Midline Supracerebellar Craniotomy

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General Considerations

The supracerebellar craniotomy is one of the most underutilized surgical approaches in neurosurgery. Its flexibility as a far-reaching corridor to the posterior medial temporal lobe, mesencephalon, posterior third ventricle and thalamus has only been recently sufficiently explored.

The supracerebellar approach exploits the natural subdural space along the supracerebellar space to allow the surgeon to avoid brain transgression and reach the pineal region, posterolateral mesencephalon, and posterior third ventricle. The operative corridor is narrow, deep, and presents technical challenges.

A continuum of supracerebellar infratentorial approaches to the posterior and lateral tentorial incisural space have been explored as one moves further away from the midline. These approaches have coalesced into the classic midline approach, the lateral or paramedian approach, and the far lateral approach. Other approaches to the region include the transtentorial supracerebellar, occipital transtentorial, and transcallosal interhemispheric variations.

I do not use the occipital transtentorial and transcallosal interhemispheric variations as these approaches often place other normal supratentorial structures at risk. The infratentorial approach is very well tolerated by patients despite manipulation of the cerebellum and can be expanded to obviate the need for these other pathways for reaching almost all lesions of the area.

The midline bilateral suboccipital supracerebellar route is traditionally designed for exposing pineal region tumors. The limitations of this

approach include limited lateral or inferior visualization caused by the angle of the tentorium and the obstructive apex of the culmen, respectively. Almost all midline bridging vermian veins are invariably sacrificed; this maneuver is not without risks.

I recently stopped using the midline bilateral suboccipital supracerebellar route for even large midline pineal region tumors in favor of the left-sided paramedian supracerebellar approach to offset some of these disadvantages. The trajectory over the lateral cerebellum or the quadrangular lobule is more direct and less steep than the one over the apex of the culmen. The paramedian corridor spares most midline vermian veins.

I believe the advantages of the paramedian versus a midline suboccipital craniotomy are similar to those of a frontolateral or pterional craniotomy versus a bifrontal craniotomy for resection of large olfactory groove meningiomas.

In this chapter, I describe the traditional midline supracerebellar approach. In the next chapter, I focus on the paramedian supracerebellar approach that provides all necessary operative access to the pineal, posterolateral mesencephalon, posterior third ventricle, and posterior basal temporal lobe.

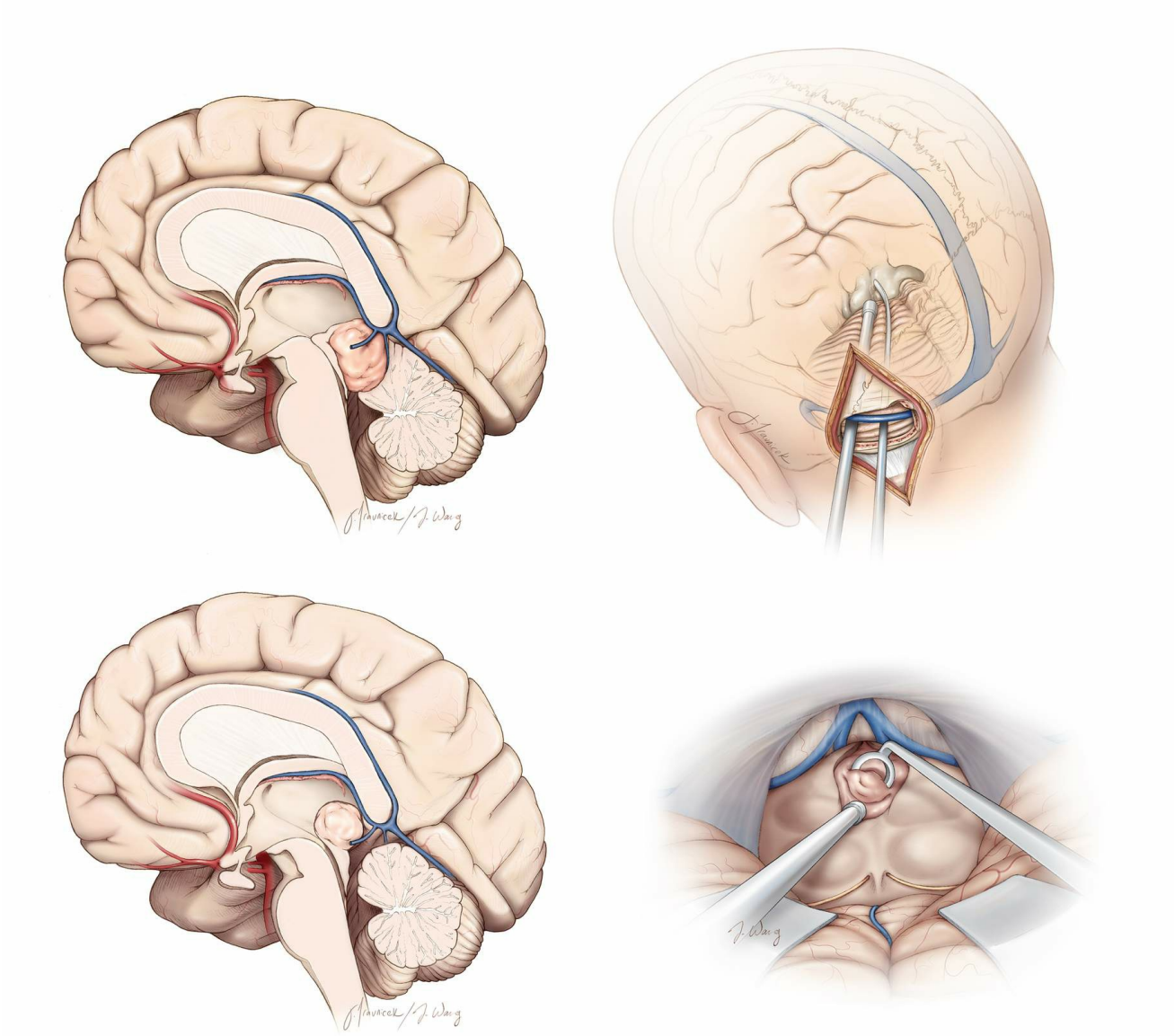

Figure 1: The paramedian supracerebellar approach has numerous advantages over the midline approach: 1) the craniotomy does not place the frequently more dominant right transverse sinus and torcula at risk and is less invasive, 2) only one cerebellar hemisphere is manipulated, 3) the vermian bridging veins are often protected, and 4) the lower slope of the lateral cerebellum provides a more inferior trajectory to the inferior pole of the tumor. Repeat surgery may be performed through the intact contralateral supracerebellar route. The paramedian or midline approach allows exposure of posterior third ventricular tumors (bottom images).

Indications for the Approach

The supracerebellar approach is useful for exposing pineal region tumors such as germ cell tumors, pineoblastomas, astrocytomas, and other rare lesions such as meningiomas, epidermoid tumors, and pilocytic

astrocytomas. Importantly, this is an alternative and my preferred approach for resection of posterior third ventricular tumors because gentle manipulation of the pulvinar is well tolerated by patients. Vascular lesions such as tentorial arteriovenous fistulae and malformations are amenable to this approach.

Other intraparenchymal posterolateral mesencephalic lesions, such as cavernous malformations and pilocytic astrocytomas, may be reached through this route. Distal superior cerebellar artery aneurysms may also be accessed.

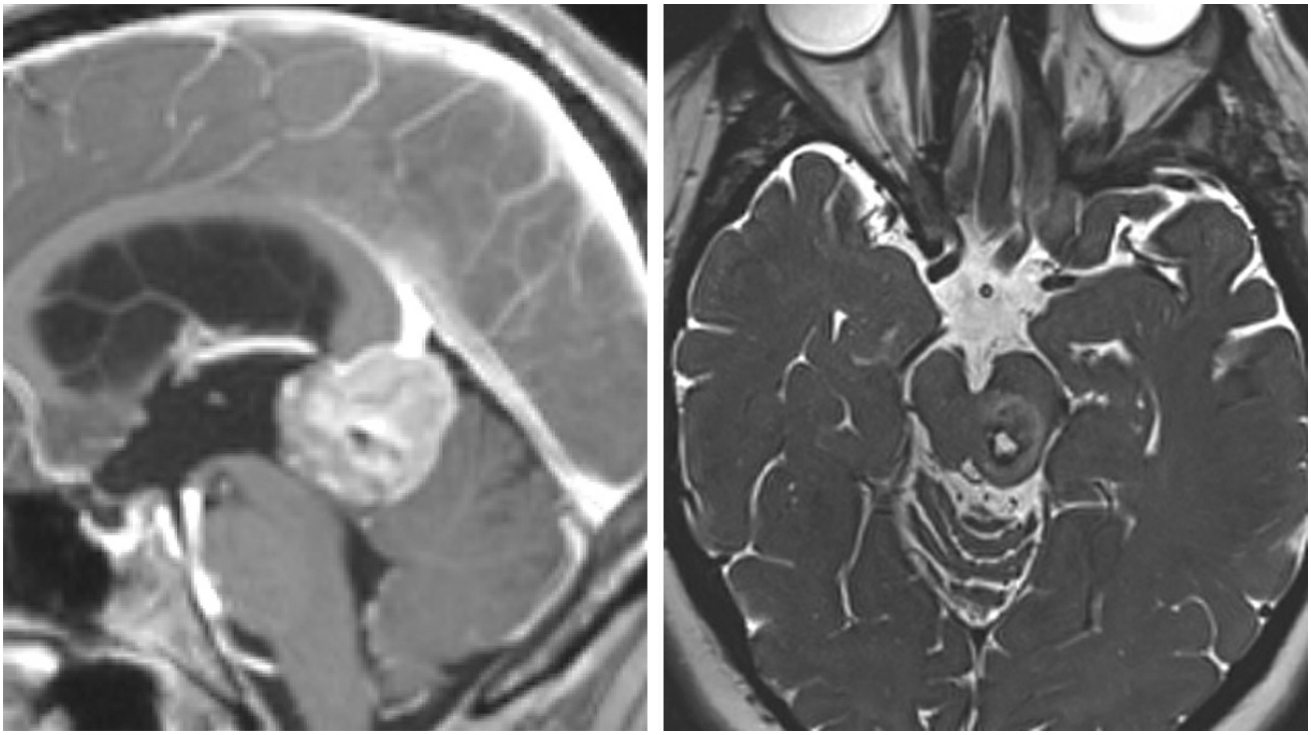

Figure 2: Large lesions in the pineal region (left image) and posterolateral mesencephalon (right image) can be readily exposed through the supracerebellar route.

The transtentorial extension of the paramedian supracerebellar operative corridor is innovative. Sectioning the tentorium through the supracerebellar space allows removal of the supratentorial extension of petrous apex meningiomas and avoids the need for a second-stage subtemporal surgery. Posterior hippocampal cavernous malformations, arteriovenous malformations, astrocytomas, and metastasis can be resected through this approach. This route is ideal for excising medial tentorial meningiomas while obviating the need for temporal lobe

retraction to reach the medial tentorium through the subtemporal pathway.

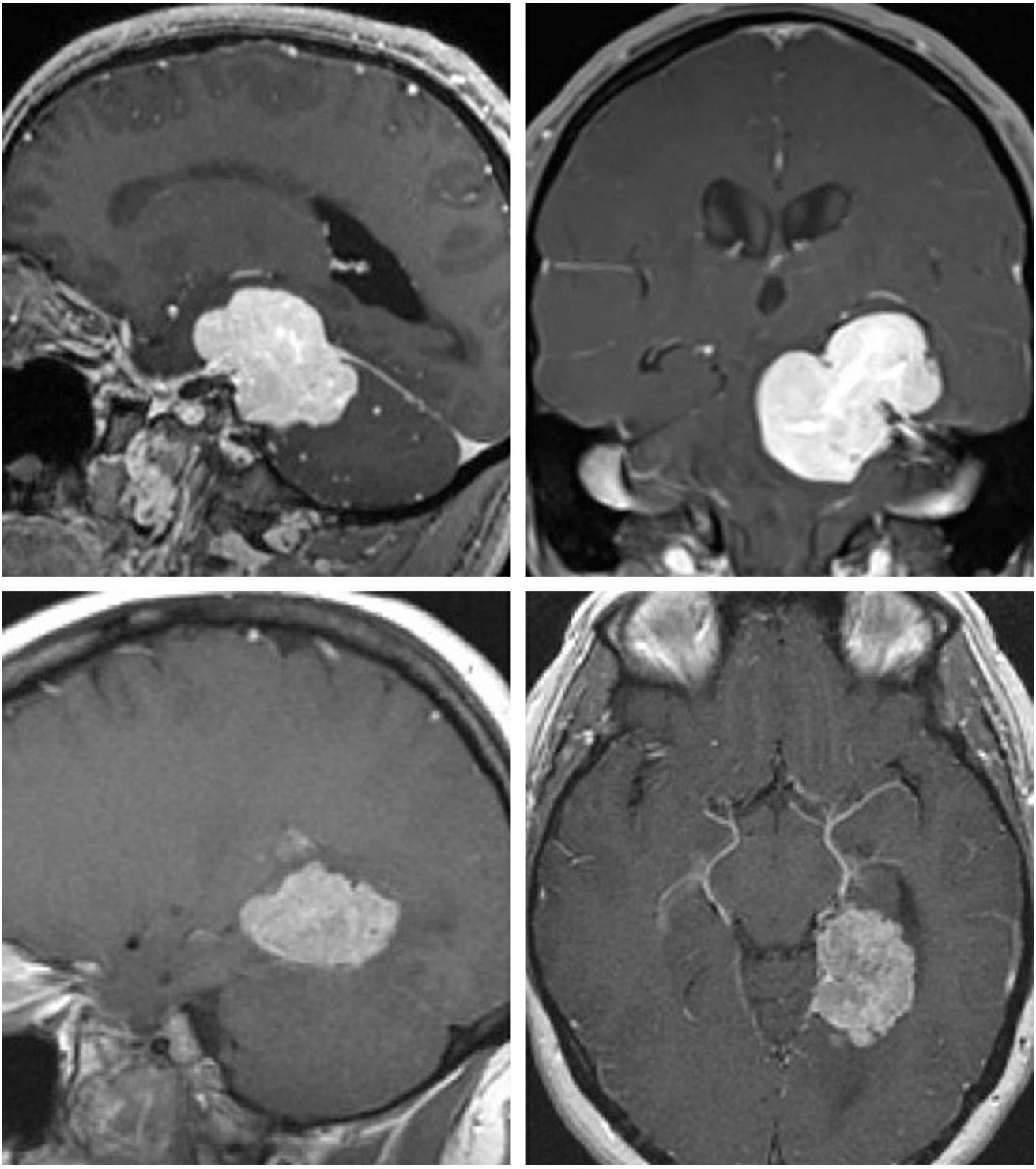

Figure 3: Transtentorial petrous apex meningiomas (upper images) and medial tentorial meningiomas (lower images) may be resected through a single-stage surgery using the paramedian supracerebellar transtentorial route.

Preoperative Considerations

Preoperative MR imaging discloses the extent of the tumor and the need

to use a combined or transtentorial corridor. Obstructive hydrocephalus requires preparation of the Keen's point or a preoperative frontal ventriculostomy. The paramedian incision can readily uncover the bony area corresponding to the burr hole for the Keen's point.

If the surgeon is considering placing the patient in a sitting position during surgery to reach the pineal region, appropriate measures are required before surgery for detection and management of a possible venous air embolism. These measures may include a right heart catheter, transthoracic Doppler, and transesophageal echocardiography. A preoperative "bubble test" will reveal a patent foramen ovale. The sitting position may have its strongest indication for resection of pineal region tumors because gravity retraction mobilizes the cerebellum inferiorly and expands the operative corridor to the deep pineal region.

The transverse and sigmoid sinuses can have slightly variable courses and their preoperative study can enhance the safety of the craniotomy. Factors such as a steep tentorial angle and a very obese patient with a short neck, although not contraindications to the use of supracerebellar route, can make the operation more challenging. The patient's neck flexion may ameliorate difficult working angles over the cerebellum, and it is recommended that the patient be placed in a sitting position in these situations.

MR images can provide critical information about the relationship of the deep venous structures (vein of Galen, basal vein of Rosenthal, internal cerebral veins, and straight sinus) to the operative trajectory and tumor. Occasionally, posterior thalamic and vermian tumors mimic pineal region masses and displace the diencephalic veins posteriorly; this configuration is a potential contraindication for use of the supracerebellar approach. The degree of tumor infiltration through the surrounding critical neural structures (e.g., midbrain, thalamus) must be studied before surgery.

Operative Anatomy

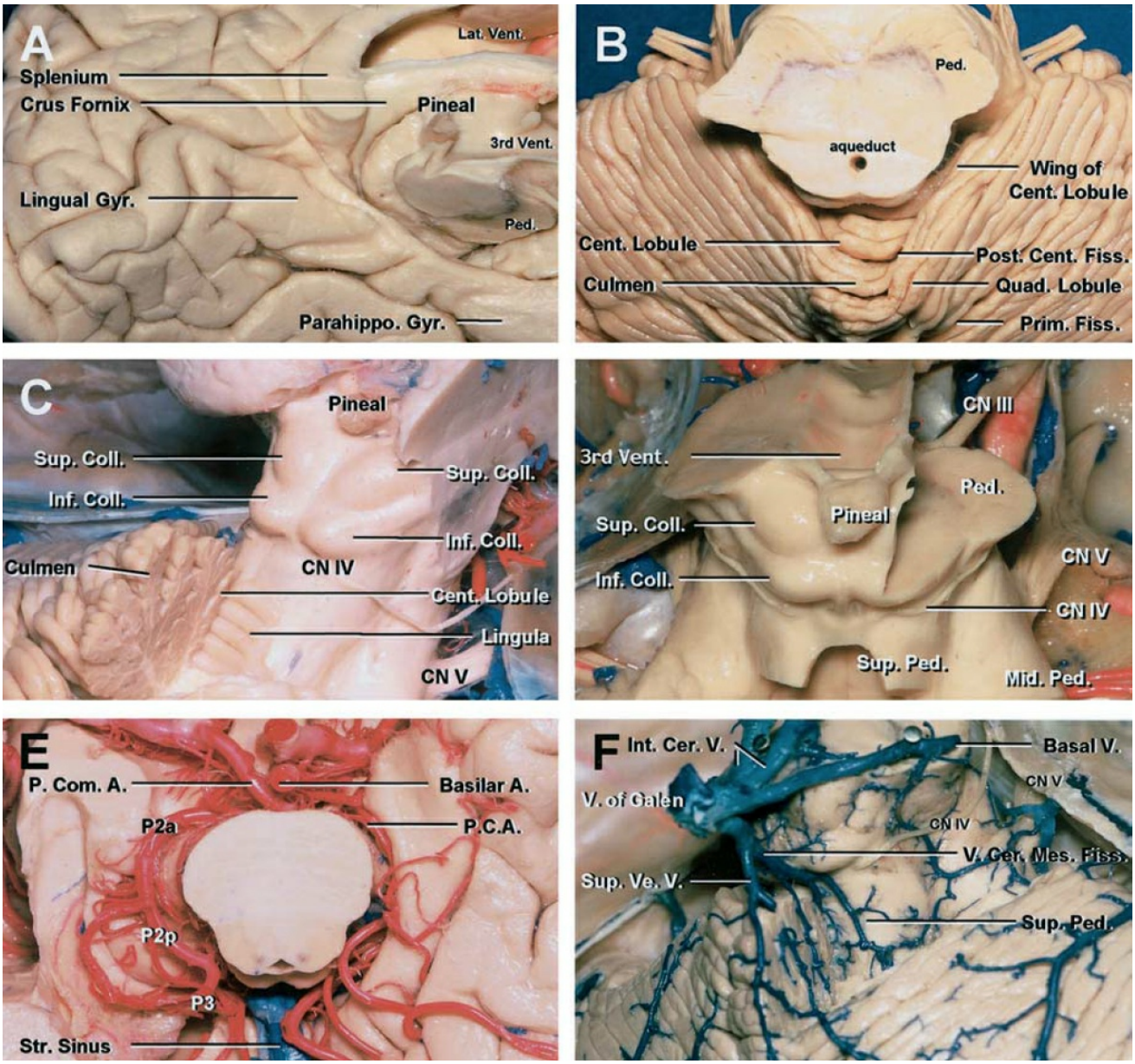

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Figure 4: The relevant anatomy for approaching the pineal region. Note the relationship of the posterior basal temporal lobe and occipital lobe to the pineal area (A). These supratentorial regions become available after transection of the tentorium through the supracerebellar route. The surface anatomy of the cerebellum (B) and posterior diencephalon (C and D) are demonstrated. The vascular arterial (E) and venous (F) anatomy is evident (Images courtesy of AL Rhoton, Jr).

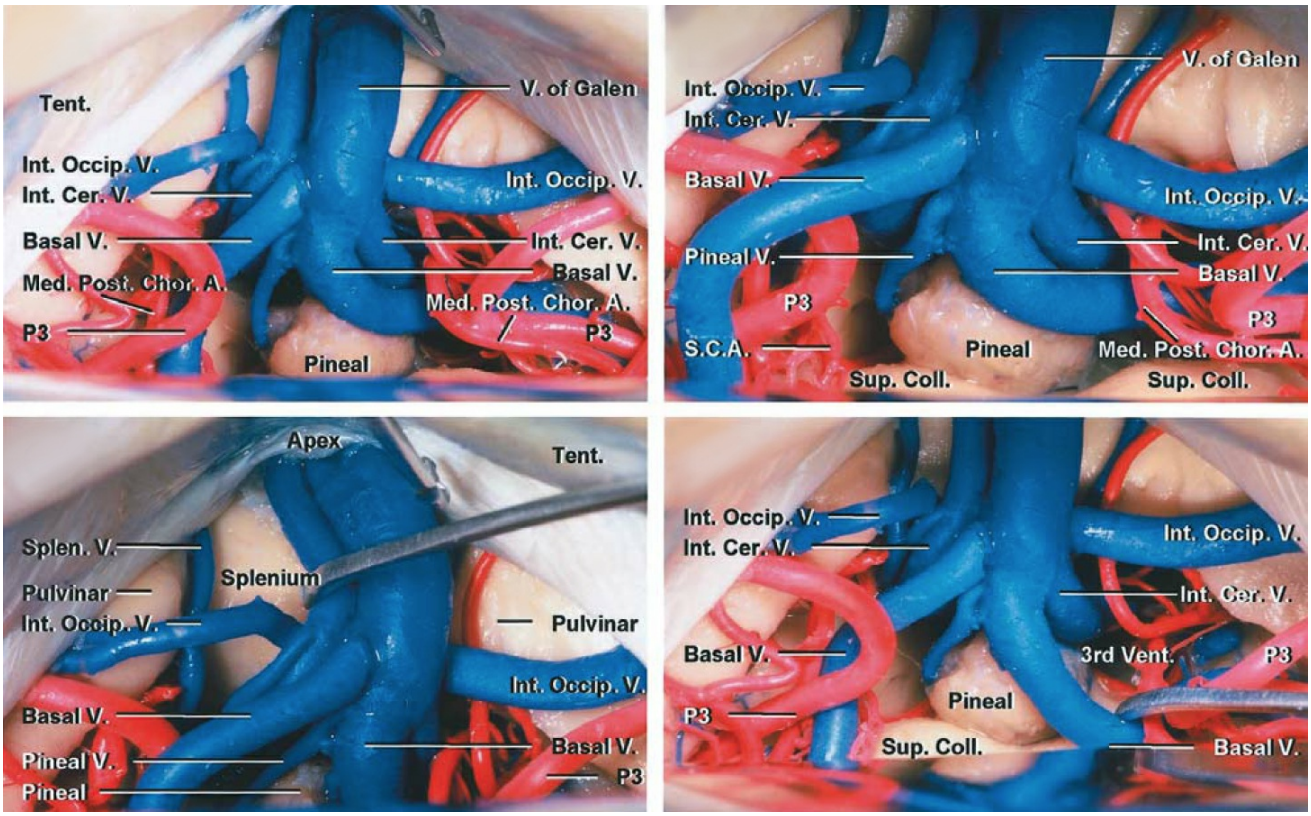

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Figure 5: Magnified images of the cerebrovascular anatomy within the pineal region through the midline supracerebellar approach are shown. The splenium is anterior to the vein of Galen. As the operator follows the contours of the tentorium toward the pineal region, he or she is led to inadvertently dissect around the vein of Galen. This temptation must be recognized and the operative trajectory readjusted inferiorly toward the pineal region (Images courtesy of AL Rhoton, Jr).

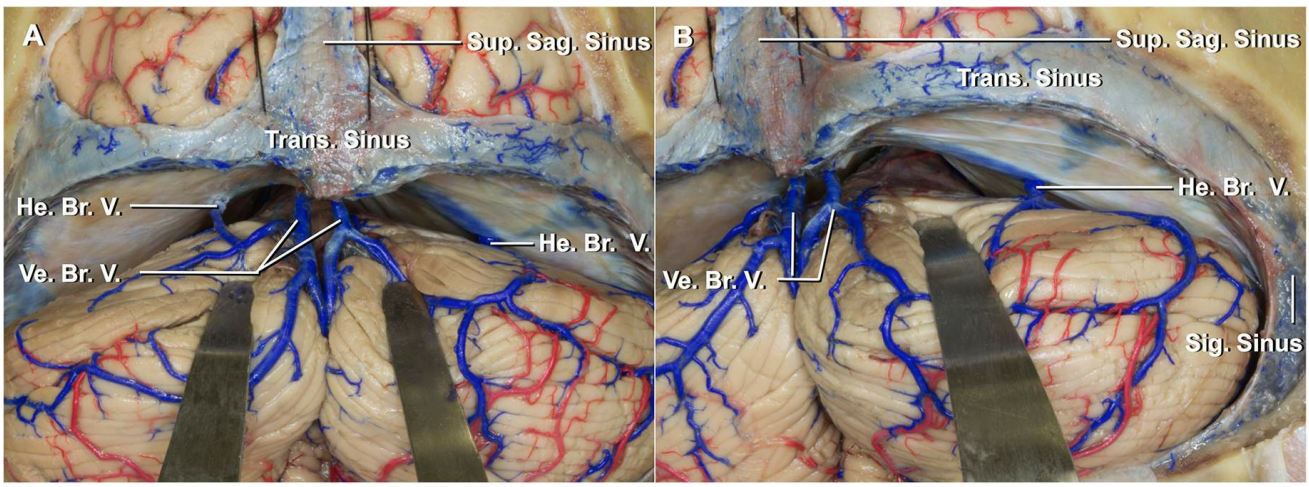


Figure 6: Compared with the midline approach (A), the paramedian

supracerebellar approach (B) avoids most of the midline vermian bridging veins.

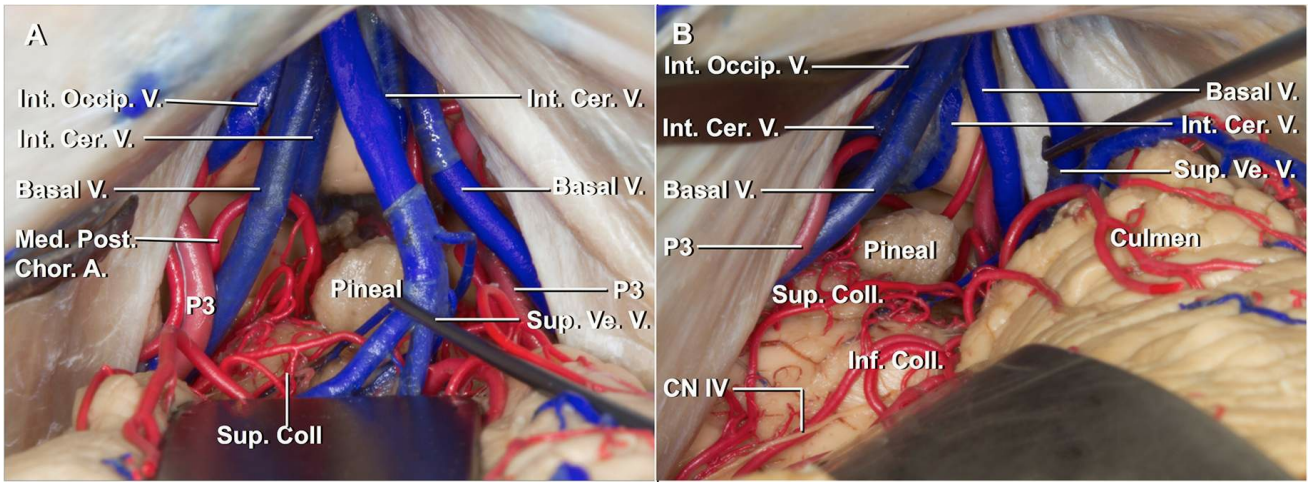


Figure 7: The midline route (A) depends upon retraction of the culmen, whereas the paramedian route (B) reaches over the more inferiorly situated lateral cerebellum. Cranial nerve IV is at the lower edge of the dissection field.

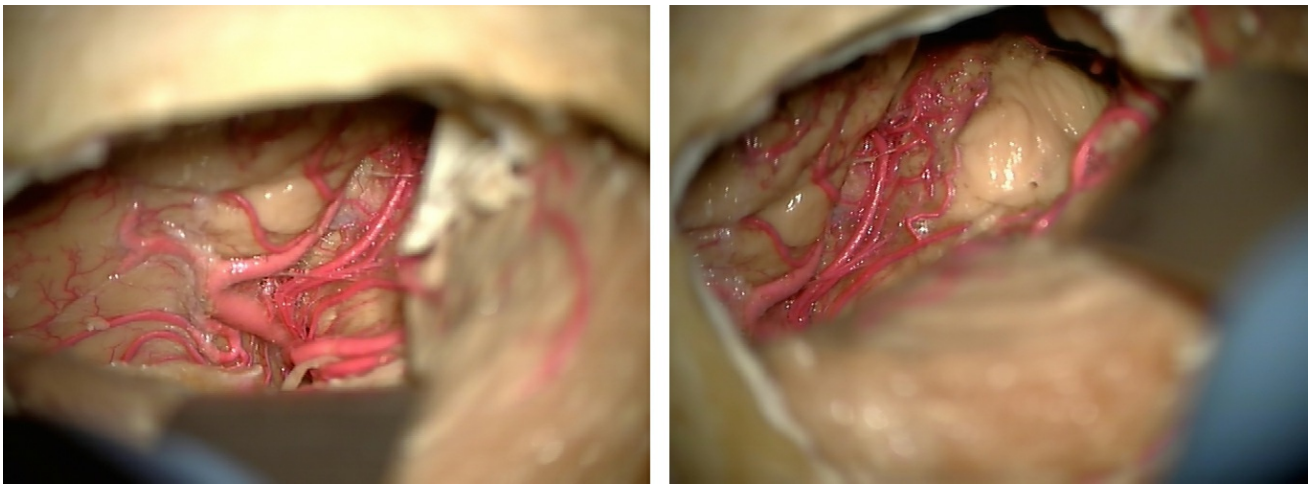


Figure 8: Sectioning a window of the left tentorium through a paramedian suboccipital craniotomy exposes the posterior basal temporal lobe and the relevant arterial anatomy (left image). A more medial view demonstrates the anatomy of the posterolateral mesencephalon (right image). Note the generous exposure of the distal posterior cerebral artery branches through this route.

MIDLINE SUPRACEREBELLAR CRANIOTOMY

As stated above, I prefer to use the paramedian supracerebellar approach to reach the pineal, posterolateral mesencephalon, and posterior third ventricular regions with the patient placed in a modified park-bench

position. However, since most surgeons use the midline bilateral suboccipital supracerebellar craniotomy to reach these structures with the patient in the park-bench or sitting position, the midline approach is reviewed in the following sections.

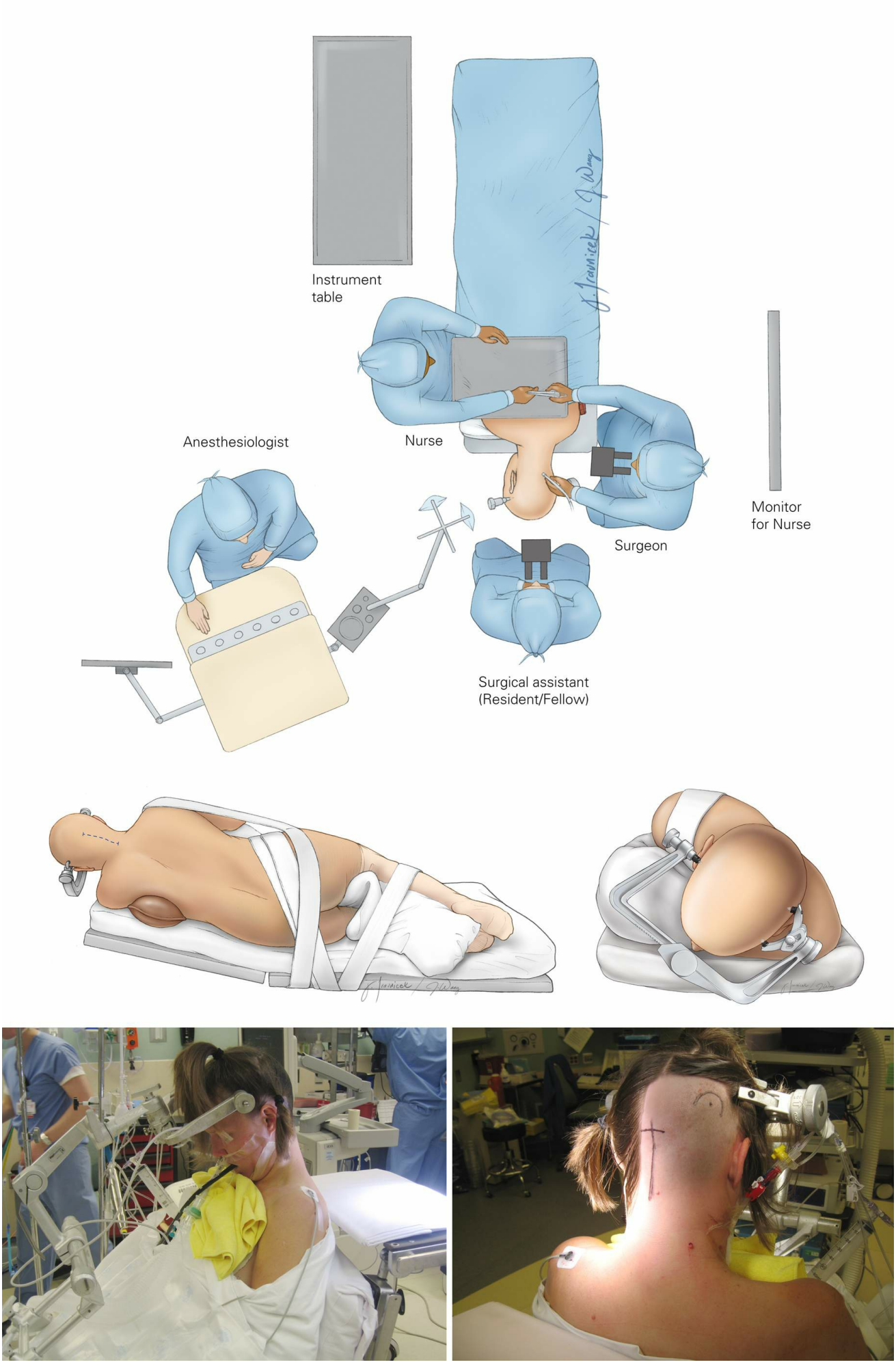
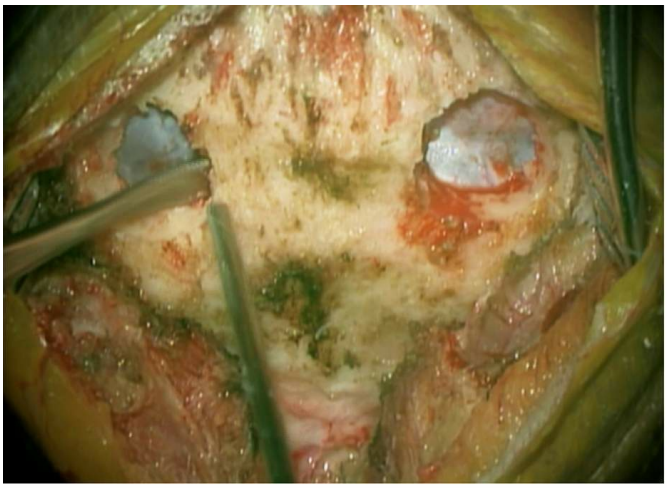


Figure 9: The operating room setup is demonstrated (top image). Note

the position of the surgeon in relation to the surgical assistant who handles the instruments. The middle images show a patient in the modified park-bench position for a midline suboccipital craniotomy. The bottom images demonstrate the setup for a sitting position. The location of the burr hole for placement of a ventricular catheter (if necessary) is illustrated. The midline incision is evident. The incision can be extended slightly superiorly, if needed, to allow for the potential need to harvest pericranium for a watertight dural closure.



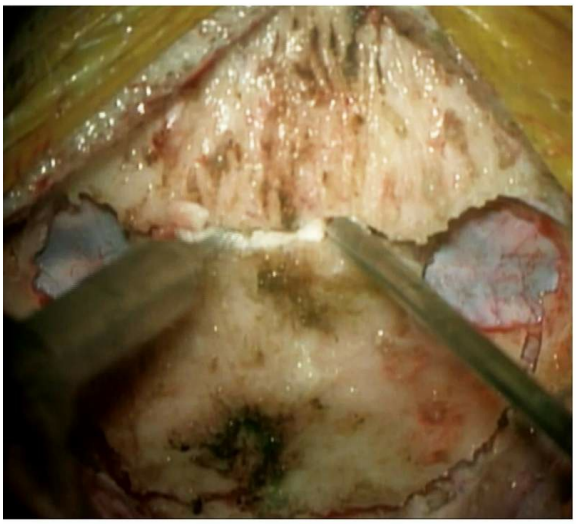
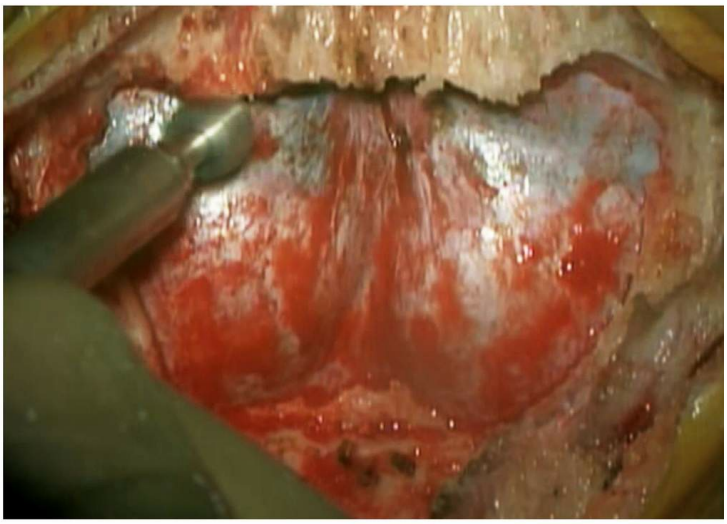
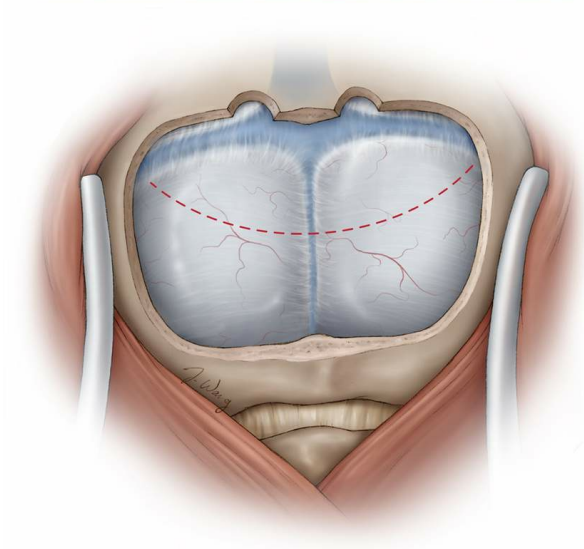
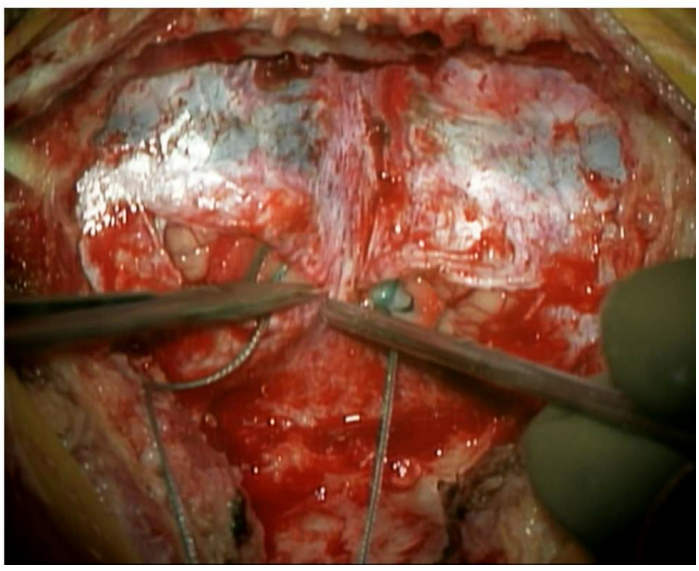
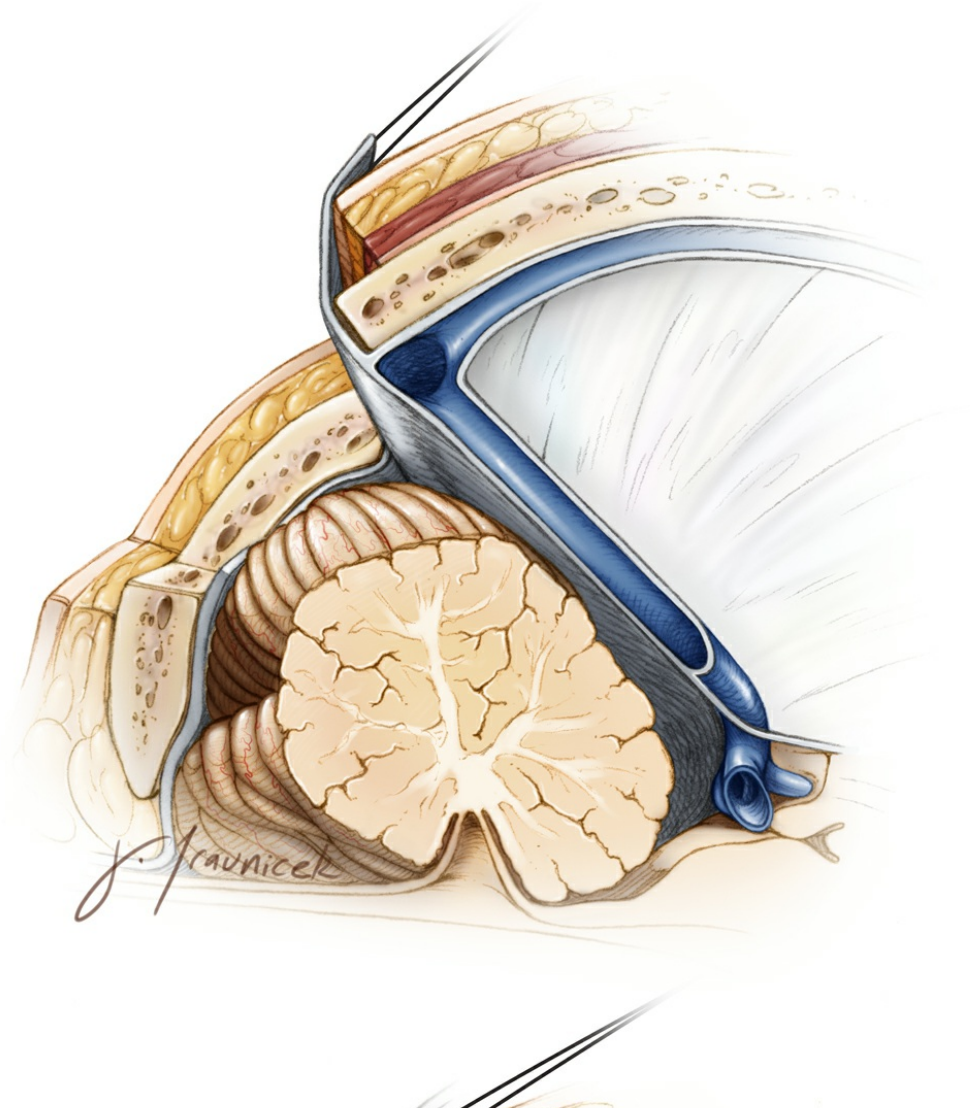





Figure 10: The locations of the burr holes and extent of craniotomy for a midline supracerebellar approach is presented. The drill's footplate near the dural sinuses is avoided and the B1 bit is used. Using a drill, the bone over the transverse sinuses and torcula may be removed in layers after the craniotomy flap is elevated. Skeletonization of the sinuses allows gentle rotation of the venous sinuses after dural opening using tentorial retraction sutures. Removal of bone over the foramen magnum is unnecessary. The dura is incised in a curvilinear fashion.

The midline occipital venous sinus can be very prominent and associated with large paramedian venous lakes. This configuration leads to excessive bleeding during dural opening. I recommend using two dural incisions, one on each side of the sinus (lower images). This maneuver will allow timely ligation of the sinus using two silk sutures and its controlled transection. The cerebellar falx is then cut and the dural flap is reflected superiorly.



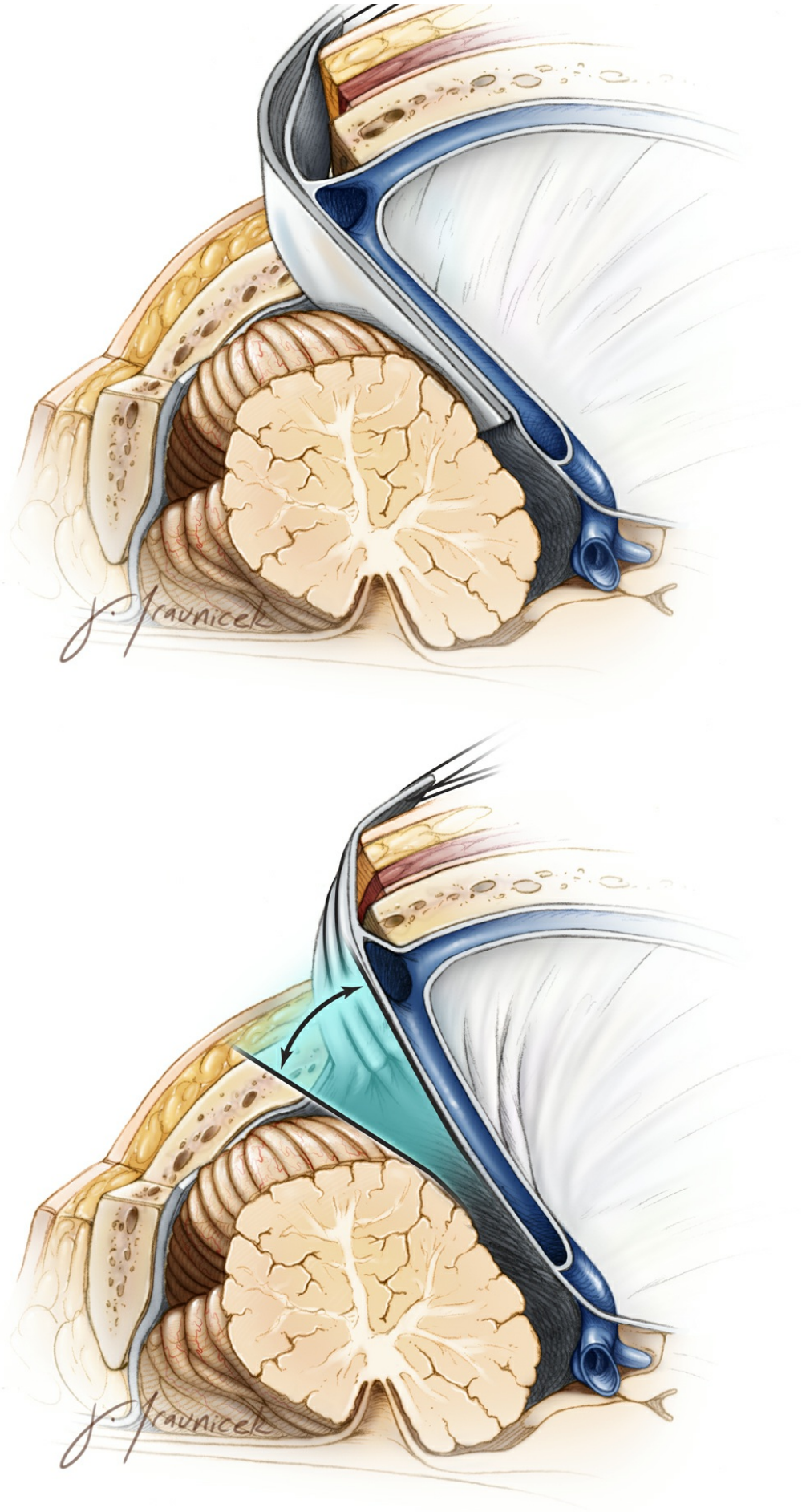


Figure 11: Traditional bony removal and dural opening restrict the working angles of the surgeon and limit the corridor within the

supracerebellar space (top image). Placement of a fixed retractor on the tentorium, despite skeletonization of the sinuses, does not significantly help improve the operative corridor, and in fact, it may interfere with working angles of the instruments (middle image). The retraction sutures anchored on the tentorium elevate the tentorium, mobilize/rotate the transverse sinus, and expand the operative corridor (bottom image).

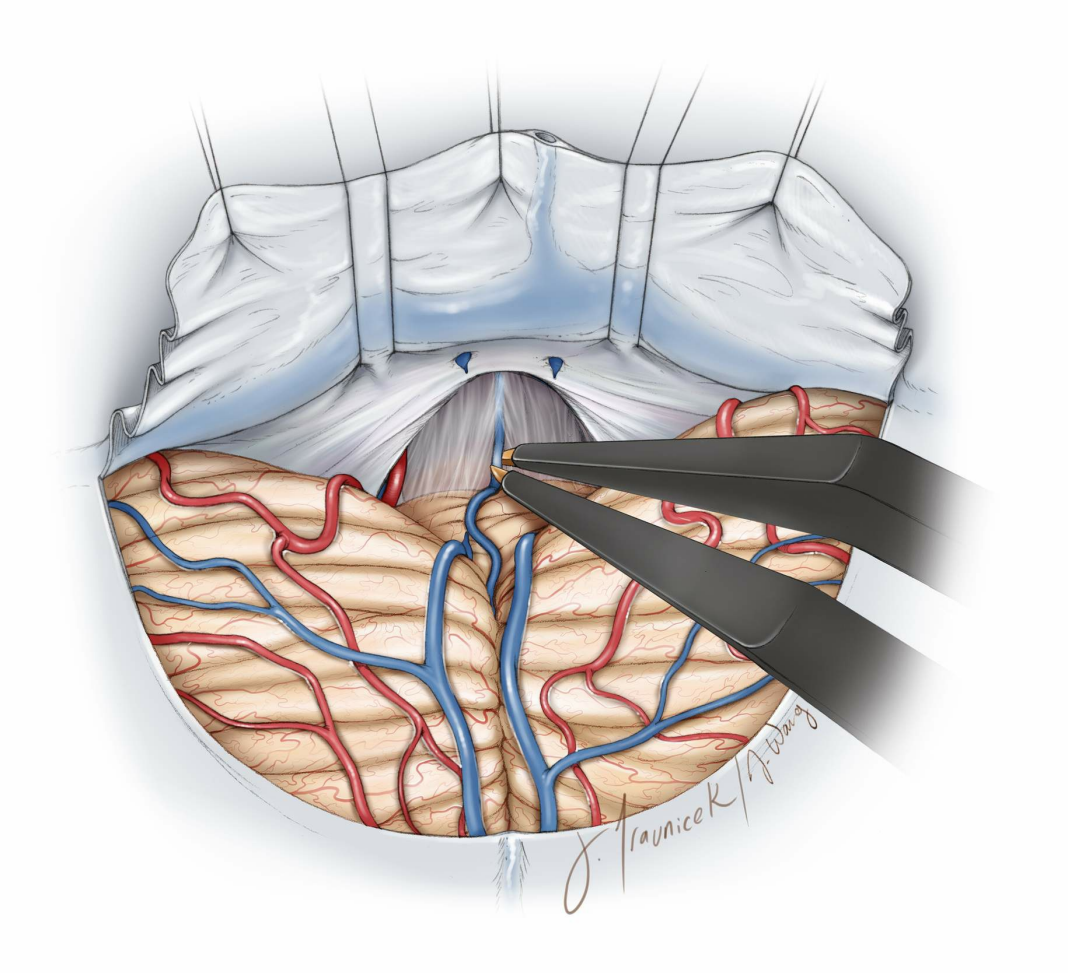


Figure 12: Midline vermian bridging veins are coagulated and cut. The precentral vein leads to the vein of Galen, is posterior to the thick arachnoid layers covering the diencephalic veins, and is connected to the culmen. This vein is sacrificed. All other more anteriorly located diencephalic veins are preserved. Note the retraction sutures placed through the posterior tentorium. These sutures gently rotate and mobilize the transverse sinuses superiorly.

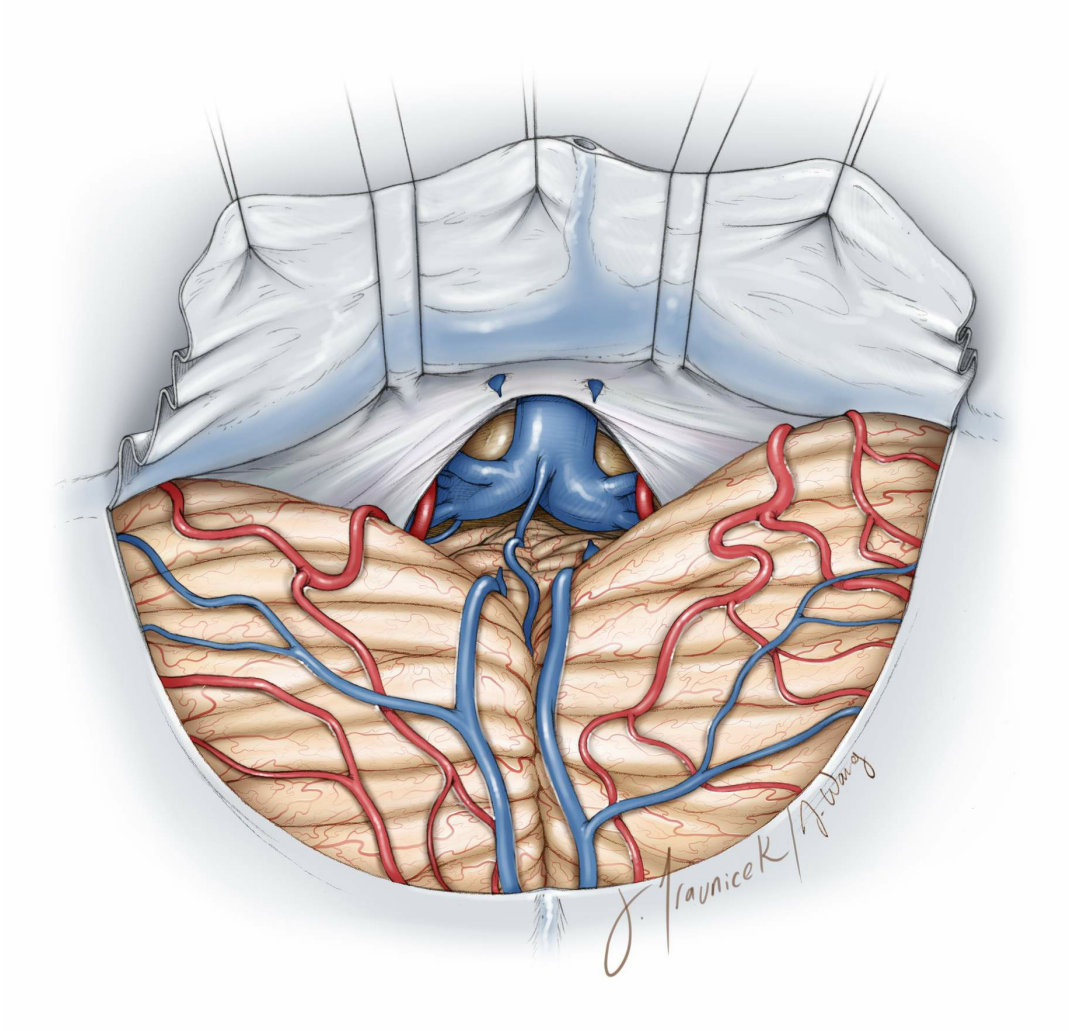


Figure 13: Dissection of the thick arachnoid membranes over the deep venous structures exposes the vein of Galen and associated vital vascular structures. This anatomy can be significantly distorted by the underlying pathology. **It is important to redirect the operative trajectory inferiorly at this time because the tumor is inferior to the vein of Galen. If the operative trajectory is not redirected, the surgeon will likely be disoriented and the vital veins will be at risk.**

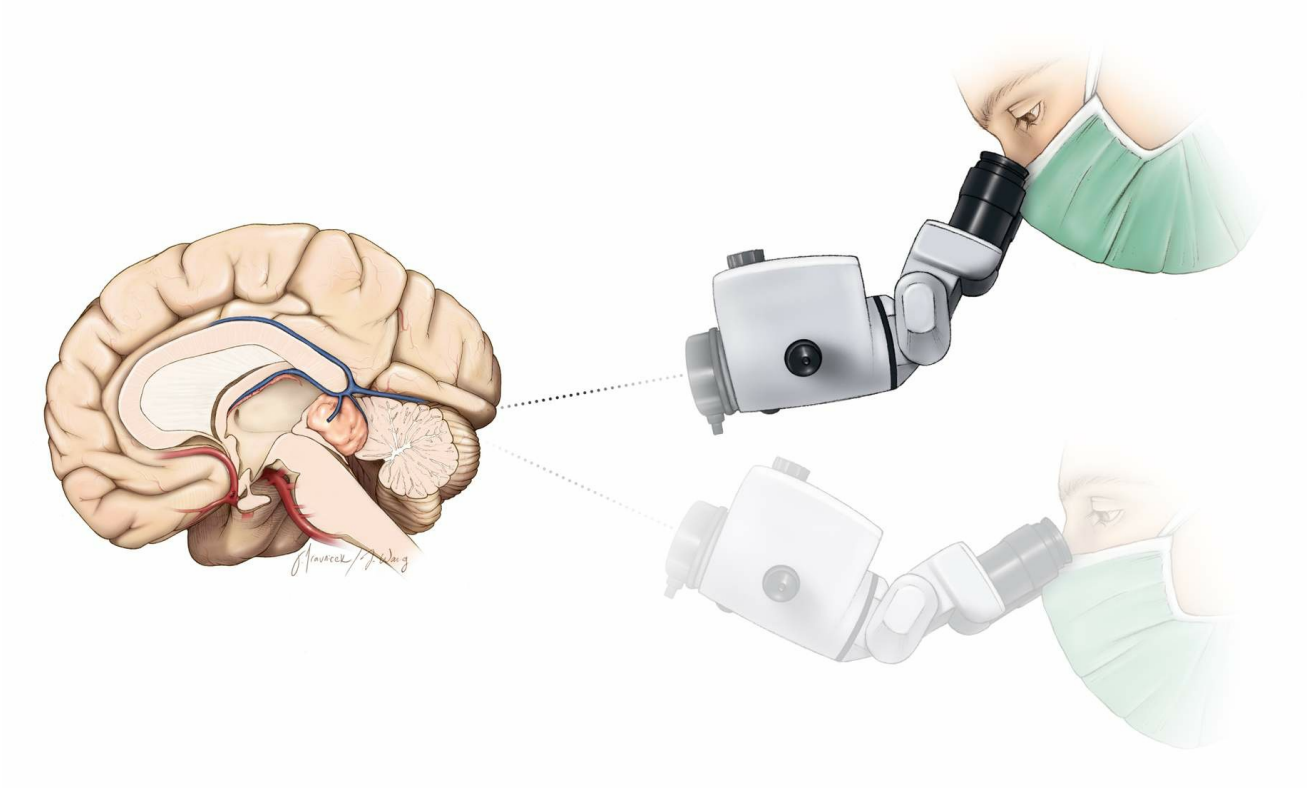


Figure 14: The trajectory of the operator's view is redirected inferiorly to avoid blind dissection around the diencephalic venous confluences.

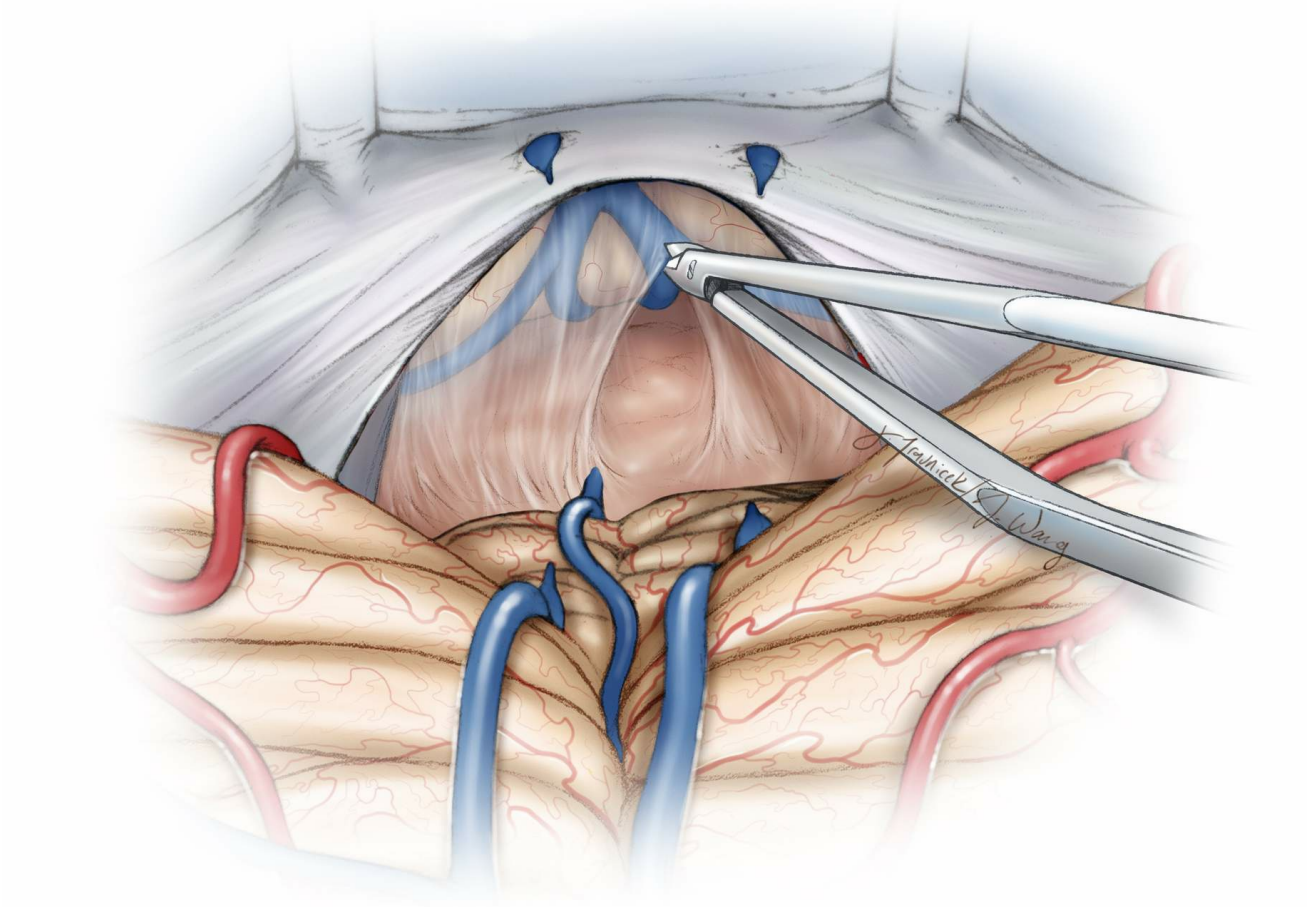


Figure 15: Upon opening the arachnoid membranes over the tumor, one can embark on microsurgical removal of the tumor. Occasionally, obstructive hydrocephalus may lead to transtentorial herniation of the occipital lobe along the posterior tentorial incisura. This herniation may need to be gently reduced and should not confuse the operator regarding the regional anatomy.

Closure

The dura must be closed in a watertight fashion because occurrence of postoperative cerebrospinal fluid fistulae is a significant risk after tumor operations in the posterior fossa. I prefer to avoid using an allograft to reconstruct the dural defect and instead use a piece of pericranial autograft.

The bone may be replaced using cranial plates. I avoid placing the deep neck muscles under significant tension and minimize their strangulation by the deep sutures because this maneuver causes muscle necrosis and uncontrolled postoperative pain. The neck muscles are gently approximated. The fascia is closed in a watertight fashion.

Postoperative Considerations

The patient is observed in the intensive care unit for a day or two after surgery and then transferred to the ward. Steroids are administered prophylactically to minimize the risk of aseptic meningitis. If preoperative hydrocephalus was present and a ventricular catheter was implanted intraoperatively, this catheter should be left in place during surgery and weaned off after surgery.

Aggressive retraction on the cerebellum can lead to postoperative edema. This can be seen on imaging and can ultimately cause symptomatic posterior fossa tension and a need for decompression. Therefore, caution should be exercised during dural closure and bone flap replacement. If the brain appears swollen, the dural closure should not cause more tension, and the bone flap should not be replaced. This brain swelling can be potentially compounded by partial transverse sinus thrombosis and

vermian veins sacrifice.

Pearls and Pitfalls

- Compared with the bilateral midline suboccipital supracerebellar approach, the paramedian supracerebellar approach is less invasive and provides adequate exposure for resection of large pineal region tumors while placing bilateral dural venous structures and cerebellar hemispheres at less risk.
- The use of tentorial retraction sutures to rotate and elevate the transverse sinuses expands the supracerebellar operative corridor.

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