Color Atlas of Brainstem Surgery

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Robert F. Spetzler
M. Yashar S. Kalani
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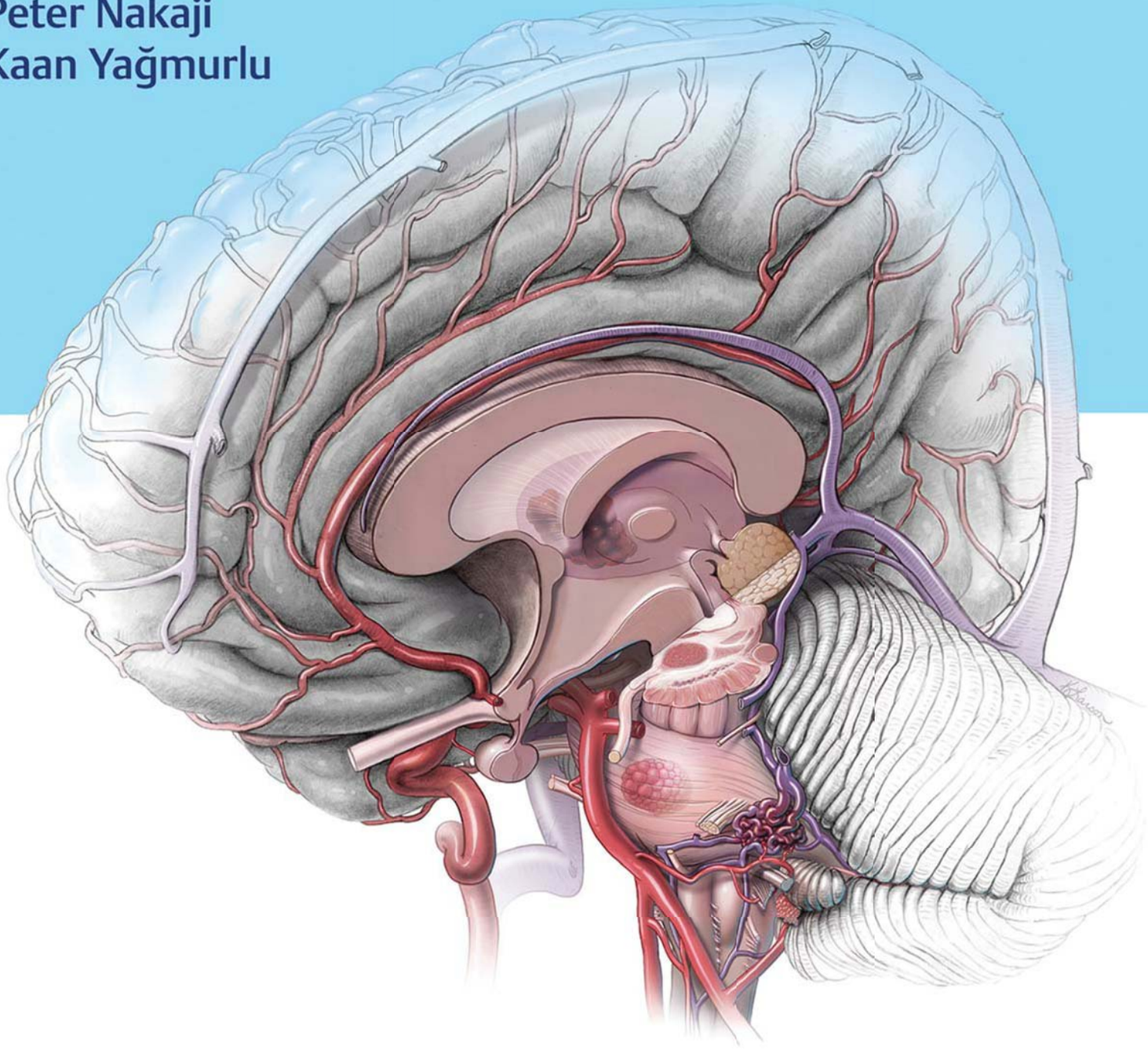

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Color Atlas of Brainstem Surgery

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This Atlas is dedicated to all my patients who have entrusted their care into my hands.
They have been my greatest inspiration and teachers.

Robert F. Spetzler, MD

To my wife Kristin.

M. Yashar S. Kalani, MD, PhD

To my residents and fellows, ever toiling upward in the night.

Peter Nakaji, MD

To my mother, Huriye Meral, and to my father, Edip, who always supported me unconditionally and encouraged me in all avenues of my life. Also, in loving memory of Dr. Albert L. Rhoton, Jr., who was the greatest mentor and teacher and who will always be a source of inspiration to me.

Kaan Yağmurlu, MD

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Foreword

No one has done more than Robert Spetzler to advance the idea that the brainstem is *not* inviolable, inoperable territory. When I was a resident at Barrow Neurological Institute in the 1990s, he began to prove this point, and patients flocked to Barrow from around the world. Other neurosurgeons, it seemed, believed that brainstem surgery was impossible, and so they referred their patients to someone brave enough to believe that it was. That extensive referral network, combined with a large Latino patient population in whom cavernous malformations were prevalent, fueled the discovery that the microsurgical resection of brainstem cavernous malformations was safe and even advisable in many patients. The convergence of a stream of cases and a master neurosurgeon practicing both high-level microsurgery and skull base surgery, at a time when other centers were moving toward endoscopic and endovascular techniques, shaped a new discipline within vascular neurosurgery. Brainstem cavernous malformation surgery began with simple concepts such as the two-point method to select the right approach to expose the lesion. This discipline adapted complex skull base surgical approaches developed for tumors to the simpler pathology of cavernous malformations. Brainstem microsurgery applied technology such as intraoperative navigation for submerged lesions, tractography for pathologies that deviate neural pathways, and microinstruments that bring precision and light to deep, dark surgical corridors. In the end, our perception of the brainstem as an impenetrable monolith was transformed, and we appreciated it instead as a complex labyrinth with zones that could tolerate safe entry.

After hundreds of cases and innumerable contributions to the literature by Dr. Spetzler and his disciples, both at Barrow Neurological Institute and beyond, the microsurgical resection of brainstem cavernous malformations has become an accepted management option in centers around the world whose specialists are well versed in the techniques described in this book. This book is a singular achievement that describes the nuanced anatomy of the brainstem, the complex surgical approaches to the skull base, and the pioneering experience of Dr. Spetzler. The insights of a master neurosurgeon, and the meticulous work of his coauthors Drs. Kalani, Nakaji, and Yağmurlu, are presented through case examples and stunning illustrations by the virtuoso artists in Neuroscience Publications at Barrow Neurological Institute. This *Color Atlas of Brainstem Surgery* is destined to become a classic on the shelf of every cranial neurosurgeon.

As I reflect on Dr. Spetzler's legacy and his contributions to brainstem surgery at this, the twilight of his brilliant neurosurgical career, the parallels to Charles Drake and vertebrobasilar aneurysm surgery are striking. In his era, Drake was the recipient of a steady stream of difficult aneurysm cases and London, Ontario, became the crucible of discovery for posterior circulation aneurysm surgery. He amassed an experience that has never been replicated, and he advanced the idea that the posterior circulation was *not* an inviolable territory for aneurysm surgery. Furthermore, he inspired a generation of young neurosurgeons to refine the techniques for basilar aneurysm surgery and to practice them around the world. The same can be said of the unique experience with brainstem surgery amassed by Dr. Spetzler, which has made Phoenix, Arizona, a crucible of discovery for brainstem surgery. The pearls embedded in this atlas will similarly inspire future generations of neurosurgeons to perform safe, curative surgery on the brainstem.

It is worth stating that brainstem surgery is not for the faint of heart or the unsteady of hand. Brainstem cavernous malformations and arteriovenous malformations are particularly challenging, and the line between success and failure is razor thin. Although this book is a testament that brainstem surgery can be safe and curative, it is also a reminder that brainstem surgery can be morbid and sometimes fatal. The pages of this book will undoubtedly inspire the reader to perform this surgery, but they do not contain the intangibles required for its success. I have learned many of these techniques throughout the years I have spent working with Dr. Spetzler, from the judicious selection of patients for surgery to the thoughtful construction of operative strategy, the dexterous dissection to reach the targets, the keen recognition of localizing anatomy, and the judgment to know how aggressively to dissect and when to stop. Learning the special art of brainstem surgery begins with the careful study of books like this one, but it continues by observing master neurosurgeons in action who possess and practice these intangibles.

Michael T. Lawton, MD
San Francisco, CA

Preface

The brainstem, until quite recently, was considered inviolable because of its tightly packed tracts and deep nuclei. Thus, patients with pathology in this region were generally managed conservatively, and their fates were often left to the natural history of their diseases. Early surgery was confounded by inadequate visualization, incomplete understanding of brainstem anatomy, lack of appropriate instrumentation, and poor results from attempted resection of brainstem pathology, particularly the failed surgical attempts to treat infiltrating gliomas.

However, improvements over time in imaging, instrumentation, patient monitoring, operating microscopes, and especially neuronavigation have led to the obvious recognition that the brainstem is just another part of the central nervous system. The natural evolution of tentative steps based on previous successes has led us to understand that the brainstem is not inviolate to surgical manipulation but instead requires proven avenues for safe resection. Brainstem cavernous malformations, whose repeated hemorrhages often demand surgical intervention, have been our greatest teachers as we sought to define safe corridors in this eloquent region. With neuronavigation enabling the neurosurgeon to delineate both a target and a path, lesions deep in the brainstem that were not visible on the surface became reasonable targets for excision. As our experience in operating in the brainstem accrued, the safest entry routes became better defined. This atlas draws on the lessons learned from more than a thousand operations in and around the brainstem conducted by the senior author, and we hope that it proves to be of benefit to our colleagues and their patients.

Many factors influence the decision about whether to operate on a specific patient, including the patient's age and medical condition, the severity of symptoms, the number of hemorrhages, the extent of accessibility, and the experience of the neurosurgeon. The associated venous anomaly frequently requires an approach from a more direct to an alternative route because experience has taught us to preserve these large veins. Although the brainstem is technically surgically accessible, it remains an extremely eloquent structure that demands rigorous decision-making when considering surgery. For example, a patient with a small asymptomatic pontine cavernous malformation in the midline below the floor of the fourth ventricle should never be considered for resection. Alternatively, a patient with a large lateral pontine cavernous malformation that has resulted in clinically significant neurologic deficits will likely receive dramatic benefit from its surgical removal.

This atlas builds on the legacy of many previous atlases. As neurosurgeons, we tend to be visually oriented. Being able to see the anatomy through artists' illustrations and animations, clinical images, operative photographs, and intraoperative videos enables us to better grasp the intricacy of the anatomic relationships and the delicate corridors that are necessary for exposure. As one might expect, this atlas approaches the brainstem regionally. Thus, the reader will find a logical and accessible map to the separate subdivisions of the brainstem, each of which has its own special anatomic and surgical considerations. The thoughtful reader will find much illumination from these shared, hard-learned lessons. We began with the assertion that the nuances found herein will translate to many more areas of neurosurgery than brainstem surgery alone. It is our sincere hope that you, the neurosurgeon, will gain from this knowledge to the ultimate benefit of your patients. We invite you to turn the pages, open your mind, and enter into the hallowed halls of the brainstem.

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Phoenix, Arizona

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No book of this magnitude could come to fruition without the ceaseless efforts of our talented and hard-working support staff in Neuroscience Publications. They include our editorial coordinators, Rogena Lake and Samantha Soto, who handled manuscript intake and formatting, and who maintained an ongoing record of the project. We thank our production editor, Jaime-Lynn Canales, whose meticulous attention to detail enabled her to keep track of more than 1,700 clinical images, photographs, and illustrations through numerous iterations. She also handled copyright and permissions for all the figures used in the atlas. To our medical editors Mary Ann Clifft, Dawn Mutchler, and Lynda Orescanin, we express appreciation for their skill in polishing our prose and ensuring consistency across the sections of the book and throughout the cases. We thank our video editor Marie Clarkson, who sifted through hours of intraoperative videos to select the intraoperative images used in the side-by-side illustrations in the cases and trimmed the videos to our specifications, then edited our recorded narrative explanations of them. She also edited the narration for the superb animations created by Michael Hickman and Joshua Lai. Above all, we thank our lead medical illustrator Kristen Larson Keil, who so admirably guided—throughout her pregnancy and after her maternity leave—a team of contract artists and in-house illustrators that included Peter Lawrence and Mark Schornak, the manager of Neuroscience Publications. Ms. Keil's artistic talent is showcased in countless illustrations throughout this atlas, particularly in the illustration she prepared for the cover. She and the other illustrators relied not only on their inherent artistic talent but also on their intensive training and their in-depth understanding of anatomy to create beautifully detailed medical illustrations of the anatomy, pathology, and neurosurgical techniques that we describe in depth. They also prepared detailed side-by-side line drawings interpreting the intraoperative photographs to clearly illustrate our step-by-step approach to each case.

Intraoperative photographs showing the positioning of patients for operations were provided by medical photographer Gary Armstrong.

We thank our families for their patience and ongoing support, and our colleagues here and elsewhere—including our current and former residents and fellows—for their input. We also thank our patients, without whom a book such as this would not be possible.

Finally, we thank the team at Thieme Medical Publishers, which includes Timothy Hiscock, Sarah Landis, Barbara Chernow, and their many colleagues. Only with their encouragement and assistance could this book have been produced.

1 Anatomy

Internal Anatomy of the Brainstem

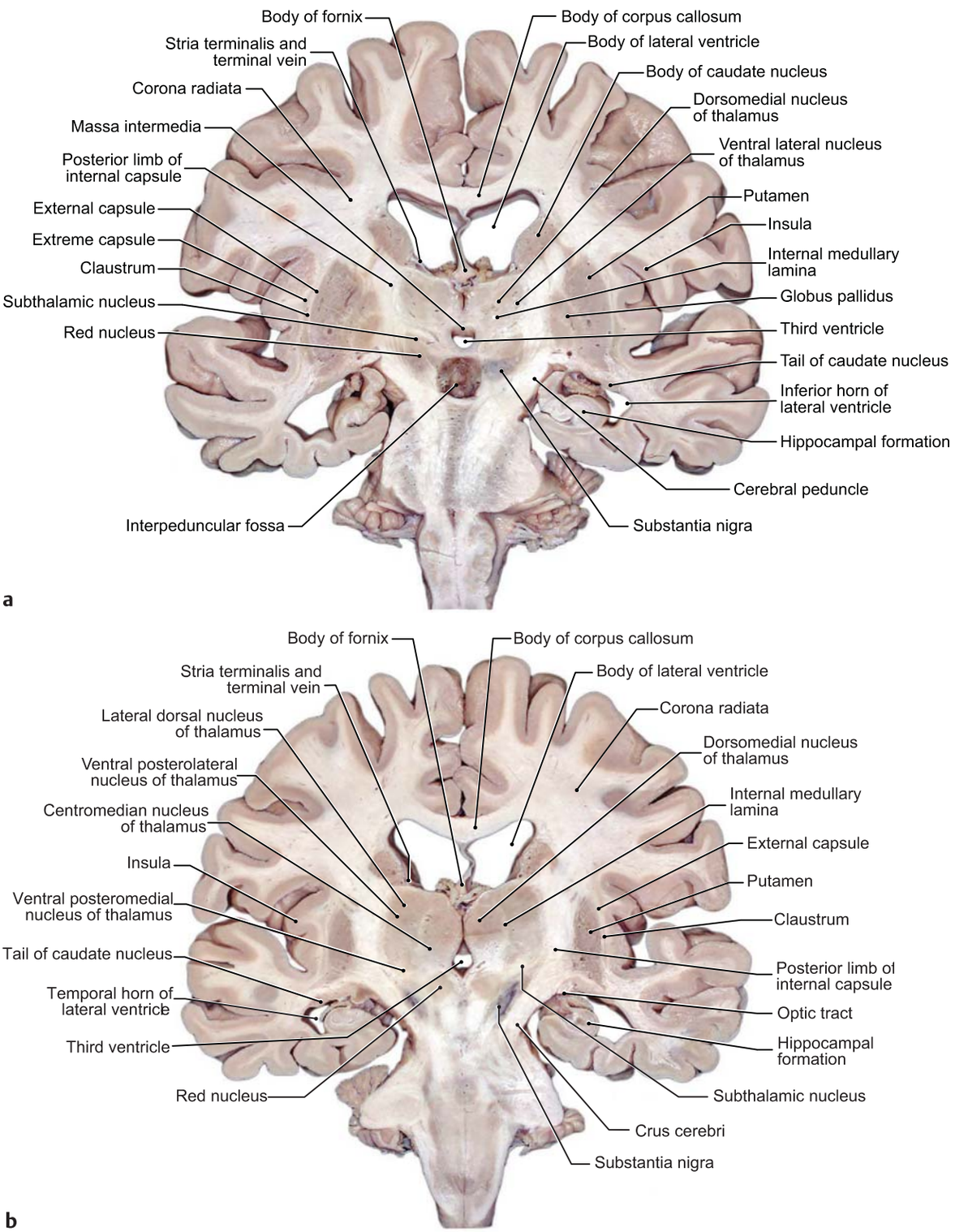
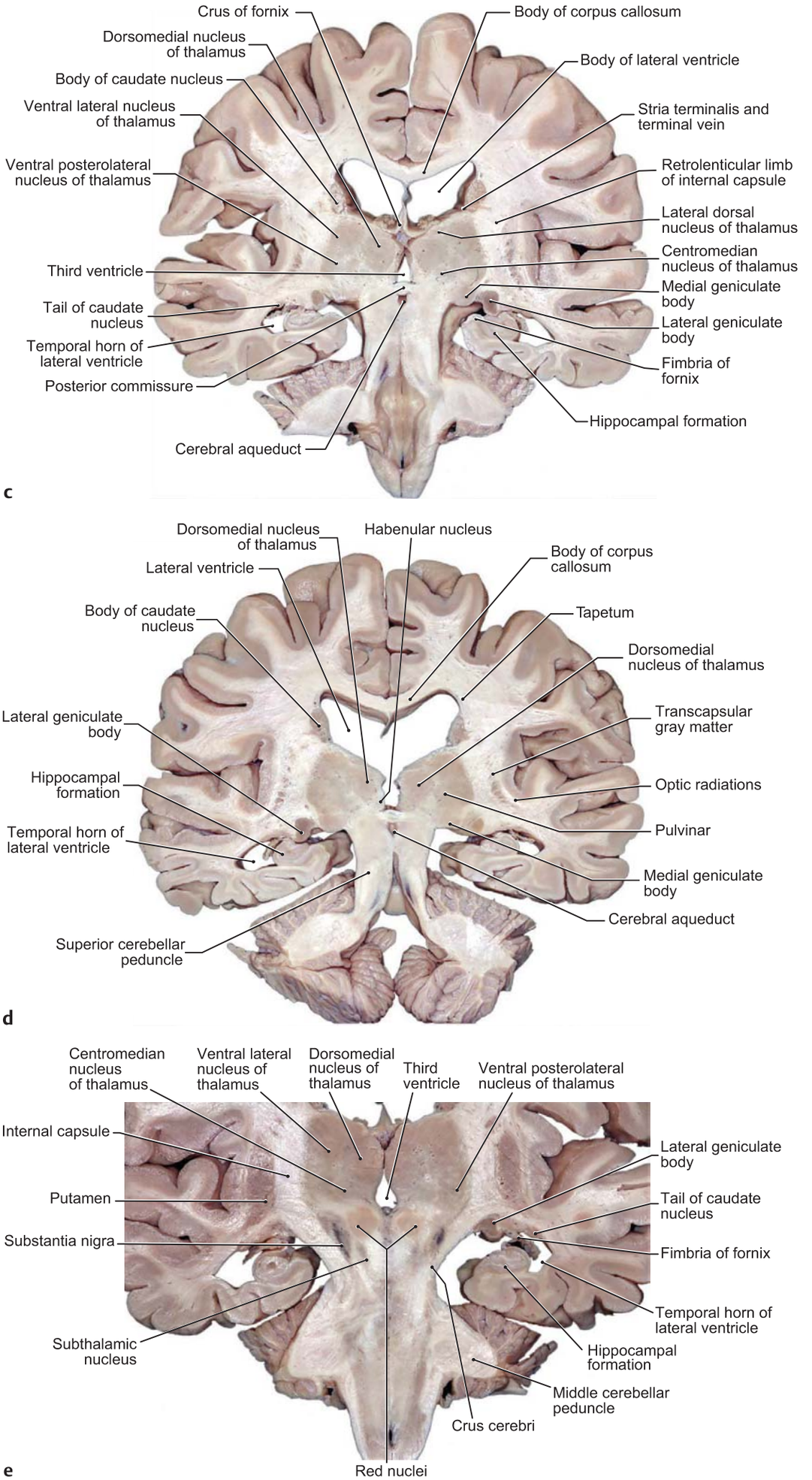


Figure 1.1. (a–e) Sequential coronal sections of the brain and brainstem depicting the structures of the diencephalon.



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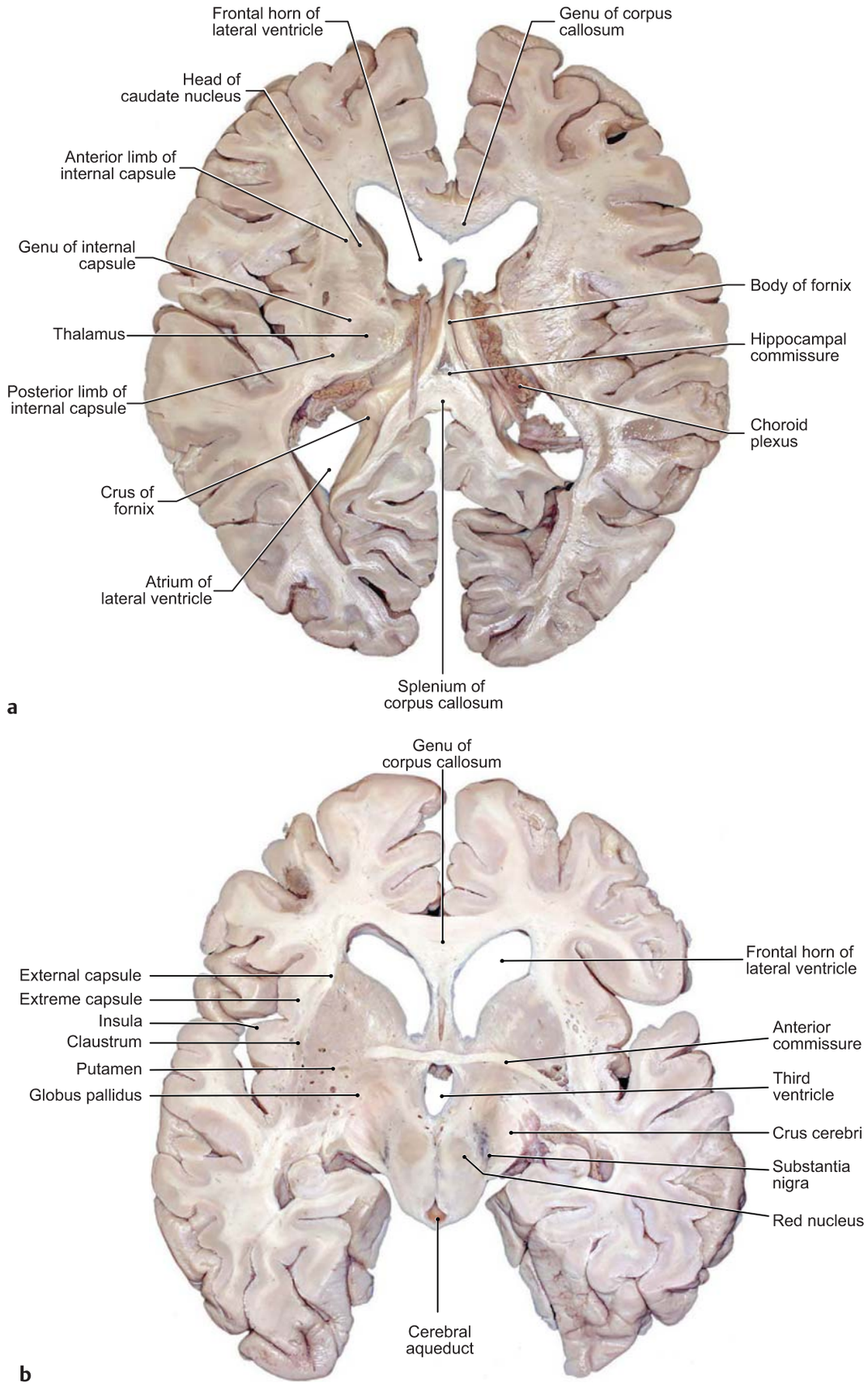
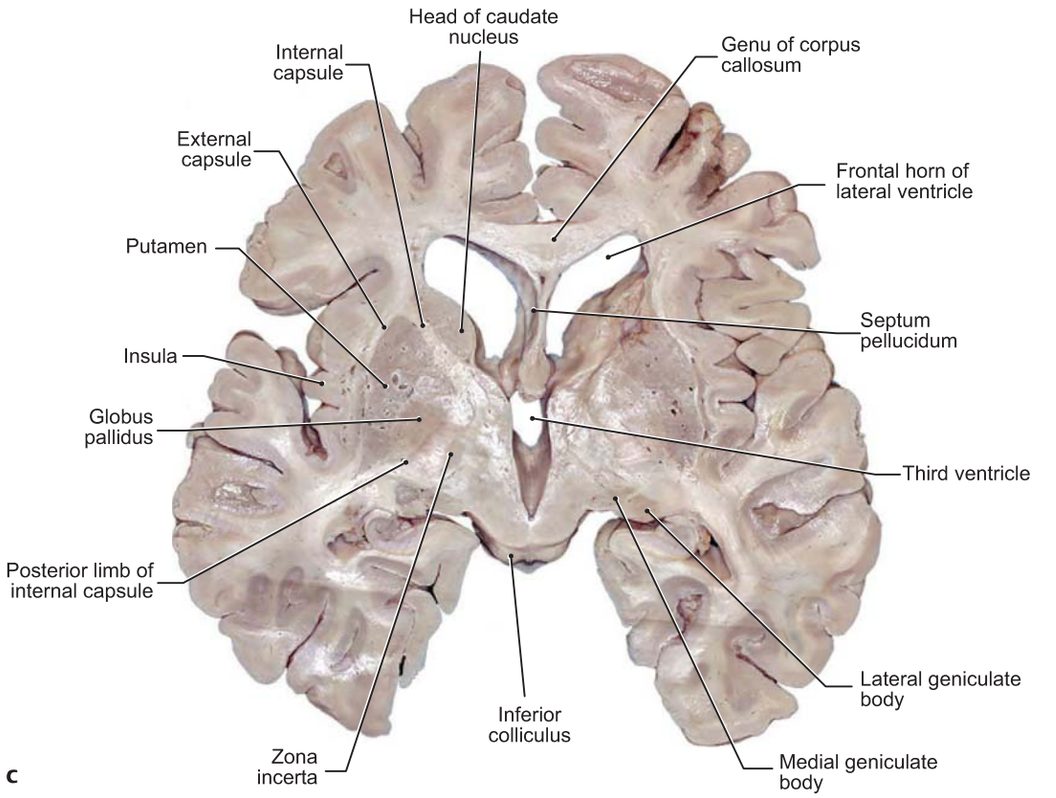
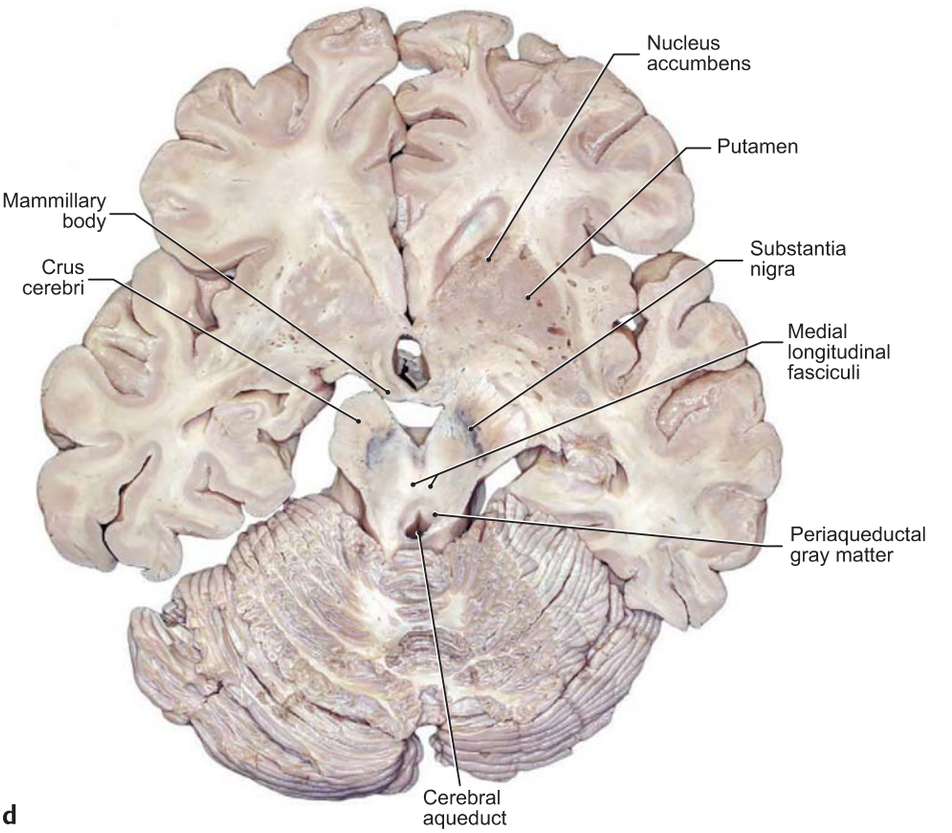


Figure 1.2. (a–d) Sequential axial sections of the brain and brainstem depicting the structures of the diencephalon.





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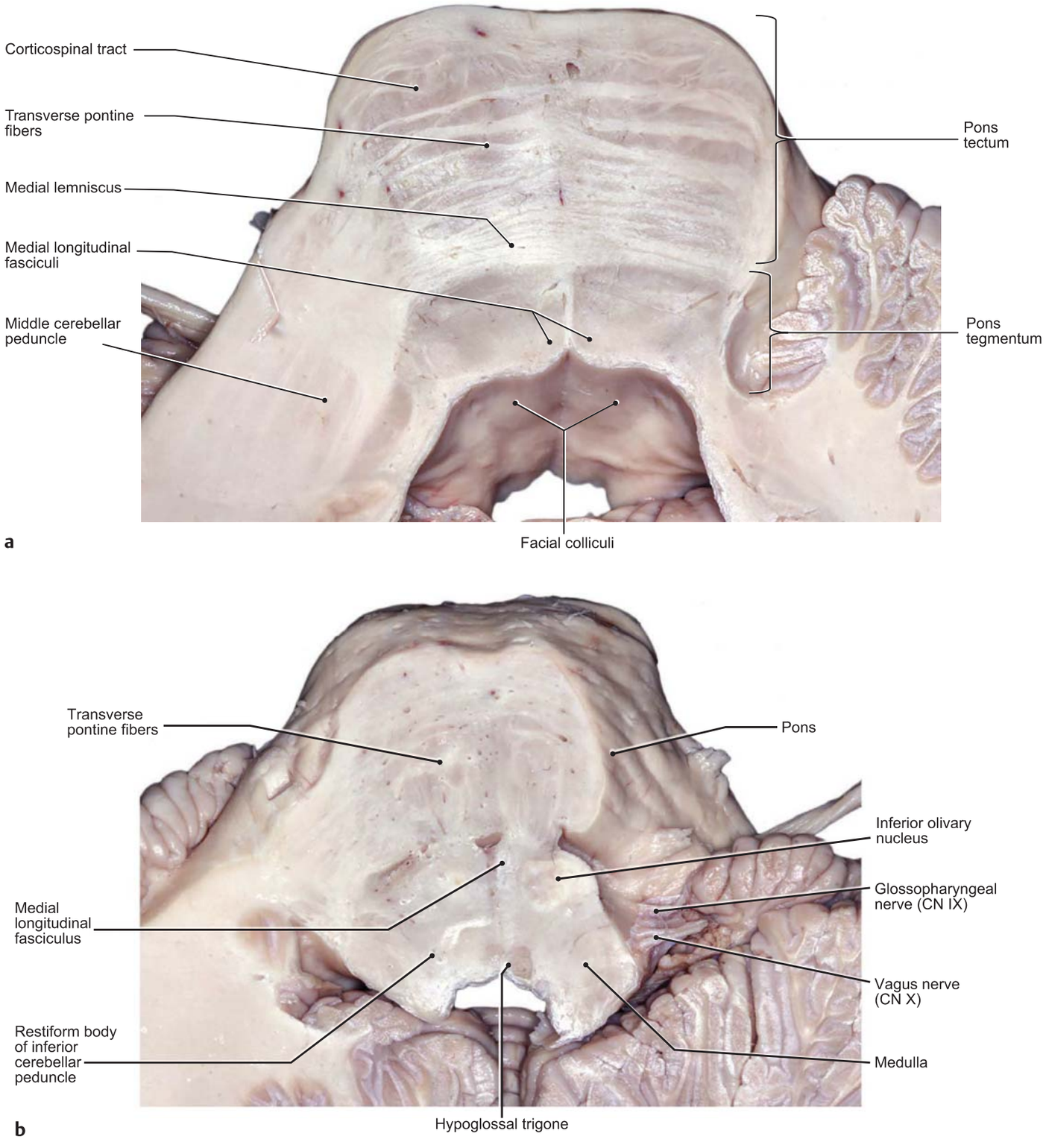


Figure 1.3. (a,b) Axial sections of the brainstem depicting structures of the pons and medulla oblongata. CN, cranial nerve.

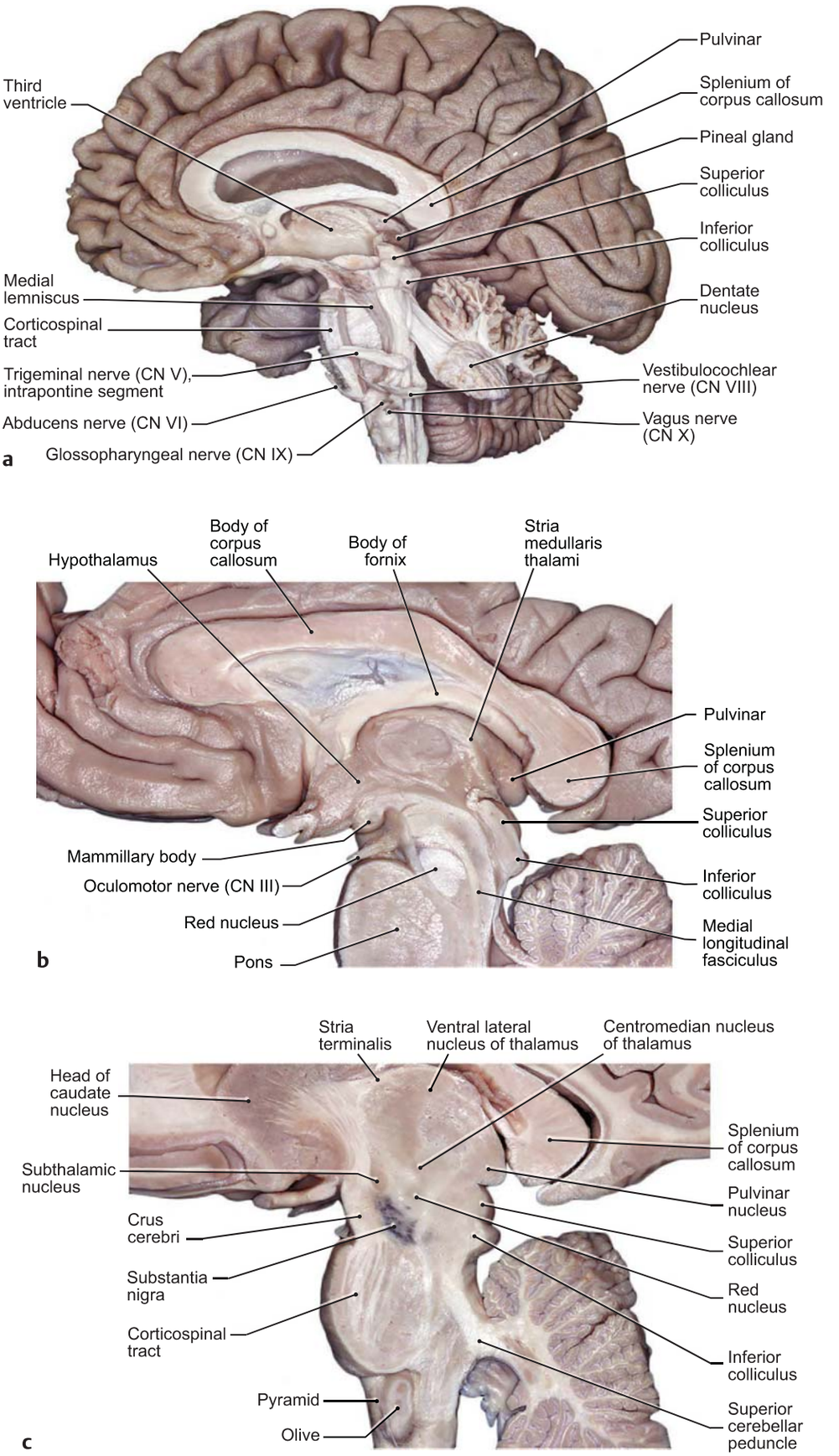


Figure 1.4. (a–c) Sequential sagittal sections of the brain and brainstem depicting critical structures of the diencephalon.

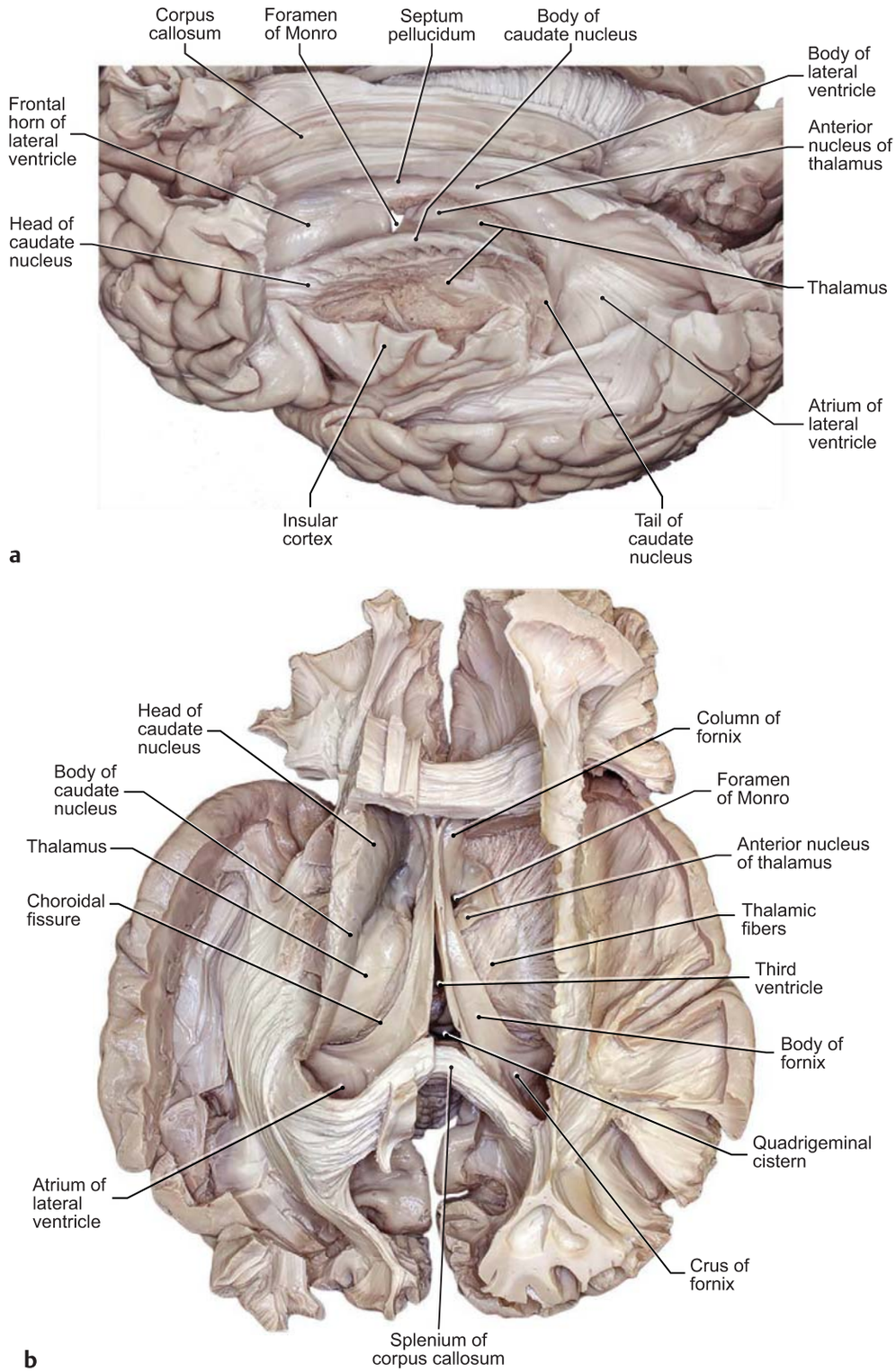
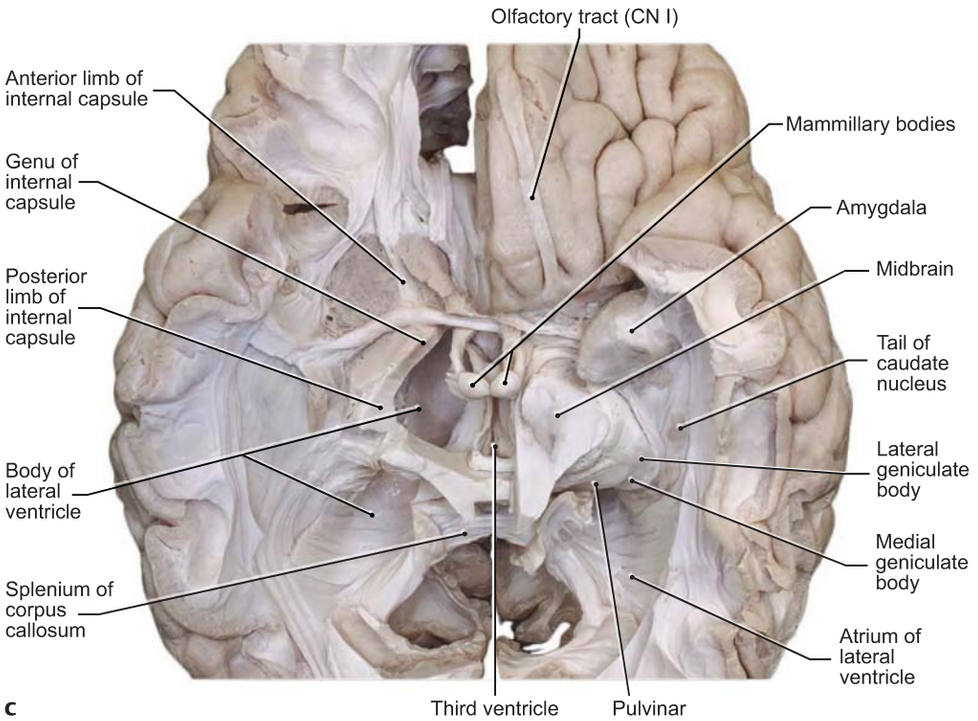
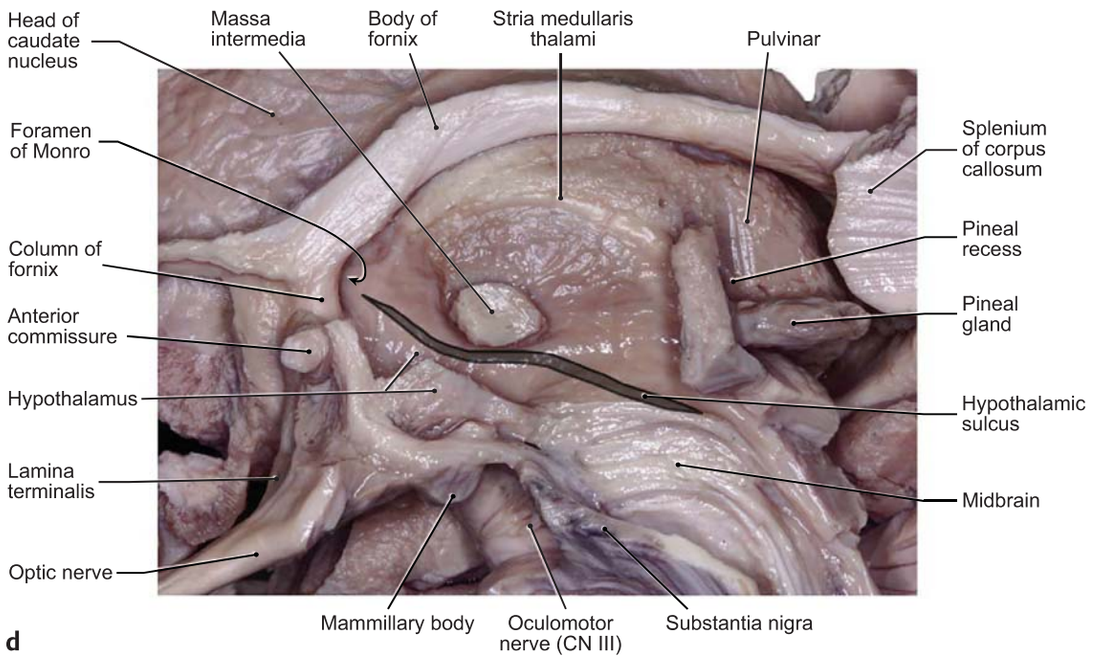


Figure 1.5. **(a)** Superolateral, **(b)** superior, **(c)** inferior, and **(d)** medial views showing the relationship of the thalamus, the lateral ventricle, and the third ventricle relative to adjacent structures.





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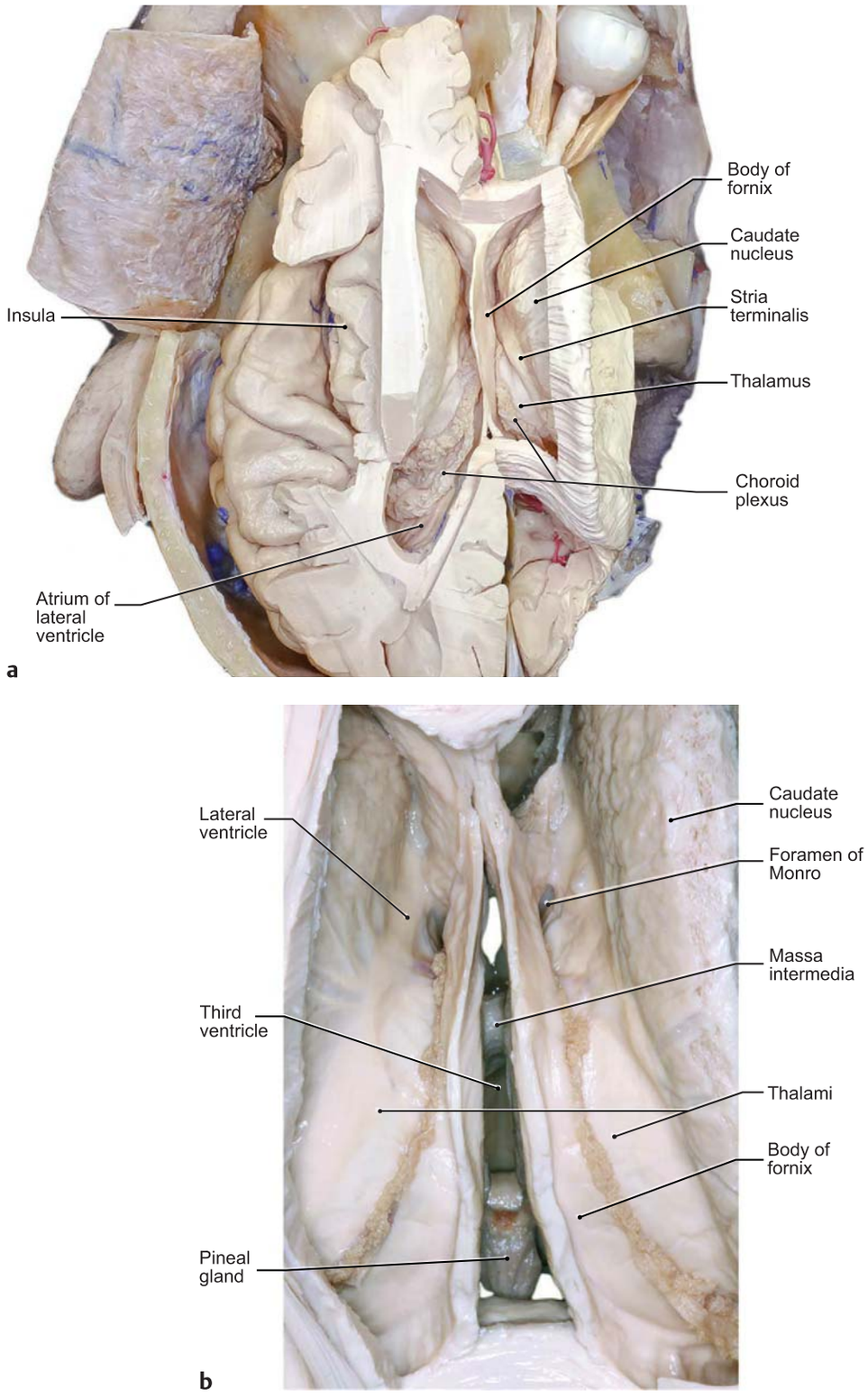


Figure 1.6. (a,b) The relationship of the thalamus to the lateral and third ventricles from a superior view.

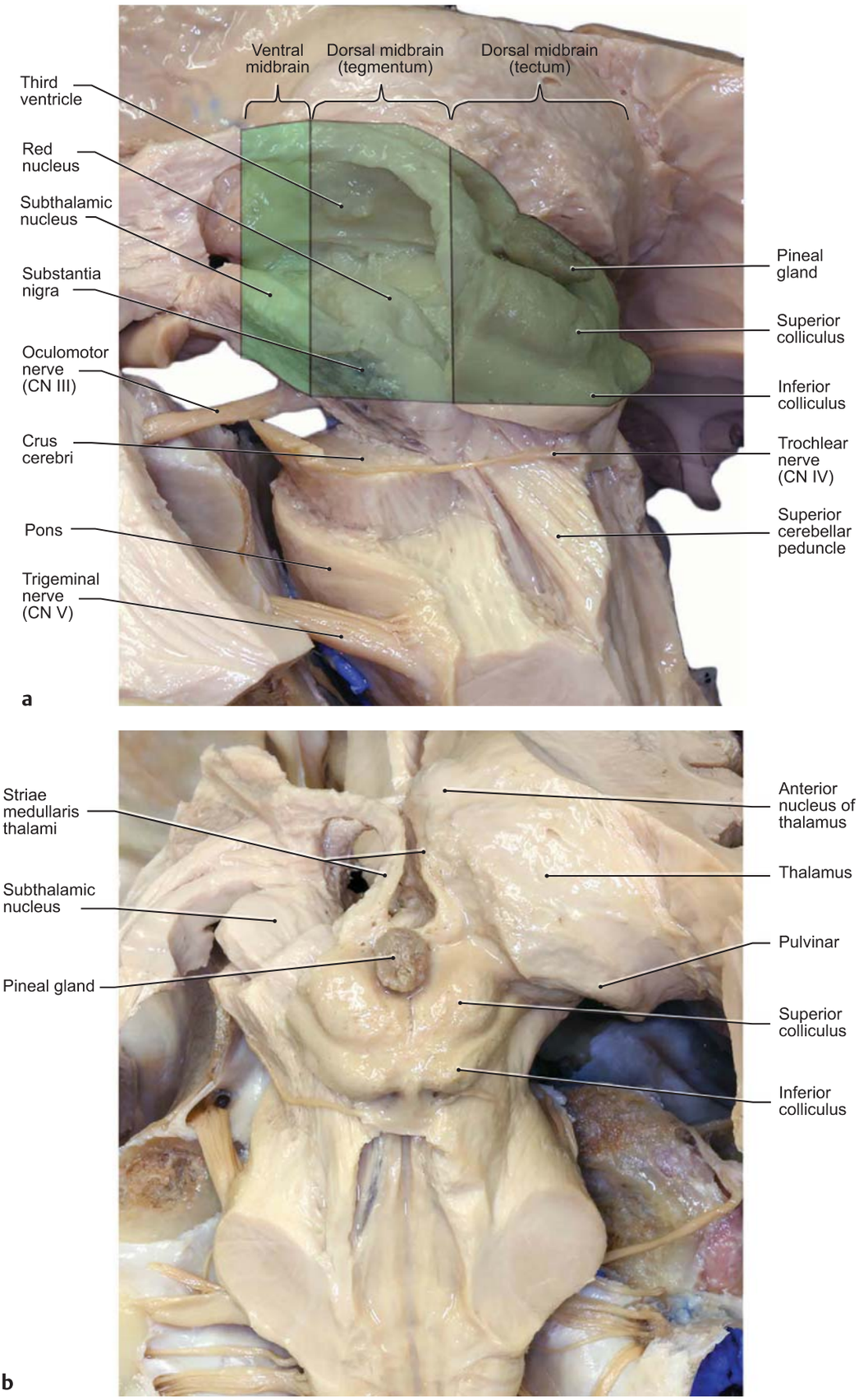
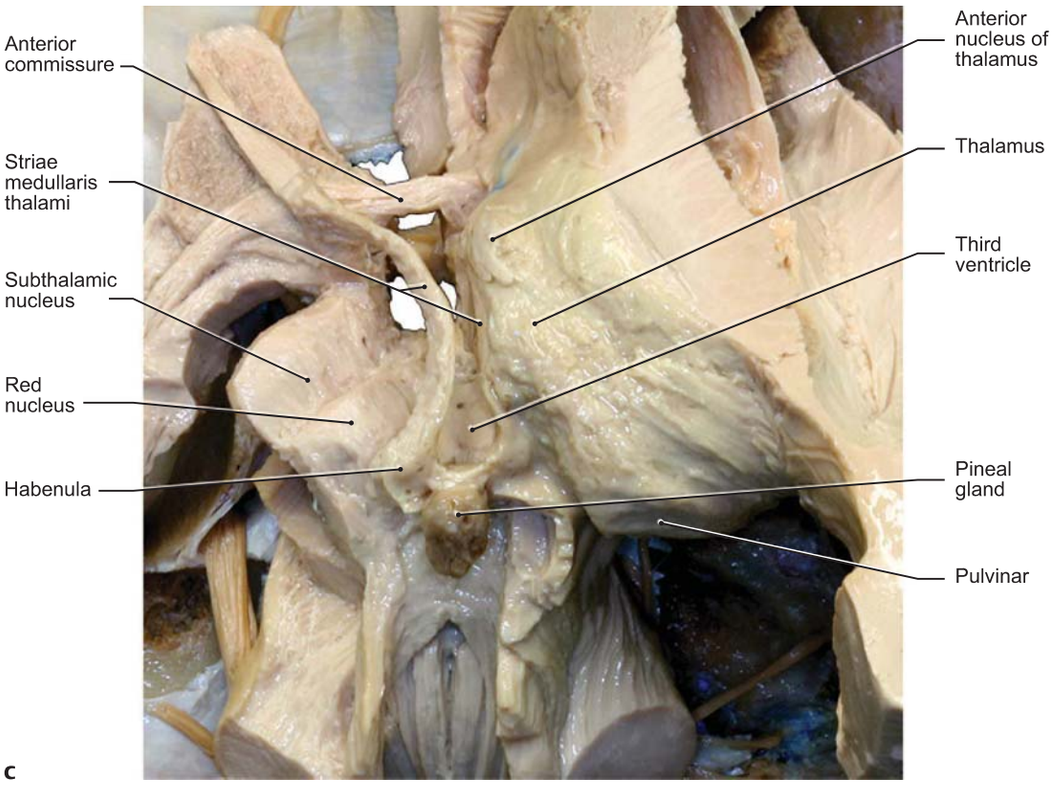


Figure 1.7. **(a)** Lateral, **(b)** posterior, and **(c)** superior views showing the relationship of the thalamus to midbrain structures.



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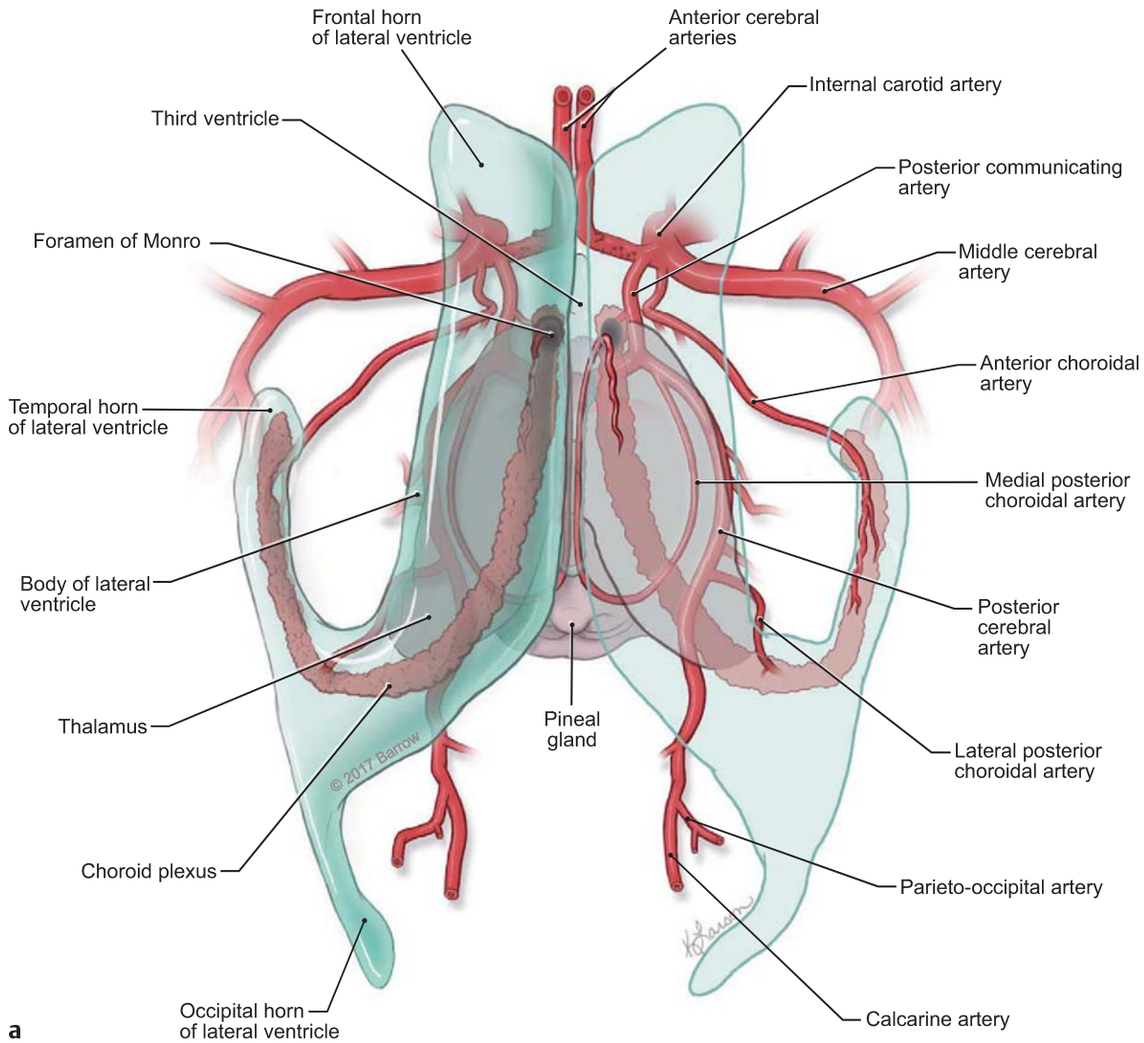
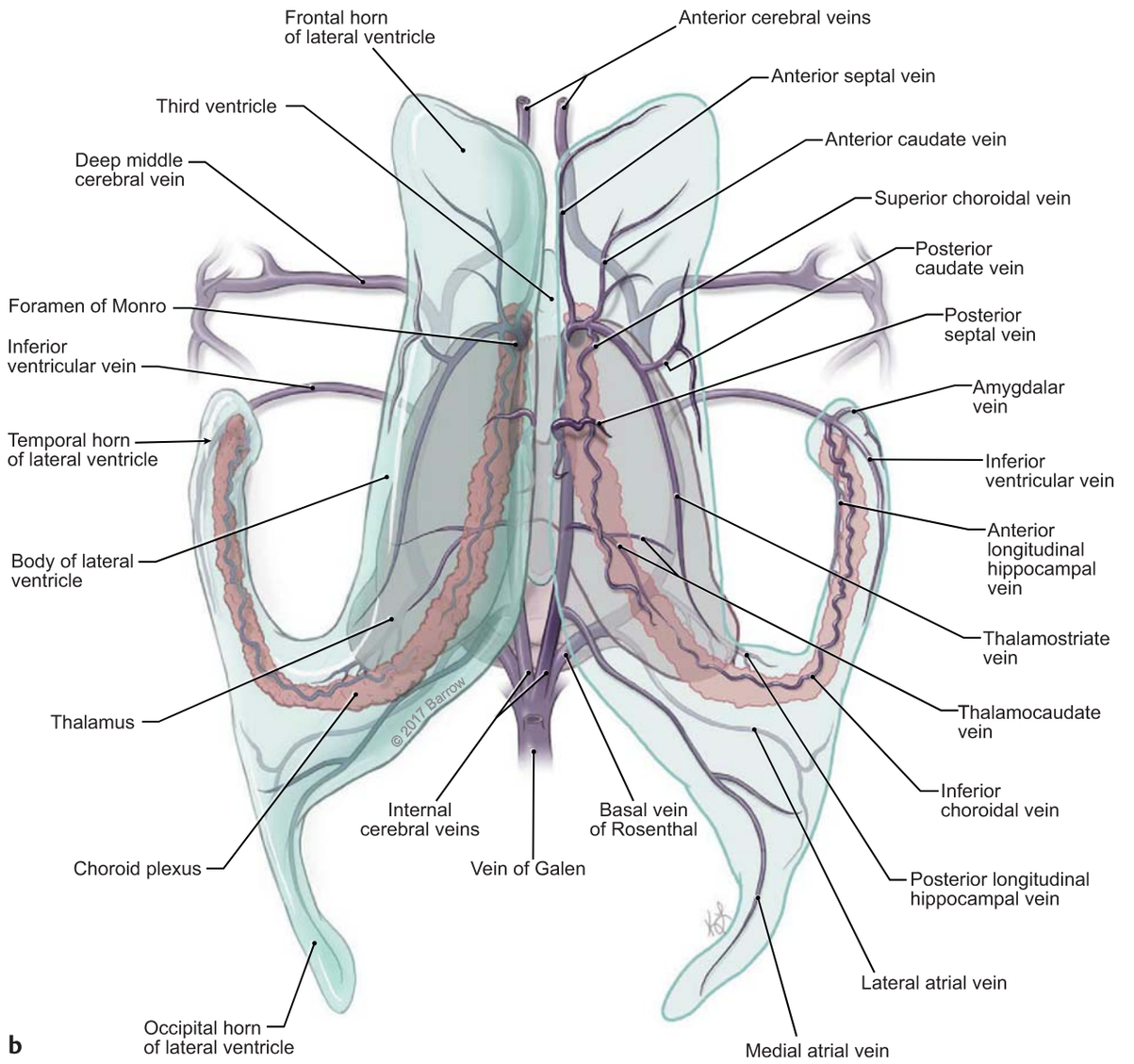


Figure 1.8. Superior view of the relationship of the cerebral **(a)** arteries and **(b)** veins to the lateral and third ventricles.



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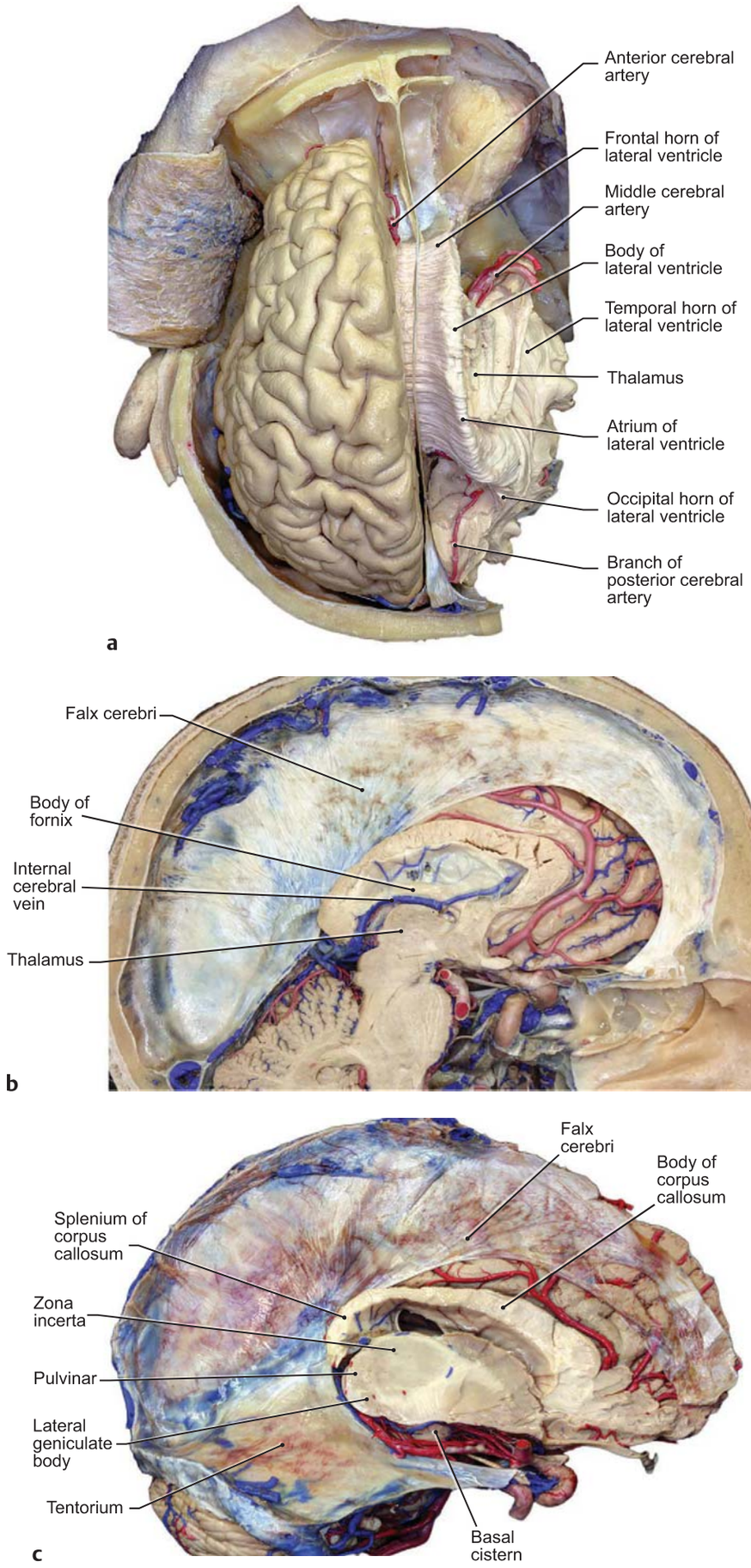

Figure 1.9. **(a)** Superior and **(b,c)** sagittal views of the vascular relationship of the thalamus and ventricles.

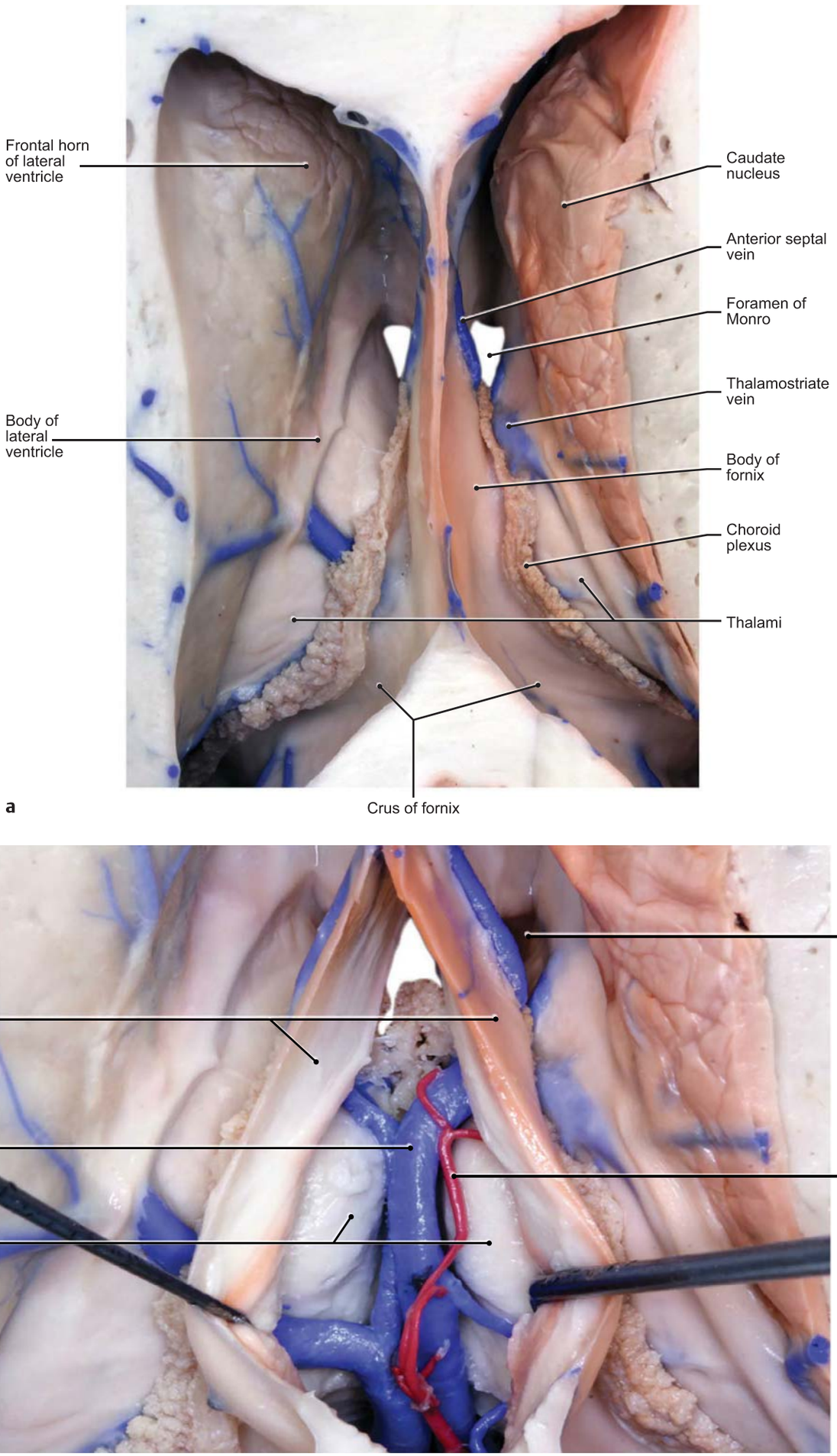

Figure 1.10. **(a)** Superior view of the venous relationship of the lateral and third ventricles. **(b)** Superior view showing the separation of the body of the fornix to expose the third ventricle and vascular structures.

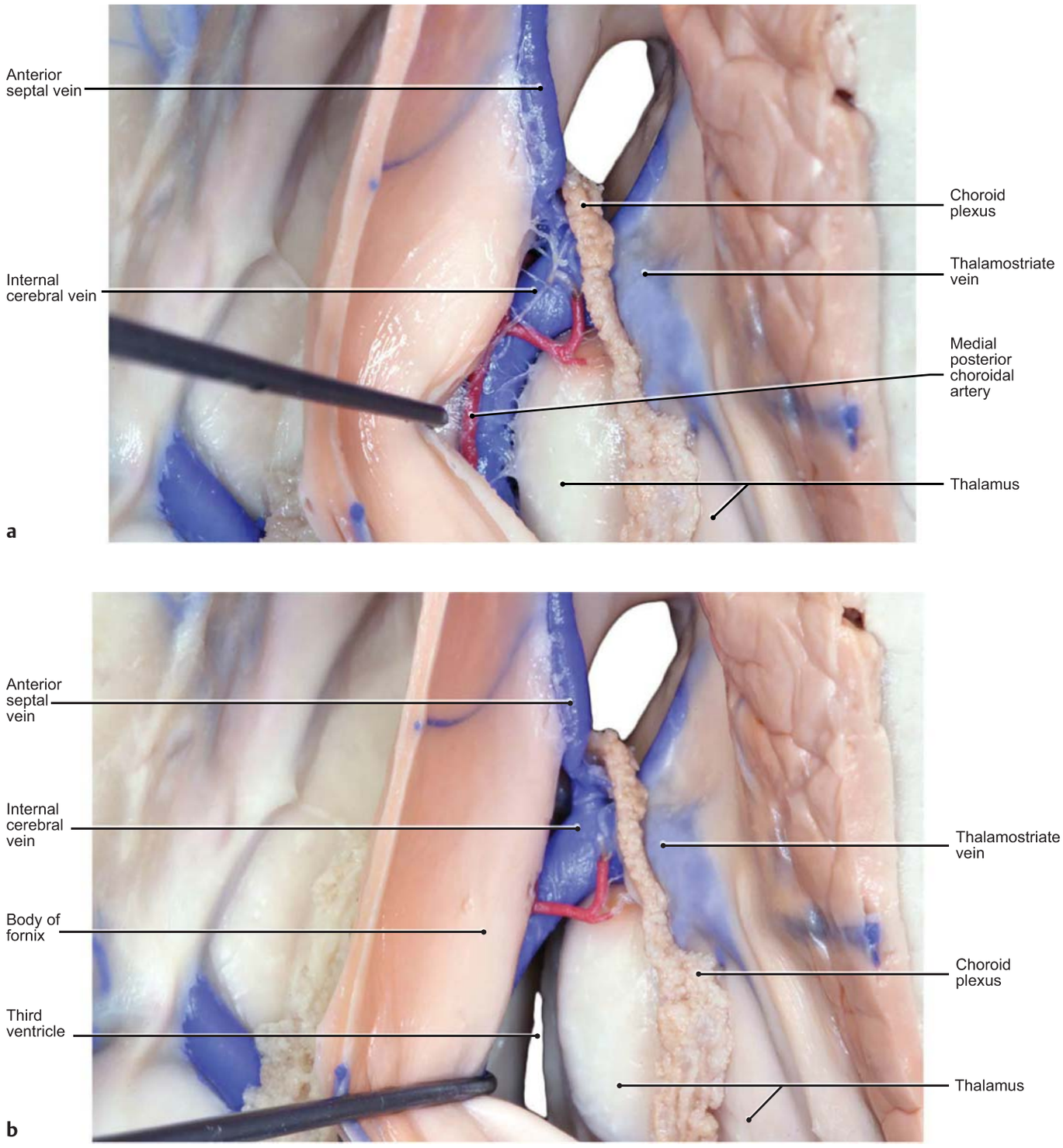

Figure 1.11. (a,b) Superior views showing the exposure of the third ventricle through the right lateral ventricle.