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Original Research

The Supracerebellar Suprapineal Approach: A Novel Method to Separate Cadaveric Brain Hemispheres and Preserve the Midline Structures

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Abstract

Objectives: To describe a novel technique for dissecting cadaver brains without damaging medial brain structures and surfaces, ensuring preservation for neuroanatomical study and training.

Methods: Ten adult cadaveric brains were dissected using the supracerebellar suprapineal approach under an operative microscope with 6x to 40x magnification. This approach allowed for the separation of the brain into two hemispheres while providing direct visualization of the third ventricle and preserving midline structures.

Results: The supracerebellar suprapineal approach enabled accurate and feasible dissection of the hemispheres without causing damage to the medial brain structures. All midline structures, including the third ventricle, were preserved, producing high-quality specimens for anatomical study.

Conclusion: The supracerebellar suprapineal approach offers a significant advancement in the technique for hemispheric brain dissection, ensuring the preservation of medial brain structures and providing superior specimens for neurosurgical training and study.

Keywords: Cadaveric brains, fiber dissection, microsurgical anatomy, supracerebellar suprapineal approach

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One of the most difficult concepts to grasp in human anatomy is neuroanatomy, especially the white matter tracts. Since the introduction of the operative microscope into neuroanatomy studies^[1], the research in this field has increased exponentially, producing detailed descriptions with the aim of better understanding brain organization.^[2-6]

In this sense, the knowledge acquired from studies of white matter fiber dissection is used to educate medical students and surgery residents because this technique accurately delineates the delicate and complex brain anatomy. For this reason, this technique is widely used in neuroanatomy studies, neurosurgery, and neuroimaging.^[7]

Thus, to correctly study the anatomy of the brain, it is necessary to have good cadaveric specimens with all structures preserved. But it is common to find brain hemispheres cut in a sagittal plane, through the corpus callosum, from a superior-to-inferior direction, without preserving medial structures such as the fornix and septum pellucidum. However, it is difficult to separate the two hemispheres and important anatomical structures equally from both hemispheres. The three-dimensional structure and individual differences must be considered.^[8] These skills are essential, and knowledge of neuroanatomy is required to appropriately cut the brain. Herein, we describe using the supracerebellar suprapineal approach under the operating microscope to cut the brain without damaging the medial structures, leaving them intact in both hemispheres.

Methods

Ten whole adult cadaveric brains (10% formalin-fixed) were obtained for our microneurosurgery laboratory. The technique used to preserve these specimens was first described by Klingler in 1935.^[7] In this technique, the specimens were washed for several hours with tap water to remove the formalin. Then, the brains were frozen for 14 days at -12 degrees Celsius. During the freezing process, the water forms ice crystals that separate the white matter fibers.

Next, the brains were thawed, allowing identification and study of the subcortical white matter tracts. The changes described in the freezing process remain after the thawing of the specimens. This technique was revitalized by Ture et al.^[1] with the use of the operative microscope for more accurate dissection. An operative microscope with 6x to 40x magnification was used for accurate separation of both hemispheres in each brain.

According to the policy of the institution where this research was conducted, ethics committee approval is not mandatory for this kind of study. This study was conducted by the ethical principles stated in the "Declaration of Helsinki". No artificial intelligence was used to generate content in this document.

Results

In our previous method, each brain was cut into two equal hemispheres with a knife or scalpel. The corpus callosum was cut from superior to inferior directions, with the blind cutting of structures below, relying on accuracy to keep the knife in the midline. However, this method usually damaged midline structures, so we sought a new method to separate the hemispheres more carefully. The supracerebellar suprapineal approach provides a direct approach to the third ventricle, and so we chose this approach to separate the hemispheres using an operative microscope.

In some cases, when the brain still had the dura mater, the falx and tentorium were removed. Removing the falx allowed the dissection of the interhemispheric fissure, which in turn allowed separation of the hemispheres. The tentorium was removed to allow good access and better mobility in the pineal area.

The cut begins superior to the cerebellum. As the goal for cutting is to produce two equal hemispheres, we used a midline cut to equally divide all the structures in the midline (Fig. 1).

The process encompasses nine steps (Fig. 2a):

1. The pineal gland and its surrounding area are cut to divide it into two similar pieces, after which the third ventricle can be observed unimpeded. If necessary, the pineal gland can be preserved on one side.

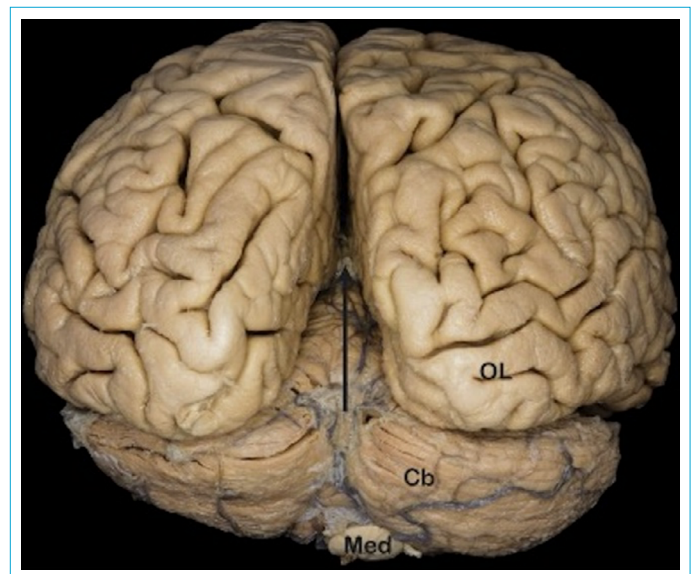


Figure 1. View of the starting point for the supracerebellar suprapineal approach.

The whole brain in which the arachnoids and vessels of the cerebrum were removed before both hemispheres were cut. The direction of the dissection can be seen, with the exact starting point superior to the pineal gland and inferior to the corpus callosum. Cb: Cerebellum; Med: Medulla oblongata; OL: Occipital lobe.

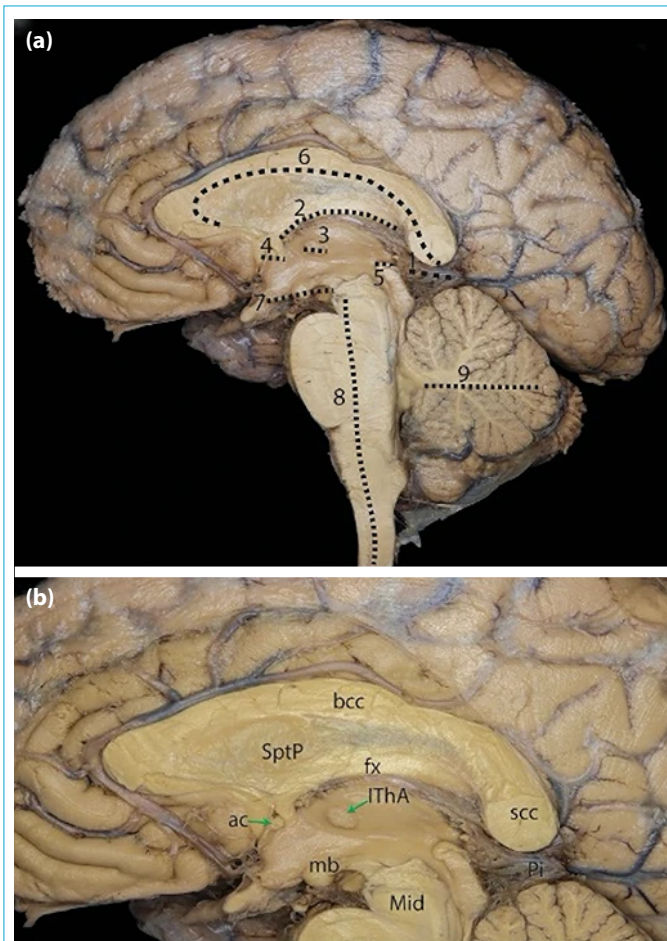


Figure 2. Novel method for cutting brains. The right cerebral hemisphere with its brainstem and cerebellum. The supracerebellar suprapineal approach was used to separate the hemispheres. **(a)** The steps used to separate the brain hemispheres: 1) The starting point is superior to the pineal gland, which is gently cut to access the third ventricle; 2) The interthalamic adhesion is cut into equal halves; 3) The anterior commissure is cut in its medial portion and the fornixes are gently separated from each other; 4) The corpus callosum is cut from its dorsal or ventral aspect without damaging midline structures below; 5) The optic chiasm and tuber cinereum are separated; 6) The brainstem is cut from its anterior or posterior aspect. From the anterior surface, the basilar impression in the pons serves as a landmark to continue dissection in an anterior-to-posterior and superior-to-inferior direction. From the posterior surface, the superior colliculi serves as a reference and dissection is continued in a posterior-to-anterior and superior-to-inferior direction. To dissect posterior to anterior, the cerebellum must first be cut into equal halves through the vermis; 7) After an anterior-to-posterior dissection in the previous step, and after the fourth ventricle is opened, dissection of the cerebellum continues through the vermis. **(b)** The same specimen with a focus on the midline structures preserved through the supracerebellar suprapineal approach.

ac: Anterior commissure; *bcc:* Body of the corpus callosum; *fx:* Fornix; *IThA:* Interthalamic adhesion; *mb:* Mammillary body; *Mid:* Midbrain; *Pi:* Pineal gland; *scc:* Splenium of the corpus callosum; *SptP:* Septum pellucidum.

2. The fornices are gently separated.
3. If an interthalamic adhesion is present, it is cut in its medial portion, completely opening the third ventricle.
4. Dissection continues anteriorly to differentiate both foramina of Monro, and the anterior commissure is cut.
5. Dissection continues posteriorly and the posterior commissure is cut.
6. Next, the septum pellucidum and corpus callosum are gently cut in half. In this step, these two structures can be cut from below (using the third ventricle) or above in a posterior-to-anterior direction (using the interhemispheric fissure). At this point, the hemispheres are separated above the third ventricle with all medial structures spared.
7. Subsequently, the optic chiasm and tuber cinereum can be cut with scissors or a scalpel from the third ventricle (inside-out), or this cut can be made externally (outside-in).
8. The midbrain, pons, medulla, and part of the spinal cord are cut, taking as a midline reference the pontine basilar impression. At this point, the cut continues superiorly and inferiorly until the fourth ventricle is reached.
9. Finally, the cerebellum is cut, taking the vermis as a midline reference point.

After these steps, all the medial structures prone to damage are preserved: the corpus callosum, septum pellucidum, fornix, anterior commissure, interthalamic adhesion, mammillary body, posterior commissure, and pineal gland (Fig. 2b).

This technique is generally used to divide the hemispheres and brainstem into two equal pieces. In some cases, however, when the brainstem is studied separately, the cerebral peduncles are cut from superior structures, separating the brainstem from the hemispheres. In either case, the interhemispheric separation is made through the supracerebellar suprapineal approach and the brainstem is subsequently easier to cut.

The approach described here was done by the most experienced member of our lab as some experience is necessary to prevent damage to the specimen. The process takes from 10 to 15 minutes and the results are excellent.

Discussion

The study of neuroanatomy is essential for advancing research and enhancing educational outcomes.^[2,5,6,9-11] In most academic programs, the classic methodology used is based on showing the whole brain for surface structures and two-dimensional slides for the inner structures within the brain.^[12] However, this methodology prevents a clear and broad understanding of the brain as a three-dimensional structure.

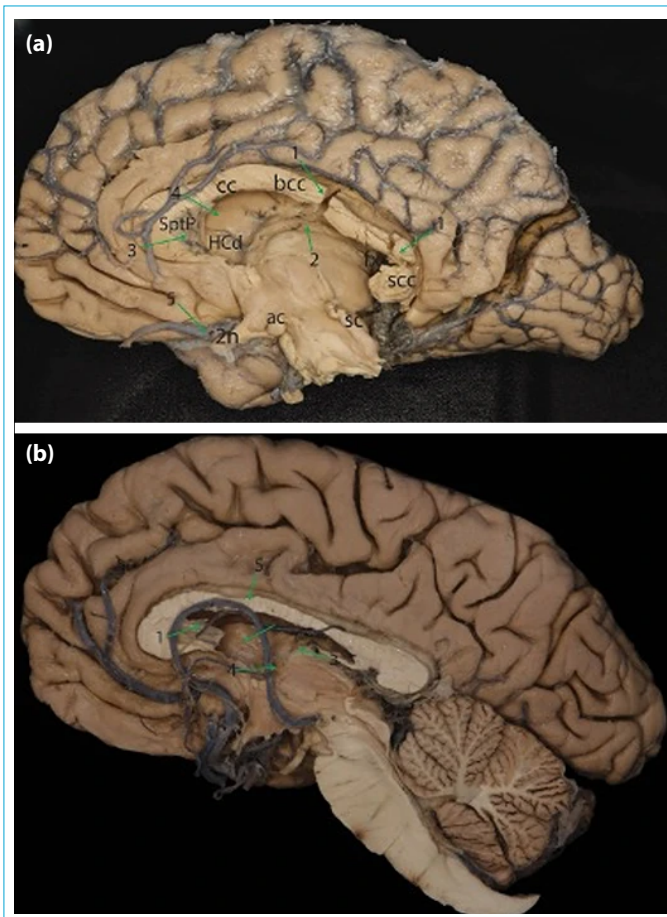


Figure 3. Normal method for cutting brains. A: Right hemisphere cut through the interhemispheric fissure without using an operative microscope, with the first cut made in the dorsal surface of the corpus callosum. We can note that the medial structures were cut inadvertently after using a knife, causing damage to important midline structures such as the corpus callosum (cc), fornix (fx) and septum pellucidum (SptP). 1) Damage of the corpus callosum, we can observe how it is unequal in different aspects of the body and splenium; 2) Damage of the body of the fornix that was inadvertently cut by the blind dissection made for separating the hemispheres; 3) Damage in the septum pellucidum, which is incomplete and not suitable for its study; 4) The frontal horn of the lateral ventricle was opened inadvertently, showing directly the head of the caudate nucleus; 5) Cortical damage made during the cutting process. B: Right whole brain (cerebrum, cerebellum and brainstem) cut using the same technique as Figure 3A, as the previous image it is evident the damage in the cerebrum midline structures: 1) Damage of the septum pellucidum, in this specimen it was preserved only a small amount of this structure; 2) The lateral ventricle was inadvertently opened, making the structures surrounding the ventricle prone to more damage; 3) Complete damage to the fornix, which cannot be seen or studied in the specimen; 4) The absence of the fornix does not allow us to understand the anatomy of the Foramen of Monro, the limits between the lateral and third ventricle cannot be differentiated from each other; 5) The pericallosal artery was displaced inferiorly and cut in its most posterior surface, its anatomy was deformed making difficult to understand its normal direction and areas of irrigation. 2n: Optic nerve; ac: Anterior commissure; bcc: Body of the corpus callosum; cc: Corpus callosum; fx: Fornix; HCd: Head of the caudate nucleus; SC: Superior colliculus; scc: Splenium of the corpus callosum; SptP: Septum pellucidum.

In this sense, knowledge of the white matter tracts is important because the correct localization and interpretation of brain structures enhance the surgical strategy to obtain maximal tumor resection, which in turn decreases postsurgical morbidity.^[13]

Although there is debate about the best method for teaching anatomy, the use of cadaveric specimens has survived as the primary method. However, this method has many limitations, such as a considerable amount of time needed for learning and a lack of economic resources and teachers.^[14] These obstacles have led to the abandonment of cadaveric specimens and increased the use of other strategies, such as technological tools.^[2,3,5,6,9-11]

Each research group seems to employ its fiber dissection technique, with variations in freezing duration and temperature. However, the fundamental steps of fixation as outlined by Klingler—freezing and thawing—are consistently observed.^[2,5-7,15,16] The brain hemispheres are frequently separated through a sagittal section above the corpus callosum in the midline with the traditional method (Fig. 3).^[7,15,16] This maneuver, however, can damage midline structures below the corpus callosum - the fornix and septum pellucidum, among others. In some cases, it can also damage structures above the corpus callosum, for example, cortical cuts in the cingular cortex, or any gyri in the medial surface. Either of these instances will result in unequal brain hemispheres and low-quality specimens.

The supracerebellar suprapineal approach can be used to address the third ventricle surface of the thalamus.^[17] Among the characteristics of a pineal approach is its midline direction. Although this region is challenging,^[18] the supracerebellar suprapineal approach has been proven useful to prepare brain hemisphere specimens in neuro-anatomical studies (Fig. 4).



Figure 4. An image demonstrating the preservation of midline structures with the novel method.

Conclusion

The supracerebellar suprapineal approach to separate brain hemispheres is accurate and provides excellent results for preserving the medial surface of brain specimens. In this way, brain hemispheres with preserved midline structures can be used in neurosurgical education.

Disclosures

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