted limited interforniceal splitting, no major deep vein manipulation, and adequate visualization of the hypothalamus, infundibular recess, and mamillary bodies.

**INTRODUCTION**

The third ventricle is a small, vital area located in the center of the brain surrounded by critical structures. Inevitably, all approaches to the third ventricle require passing through some neural structures (26). Most lesions affecting the third ventricle, including tumors, cysts, and vascular malformations, can be treated successfully by microsurgical techniques, but the surgical approach must be planned carefully. Recently, interest has focused on the surgical treatment of hypothalamic hamartomas through the transcallosal anterior interforniceal (AIF) approach using frameless stereotactic navigation. As reported by Rosenfeld (22) and Rosenfeld et al. (23), the approach involves limited interforniceal splitting and is defined anteriorly by the posterior aspect of the anterior commissure and posteriorly by the posterior aspect of the foramen of Monro. We examined the complex and
challenging microsurgical anatomy and surgical techniques of
the transcallosal AIF approach using frameless stereotactic
navigation to facilitate dissection.

MATERIALS AND METHODS

Cadaveric Preparations

Five cadaveric heads without known brain abnormalities were
injected with colored silicone before being preserved in
embalming fluid. Subsequently, navigation fiducial markers
were attached. Computed tomographic and magnetic
resonance imaging studies performed in all heads yielded data
for the stereotactic navigational system.

Surgical Technique and Anatomic Dissections

The cadaveric heads were placed at 90 degrees in the lateral
position, and the vertex was elevated 30 degrees. The heads
were held rigidly by Mayfield head clamps (Codman, Inc.,
Raynham, MA), and the active reference arch of the frameless
stereotactic navigator (StealthStation; Medtronic SNT,
Louisville, CO) was attached firmly.

Before a bifrontoparietal craniotomy was performed 6 cm
anterior and 2 cm posterior to the coronal suture, the pilot
trajectory to the anterior third ventricle was determined by
the navigational device to ensure adequate exposure. The
pilot trajectory was aimed at the anterior limit of the
mamillary body. Its anterior and posterior limits were the
anterior commissure and foramen of Monro, respectively. To
permit evaluation of the anatomy and access to the best
trajectory for this approach, the craniotomy was intentionally made larger than that used in clinical situations.

The interhemispheric fissure was dissected, and the cingulate gyrus, a pair of pericallosal arteries, and the corpus callosum were identified. The midline callosal incision was defined by the trajectory in both sagittal and coronal planes relative to the location of the pericallosal arteries. The septum pellucidum was identified and split strictly midline by blunt dissection until the thick fibers of the fornix were visible. The interforniceal raphe division was also dissected in a blunt manner from the level of the foramen of Monro to the junction between the column of the fornix and the anterior commissure. Care was taken not to dissect too far anteriorly beyond the anterior commissure or posterior to the foramen of Monro.

Retractors were placed on both fornices to expose the anterior third ventricle. The best posteriorly directed trajectory (henceforth referred to as the posterior trajectory) was determined by a line drawn from the maximum posterior exposure on the floor of the third ventricle to the posterior limit of the foramen of Monro. The best anteriorly directed trajectory (henceforth referred to as the anterior trajectory) was a line drawn from the maximum anterior exposure to the anterior commissure (Fig. 1). After simulated surgical dissection, further anatomic dissections were performed to demonstrate anatomic relationships of vital structures to this approach.
Figure 1. Sagittal view from the frameless navigational device shows the anteriorly directed trajectory (anterior trajectory) limited by the anterior commissure and the posteriorly directed trajectory (posterior trajectory) limited by the posterior margin of the foramen of Monro. The line from the posterior trajectory on the skull surface (A) to the coronal suture (B) and the line from the anterior trajectory on
the skull surface (C) to the coronal suture (B) are illustrated. The line from the most anterior part of the genu of the corpus callosum (D) to the posterior trajectory on the corpus callosum (E) and the line of the callosal incision between the posterior trajectory and the anterior trajectory (F) on the corpus callosum are depicted. The line between the genu of the corpus callosum (D) and the posterior trajectory on the corpus callosum (E) connects to the anterior trajectory on the corpus callosum (F), showing the distance from the genu of the corpus callosum to the anterior trajectory. The line drawn between the anterior commissure (G) and the posterior border of the foramen of Monro (H) is also illustrated. The line between the anterior commissure (G) and the rostrum of the corpus callosum (I) is shown. A, anterior; P, posterior; S, superior; I, inferior. (Images courtesy of AL Rhoton, Jr.)

**Measurements**

The following crucial surgical distances were measured with the help of the navigation device and digital calipers: 1) the distance between the posterior trajectory and the coronal suture; 2) the distance between the anterior trajectory and the coronal suture; 3) the distance from the posterior trajectory to the genu of the corpus callosum; 4) the distance from the anterior trajectory to the genu of the corpus callosum; 5) the length of the callosal incision; 6) the distance from the posterior border of the anterior commissure to the posterior border of the foramen of Monro; and 7) the distance between the posterior border of the anterior
commissure and the lower end of the rostrum corpus callosum.

RESULTS

Microsurgical Anatomic Considerations

After the midline callosotomy was performed, the raphe of the septum pellucidum was visible as the thin gray midline structure between paired laminae of the septum pellucidum. Dissection continued in the midline, and both sides of the septum pellucidum were separated. Each shiny white wall contained the septal vein and its small tributaries (Fig. 2A). The ventricular side of the septum pellucidum was lined with ependyma. If the septum pellucidum was torn, the ependymal surface appeared as a grayish membrane before the lateral ventricle was reached. At the inferior insertion of the septum pellucidum, the termination of the rostrum of the corpus callosum, the anterior commissure, the column, and the body of the fornix were oriented anteriorly to posteriorly (Figs. 2B and 3A). The anterior part of the septum pellucidum extended beyond the third ventricle, attaching to the genu and rostrum of the corpus callosum. Thus, dissection of the septum pellucidum too far anteriorly can violate a thin membrane of the rostrum of the corpus callosum and enter the subarachnoid space in the anterior interhemispheric fissure (Fig. 3, A–D).
Figure 2. Stepwise dissection of the transcaldosal anterior fornical approach after callosotomy. A, the split septum pellucidum revealed the septal veins and their tributaries. B, the interfornical plane and bilateral columns of the fornix. Note the transition from the thin septum pellucidum to the thick columns of the fornix. C, the third ventricle was accessed through the corridor bound anteriorly by the anterior commissure, laterally by the columns of the fornix, and posteriorly by the choroid plexus. D, exposure of the structures at the floor of the third ventricle anteriorly to posteriorly: infundibular recess, tuber cinereum, translucent
portion of the third ventricle, and mamillary bodies. The columns of the fornix on the lateral wall were also visible. E, posterior view shows the posterior exposure bounded by the massa intermedia. An area posterior to the mamillary bodies corresponds to the posterior perforated substance. F, the third ventriculostomy performed through the translucent area anterior to the mamillary bodies exposed the basilar artery in the basal cistern. a., artery; v., vein. (Images courtesy of AL Rhoton, Jr.)

Figure 3. Anatomic demonstration. A, sagittal view shows the septum pellucidum attached to the rostrum of the corpus
callosum, anterior commissure, and fornix from anterior to posterior. The columns of the fornix form the roof and anterior border of the foramen of Monro. Embedded into the third ventricular wall, the fornix was covered with ependyma. The floor of the third ventricle line is aligned with the supraoptic recess, optic chiasm, infundibular recess, tuber cinereum, mamillary bodies, and area corresponding to the posterior perforated substance. Dashed arrows show the area of exposure and projections associated with the AIF approach. B, the relationship of the foramen of Monro and hippocampal commissure. Note the distance between these structures. C, the internal cerebral veins and medial posterior choroidal arteries located in the tela choroideae posterior to the corridor of the AIF approach. The classic interforniceal approach mandates the dissection of these structures. D, the relationships among the anterior commissure, septum pellucidum, rostrum of the corpus callosum, columns of the fornix, and anterior interhemispheric fissure. There is no distinct plane between the anterior commissure and the structures superior to it. The anterior interhemispheric fissure can be entered if dissection proceeds too far anteriorly. E, the classic interforniceal approach allows more posterior exposure to the third ventricle but requires more manipulation of the fornix. a., artery; v., vein. (Images courtesy of AL Rhoton, Jr.)

The pair of fornices partially formed the roof of the anterior third ventricle. As the fornices coursed anteriorly from the posterior part of the foramen of Monro, they gently curved
caudally and diverted to form the columns of the fornix, which created the superior and anterior border of the foramen of Monro (Fig. 3, A and B). Just superior and posterior to the anterior commissure, the columns of the fornix turned posteriorly, caudally, and laterally to become a part of the lateral wall of the third ventricle. The columns terminated in the mamillary body (Figs. 2, C–E, and 3A). After the septum pellucidum was separated, the pair of fornical columns also split to enter the third ventricle along the midline. The thick fornical fibers were used to guide dissection by following them posteriorly to the anterior commissure (Fig. 2B). At the level posterior to the anterior commissure, the fornical columns were covered with ependyma as they became embedded into the lateral wall of the third ventricle (Figs. 2C and 3A).

The anterior commissure, the anterior border of this approach, was located anterior to the columns of the fornix and inferior to the rostrum of the corpus callosum and the septum pellucidum (Figs. 2C and 3A). It was difficult to recognize the anterior commissure by dissecting superiorly to inferiorly because the plane formed at the junction between the anterior commissure, septum pellucidum, and rostrum of the corpus callosum was indistinct. To avoid injury to the anterior commissure during dissection, the structures should be identified from the ventricular side (Figs. 2C and 3D).

The third ventricular roof, lined with ependyma, was approached in the midline after interfornical dissection. The
anterior third ventricle was exposed through the corridor bounded by the anterior commissure anteriorly, the choroid plexus at the foramen of Monro and massa intermedia posteriorly, and the lateral wall of the third ventricle with the columns of the fornix laterally (Fig. 2C). This approach avoided encounters with the pair of internal cerebral veins and thalamostriate veins (Figs. 2C and 3, C–E) and hence the need to manipulate these structures.

After the extent of exposure was determined, the following structures on the floor of the third ventricle were encountered along a straight axis without difficulty from anterior to posterior: the infundibular recess, the median eminence, the tuber cinereum, the pair of mamillary bodies, and the ventricular side corresponding to the posterior perforated substance (Fig. 2, D and E). To expose the optic chiasm and chiasmatic recess without retracting the anterior commissure requires extending the exposure beyond the posterior limit of the foramen of Monro and the typical extent of this approach. The well visualized lateral wall of the third ventricle showed the prominence of the columns of the fornix as they coursed toward the mamillary body (Fig. 2, D and E). The floor of the third ventricle anterior to the mamillary bodies had a translucent area. It can be used as a corridor for third ventriculostomy, revealing the interpeduncular cistern and basilar artery (Fig. 2F).

**Measurements**

The measurements involving the key landmarks of this
approach were as follows (Table 1). The mean distance from the posterior trajectory anterior to the coronal suture was 44.8 mm (range, 43.8–46.2 mm). The mean distance from the anterior trajectory posterior to the coronal suture was 4.66 mm (range, 0–8.9 mm). The mean distance from the posterior trajectory to the genu of the corpus callosum was 14.88 mm (range, 14.1–15.7 mm). The mean distance from the anterior trajectory to the genu of the corpus callosum was 32.6 mm (range, 30.5–33.9 mm). The length of the callosal incision averaged 17.52 mm (range, 16.2–19.1 mm). The mean distance from the posterior border of the anterior commissure to the posterior border of the foramen of Monro, which is the extent of this approach, was 10.52 mm (range, 9.7–11.5 mm). Finally, the mean distance between the posterior border of the anterior commissure and the lower end of the rostrum of the corpus callosum was 5.22 mm (range, 4.6–5.6 mm).

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**DISCUSSION**

Dandy (9–12) pioneered the transcallosal interhemispheric approach to the third ventricle. Since then, it has undergone many modifications, including the transforaminal, transchoroidal, subchoroidal trans-velum interpositum, and
interforniceal approaches (2–4, 13, 15, 16, 18, 24, 26, 31), to improve exposure and to minimize damage to related structures. In 1944, Busch (7) introduced the first interforniceal approach for the removal of tumors of the third ventricle through the right frontal transcortical route. Apuzzo and Amar (2) reported the outcomes of 11 patients who underwent the transcallosal interforniceal approach for the treatment of anterior and middle third ventricular lesions. Apuzzo et al. (2–4) emphasized the advantages of this approach. It provides a natural corridor in the midline and affords exposure of lesions involving the anterior and middle portions of the third ventricle, especially when the transforaminal approach is inadequate. Subsequently, the transcallosal interforniceal approach has been used to treat a variety of lesions in and outside the third ventricle (1, 5, 17, 19–21, 25, 26, 29).

As described by Apuzzo et al. (2, 3), developing the interforniceal plane requires passing through the lateral ventricles to identify the septum pellucidum as a midline landmark. Anteriorly, fornical dissection does not extend beyond the interface region between the columns of the fornix and anterior commissure. The posterior extent should be no more than 2 cm posterior to the foramen of Monro to avoid injury to the hippocampal commissure (Fig. 3B). Winkler et al. (29, 30) suggested separating the septum pellucidum and fornices posterior to the midpoint of the foramen of Monro to avoid injury to the anterior commissure, which serves as an important connection between the mesial
temporal and frontal areas (27, 28). Botez-Marquard and Botez (6) reported deficits in visual retention related to injuries to the anterior commissure and right fornix.

Rosenfeld et al. (22, 23) proposed the limited forniceal splitting anterior to the posterior border of the foramen of the Monro, which we refer to as the AIF approach. The procedure requires frameless stereotactic navigation, which provides three benefits. First, determining the midline, which is key to dissecting the callosotomy, septum pellucidum, and fornices, avoids unnecessary transgression into the lateral ventricle. Second, the well-defined anterior and posterior trajectories facilitate planning of the craniotomy site, callosal incision, and interforniceal dissection. Finally, distinguishing important structures such as the anterior commissure and mamillary bodies prevents them from being injured.

The appropriate craniotomy site for an AIF approach is defined by a mean distance from the posterior trajectory anterior to the coronal suture of 44.8 mm and from the anterior trajectory posterior to the coronal suture of 4.66 mm. This location is more anterior than that used with the conventional transcallosal approach. The callosal incision extends a mean of 17.52 mm to a mean of 32.6 mm posterior to the genu of the corpus callosum. Both locations result from aiming the trajectory toward the anterior border of the mamillary body, which is posterior to the foramen of Monro. Approaching the interhemispheric fissure more anteriorly avoids injury to the motor cortex and major bridging veins,
which are located primarily posterior to the coronal suture (2, 29, 30). The mean length of 17.52 mm for the incision at the body of corpus callosum also helps avoid deficits (15, 24, 25).

Separating the septum pellucidum and fornical columns is crucial to maintain the dissection in the midline and within the anteroposterior trajectory. According to the experience of one of the senior authors (HLR), when resecting hypothalamic hamartomas via this approach, the midline plane of the septum pellucidum and the fornical columns are easily identifiable and separable in children. In adults and cadaveric specimens, however, these two structures are firmly fused. To avoid manipulation of the anterior commissure anteriorly and of the deep veins of the ventricle posteriorly, it seems safe to enter the third ventricle at the middle of the foramen of Monro before extending the dissection to the anterior and posterior boundaries. In the AIF approach, the length of fornical splitting was decreased to a mean of 10.52 mm and was limited to the column of the fornix, thereby decreasing manipulation of the fornix (Figs. 2C and 3E). Minimizing manipulation of the fornix may reduce the risk of memory deficits. Rosenfeld (22) noted that of 28 patients, 13 had early short-term memory deficits and 3 had a mild degree of short-term memory deficits even 8 to 57 months after surgery. However, the deficits also may have resulted from the removal of hamartomas from the mamillary bodies. Nonetheless, if dissection is limited to the foramen of Monro, the risk of injury to the hippocampal commissure is negligible. Furthermore, the AIF approach avoids unnecessary
manipulation of deep venous drainage, specifically the internal cerebral veins and thalamostriate veins. Çagatay et al. (8) described a high incidence of false venous angles (mean, 6.9 mm), in which the junction of the anterior septal vein and internal cerebral vein is posterior to the foramen of Monro. On the basis of these findings, they highly recommend magnetic resonance venography during preoperative planning for surgery of the third ventricle. If a false venous angle is present, working space possibly could be added to the AIF approach by extending interforniceal splitting beyond the posterior border of the foramen of Monro. However, the potential gain must be weighed against the increase in the length of interforniceal splitting.

The AIF approach provided adequate access along a straight axis to the anterior portion of the third ventricle from the infundibular recess anteriorly to the ventricular site corresponding to the posterior perforated substance posteriorly. The center of this approach is the mamillary bodies and tuber cinereum, which are involved by hypothalamic hamartomas (14). Unlike other nonmidline approaches, the AIF and classic interforniceal approaches have two major advantages. First, they do not depend on the size of the foramen of Monro, which is seldom enlarged when hypothalamic hamartomas are present. Second, the straight axis improves visualization of the floor of the third ventricle. Therefore, the approaches are suitable for lesions located primarily in the inferior portion of third ventricle, not only for masses that distend and raise its roof.
The interforniceal approach should be reserved for lesions that cannot be removed safely via the transforaminal approach because of the size, location, or texture of the mass (2–5, 19–21, 25, 29, 30). The disadvantages of the AIF approach are related to the small anterior-to-posterior diameter of the surgical corridor, which requires manipulation of the fornix. Because of this small corridor, the AIF approach is inappropriate for patients with a narrow third ventricle, for patients with hypothalamic hamartomas that extend beneath the floor or laterally beneath the tuber cinereum, and for patients with extremely large hypothalamic hamartomas that significantly fill and distort the third ventricle (23). The anterior commissure is at risk, and the anatomy of the anterior third ventricle is unfamiliar. Frameless stereotactic navigation and practice in the cadaver laboratory are mandatory for those unfamiliar with this approach. As a further caveat, all measurements in this study were performed in cadavers with normal-sized ventricles free of abnormalities. The distances between important landmarks and the trajectory are likely to differ in clinical situations.

**CONCLUSION**

The AIF approach is technically safe and offers adequate exposure of the anterior third ventricle. Interforniceal splitting is limited, no major deep vein must be manipulated, and visualization of the hypothalamus, infundibular recess, and mamillary bodies is adequate.

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The Neurosurgical Atlas is honored to maintain the legacy of Albert L. Rhoton, Jr., MD.

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