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Tentorial Venous Anatomy: Cadaveric and Radiographic Study with Discussion of Origin and Surgical Significance

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■ BACKGROUND: **Described variations of tentorial venous anatomy impact surgical sectioning of the tentorium in skull base approaches; however, described configurations do not consistently explain postoperative complications. To understand the outcomes of 2 clinical cases we studied the tentorial venous anatomy of 2 cadavers.**

■ METHODS: **The venous anatomy of the tentorium isolated in 2 uninjected fresh cadaver head specimens with preserved bridging veins was observed by trans-illumination before and after methylene blue injection of the dural sinuses and tentorial veins. Our findings in cadavers were applied to explain the clinical and radiologic (magnetic resonance imaging and computed tomographic venography) findings in the 2 cases presented.**

■ RESULTS: **A consistent transtentorial venous system, arising from transverse and straight sinuses, communicating with supra- and infratentorial bridging veins was seen in the cadaver and patient radiography (magnetic resonance imaging and computed tomographic venography). Our first patient had a cerebellar venous infarct from compromise of the venous drainage from the adjacent brain after ligation of a temporal lobe bridging vein to the tentorium. Our second patient suffered no clinical effects from bilateral transverse sinus occlusion due to drainage through the accessory venous system within the tentorium.**

■ CONCLUSIONS: **Herein, we elaborate on transtentorial venous anatomy. These veins, previously reported to obliterate in completed development of the tentorium, remain patent with consistent observed configuration. The same transtentorial venous system was observed in both cases and provided insight to their outcomes. These findings emphasize the importance of the transtentorial venous system physiologically and in surgical approaches.**

INTRODUCTION

Many approaches to the skull base involve sectioning of the tentorium to widen the surgical corridor.[1-4] Combined presigmoid/retrosigmoid approaches have been framed around the safety of incising avascular regions of the tentorium. The study of tentorial vascular anatomy has been related to direct observation of the visible hemispheric and cerebellar bridging veins (BVs).[5-7] The radiologic study has added to the understanding of the tentorial venous anatomy.[8]

Al-Mefty[9] defined patterns of venous drainage of the cerebellum in silicon-injected cadaveric specimens and found that most cerebellar BVs drain medially into the tentorium, providing a greater understanding of the territories of cerebellar BVs in the supracerebellar infratentorial approach. However, this did not examine venous structures within the tentorium. Rhoton Jr.[10] and

Key words
- Cadaver
- Development
- Tentorial sinuses
- Transtentorial approaches
- Venous anatomy

Abbreviations and Acronyms
BV: Bridging vein
CSF: Cerebrospinal fluid
ITV: Intermediate tentorial vein
LTS: Lateral tentorial sinus
LTV: Lateral tentorial vein
MRI: Magnetic resonance imaging
MTS: Medial tentorial sinus
MTV: Medial tentorial vein
PA: Plexiform anastomosis
SPS: Superior petrosal sinus
SS: Straight sinus
TS: Transverse sinus
VG: Vein of Galen

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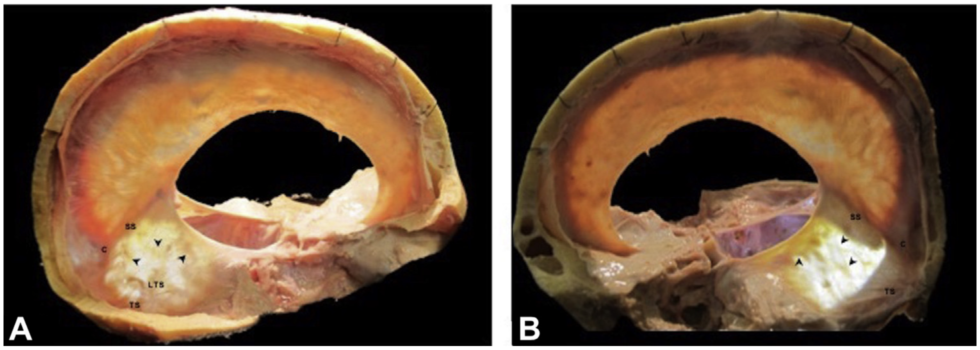

Figure 1. (**A** and **B**) Preparation and transillumination of the tentorium in the cadaver specimens. Venous channels can be seen connecting the straight sinus and transverse sinus coursing in the direction of attachment of the tentorium at the petroclival region. The channels are identified by the *arrowheads*. C, confluens; LTS, lateral tentorial sinus; SS, straight sinus; TS, transverse sinus.

Matsushima[7] defined patterns and variants of the lateral tentorial sinus (LTS) and the medial tentorial sinus (MTS), respectively, related to parenchymal BV drainage in silicon-injected heads.

Kaplan and Browder[5,11,12] studied the venous configuration of the tentorium directly, but did not explain how tentorial manipulation could cause remote infarcts or how tentorial veins could act as accessary venous pathways to mitigate the effects of sinus obstruction. To better understand the role of the tentorium in venous drainage and the effect of tentorial manipulation, we studied the venous anatomy of the tentorium in 2 cadaveric specimens and related our findings to 2 clinical cases: 1) bilateral remote cerebellar infarct after resection of a medial temporal lobe glioma and 2) tolerance of bilateral transverse sinus (TS) and straight sinus (SS) thrombosis.

METHODS

Two fresh noninjected cadaver head specimens were dissected. Bilateral hemicraniectomy and suboccipital retrosigmoid craniectomy were performed to visualize the tentorium and adjacent compartments. The parenchyma and vascular structures were removed with preservation of BVs. Uninjected tentorial anatomy was observed. Cannulation of the dural venous sinuses and a fluoroscopic study of barium contrast injection with blockage of sinus outflow were performed before methylene blue injection into the dural sinuses. Veins in the tentorium were identified by transillumination and digitally photographed. Additional fluoroscopic studies were performed after methylene blue washout. Radiologic studies from clinical patients who underwent craniotomy were reviewed and evaluated for potential tentorial venous drainage. Institutional review board/ethics committee approval was not required for the cadaver or retrospective chart review because patient 1 was deceased and no intervention was provided for patient 2.

RESULTS

Cadaver Findings—Tentorial Venous Channels

Transillumination allowed visualization of veins in the tentorium (Figure 1), confirmed by direct injection with methylene blue (Figure 2). Orientation of the cadaver is shown (Figure 2A). Larger veins throughout the tentorium had a more regular pattern than smaller, anastomotic veins. Initial injection of the Vein of Galen (VG) and SS through the VG confluens partially filled the TS, falcine vessels near the confluens, and MTS in the posterior tentorium (Figure 2B). The anterior half of the SS was duplicated in both specimens. The VG was appreciated as a separate channel within the falx inserting in the posterior half of the SS. Subsequent injection of the superior petrosal sinus (SPS) at the petrous apex filled the ipsilateral TS, the LTS, and the MTS, with the LTS and MTS communicating through intratentorial venous channels (Figure 2B–D).

The injection into the LTS filled the most lateral venous channels, the lateral tentorial vein (LTV), and plexiform anastomosis (PA) located more medially in the tentorium. A repeat injection into the ipsilateral compartment of the duplicated SS filled the venous channels arising from the anterior half of the SS, the medial tentorial vein (MTV), and the intermediate tentorial vein (ITV). The PA centered in the tentorium receives channels from both the SS and TS or LTS; the ringed configuration appears to also be a channel connecting the LTS and MTS at PA (Figure 2C and D).

In the suboccipital retrosigmoid view (Figure 2E), a cerebellar BV is seen inserting into the tentorium, arising from the PA between the ITV and LTV, medial to the LTS. PA along the tentorial free edge receives channels from the SS and from vessels draining the petroclival region at the tentorial insertion (Figure 2C and D). Before ligation, BVs from the tentorium to the inferior temporal lobe were appreciated (Figure 3A) in continuity with the MTV leading to the PA on the tentorial free edge. This tentorial vein joined the SPS at the petrous apex. Under fluoroscopy, contrast injected into the ipsilateral TS while clamping the ipsilateral sigmoid sinus and contralateral TS flowed into the SPS, circular sinus, and sphenoparietal sinus. This pattern of drainage also included the apical tentorial vein (Figure 3B and C).

Case Review

Case 1—Remote Cerebellar Infarct. A 77-year-old man presented with a past medical history of atrial fibrillation with warfarin

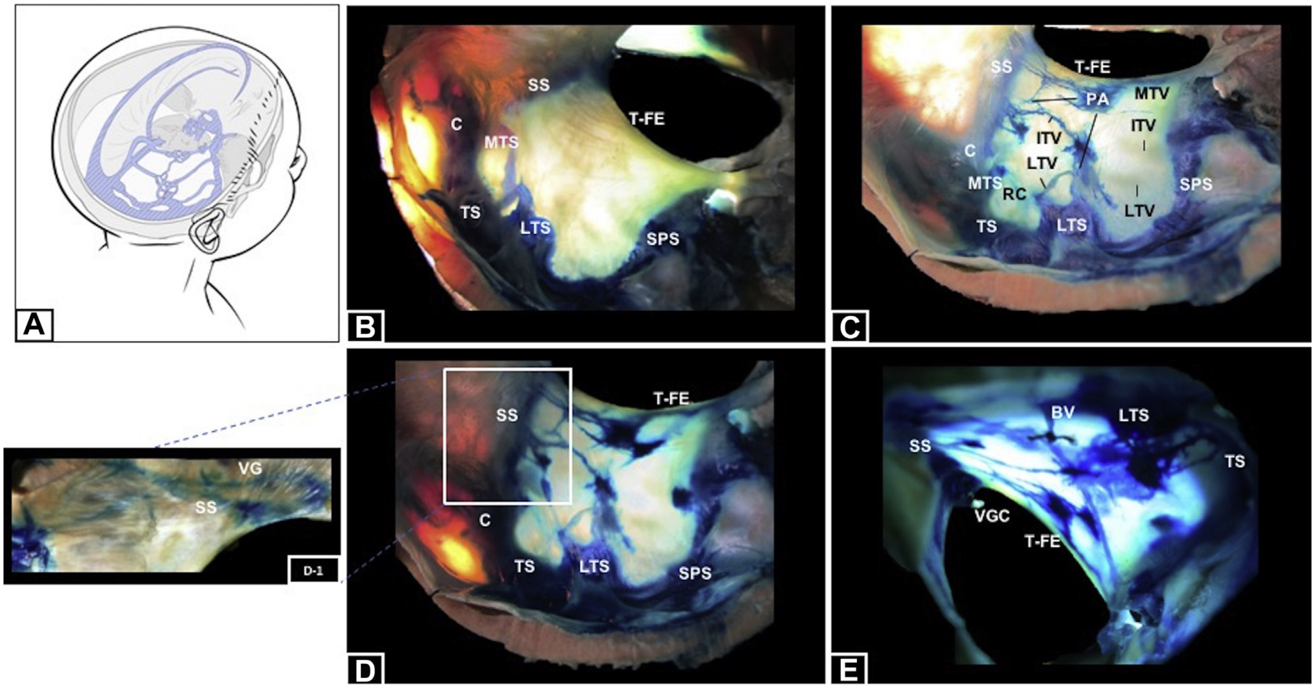

Figure 2. Serial injection of the dural sinuses with methylene bue. (**A**) The orientation of the tentorium in the cadaveric dissection. The supratentorial compartment is observed in (**B**)—(**D**) and methylene blue is seen filling first the lateral tentorial sinus (LTS) from the superior petrosal sinus (SPS) injection. The inset (**D-1**) shows the separation of the vein of Galen (VG) from the straight sinus (SS) within the falx seen on the initial injection of the VG confluens (VGC). (**C**) Plexiform anastomosis between venous channels arising from both the SS and transverse sinus (TS) are seen along the tentorial free edge (T-FE), medially in the plane of the tentorium, and laterally draining into the large dural sinuses. (**E**) The bridging vein (BV) draining into the venous channels from the retrosigmoid suboccipital view. ITV, intermediate tentorial vein; LTV, lateral tentorial vein; MTS, medial tentorial sinus; MTV, medial tentorial vein; PA, plexiform anastomosis; RC, ring configuration.

anticoagulation, MEN-2A syndrome status after bilateral adrenalectomy and thyroidectomy, and previous subarachnoid hemorrhage of unknown etiology. Prior imaging and angiography were negative for vascular malformation. He presented to the emergency unit with nausea and vomiting. Neurologic examination was normal. Head magnetic resonance imaging (MRI) scan was performed; an enhancing right anteromedial temporal lobe mass (**Figure 4A**) was found. The venous architecture was seen on T1 after contrast sequence (**Figure 4B—E**).

An inferior vena cava filter was placed and warfarin was stopped. The patient underwent tumor resection through a right frontotemporal craniotomy and transsylvian approach after coagulation normalized. Intraoperative pathology demonstrated hemorrhagic glioblastoma, World Health Organization grade IV. The patient awoke without neurologic deficit after tumor resection. Routine postoperative MRI and computed tomography performed within 24 hours demonstrated remote infarcts in the right and left cerebellar hemispheres and hemorrhage within the resection cavity (**Figure 4F—I**). Delayed-phase computed tomography angiography is shown in **Figure 4J**. Elevated intracranial pressure from brain swelling was reduced by external ventricular drainage and bilateral suboccipital decompressive craniectomy.

Case 2—Venous Sinus Thrombosis. A 30-year-old woman with a past medical history of psoriasis presented with a 3-day history of right ear pain, nausea, and severe bifrontal headache. Evaluation by computed tomographic venography showed complete TS thrombosis bilaterally and partial SS thrombosis (**Figure 5A—J**). Extensive collateral venous drainage through the entire tentorium was also shown.

DISCUSSION

General and Technical Considerations

Prior studies of the intracranial venous anatomy used cadaver heads with latex-filled vessels via cannulation of the carotid arteries and jugular veins.[7,10] Tentorial veins may not fill with this method because of the small caliber of the tentorial veins, viscosity of the latex mixture, and effect of fixation techniques. Larger vessels have lower resistance to flow; the absence of intracranial pressure effects on vein diameter further decreases resistance.

Browder and Krieger[5,11,12] used vinylite casts to study drainage of the major dural sinuses, the tentorium, and the circular and cavernous sinuses. Casting through the dural sinuses and digesting the parenchyma demonstrated venous channels arising from the dural sinuses, but the properties of vinylite may adversely affect venous anatomy. Vinylite is dissolved in acetone to allow perfusion of fine structures; evaporation of the acetone through the parenchyma allows polymerization and incurs thermal expansion and shrinkage.[13,14] This may disrupt the walls of the

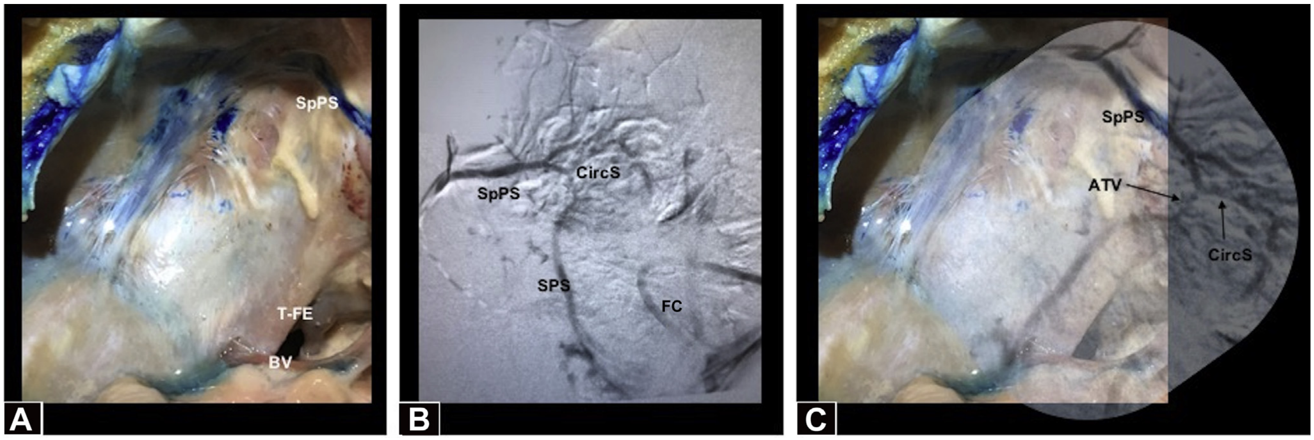

Figure 3. Correlation of tentorial venous channels with the fluoroscopic study. (**A**) A bridging vein (BV) from the temporal lobe is seen entering the free edge of the tentorium (T-FE) on gross dissection; the tentorial vein and sphenoparietal sinus (SpPS) are seen stained with methylene blue. (**B**) Contrast injection into the ipsilateral transverse sinus was performed through Foley catheter (FC) with the superior sagittal sinus, contralateral transverse sinus, and ipsilateral sigmoid sinus clamped. Venous channels in the tentorium were found to be dependent on pressure-dependent backflow not captured in this injection; however, this injection identified continuity of the sphenoparietal sinus (SpPS) with the circular sinus and the tentorial venous channel on the free edge arising from the bridging vein (BV) of the inferior temporal lobe. The gross and fluoroscopic cadaveric images are overlaid in (**C**) to demonstrate the anatomy. The fluoroscopic image was rotated to match the cadaver due to the different angle (30° AP; 15° lateral) required for the fluoroscopic study. AP, anterio-posterior; ATV, apical tentorial vein; CircS, circular sinus; SPS, superior petrosal sinus; T-FE, tentorial free edge.

venous channels within the tentorium.[12] Cured vinylite is brittle and requires pruning.[15] These considerations may explain the interpretation of negative casting in the center of the tentorium as venous lakes, whereas the remainder of the venous anatomy was positively casted, implying that the finer plexuses were disrupted in the casting process.

To better appreciate tentorial venous anatomy and avoid the shortcomings of these techniques, we injected methylene blue directly into the dural sinuses and observed the pattern of blue vessels in and around the tentorium. We supplemented and compared this study with fluoroscopic imaging of contrast-infused veins within and around the tentorium. Resistance was met on perfusion of the PA of the ITV and LTV from the LTS. The courses of the ITV and LTV can be seen by transillumination to continue to the SPS in **Figure 2C** and **D**. Dye perfusion was not continued to avoid rupture. In the cases presented, these channels can be seen in the same configuration, further supporting the identification of these channels based on venous development.

Embryologic Considerations

The venous channels observed within the tentorium communicate with the TS and/or the SS. Padget[16] and Streeter[17] elucidated embryologic origins of the dural sinuses and demonstrated the presence of venous plexiform channels within the prosencephalic, tentorial, and myelencephalic dorsal mesenchymal dural fields. The development of the adult dural sinuses is a result of sloping of the tentorium and alteration in the direction of flow through the paths of least resistance (**Figure 6**).[17]

As primary neurulation is completed and retrogressive differentiation begins, the forebrain compartment of the neural tube exceeds gradient regulation and regulative positioning imposed by the posterior neuropore signaling source.[18] The isthmic organizer arises between the posterior fossa and diencephalon, and transverse organizers arise laterally as the forebrain is segmented.[18,19] The mesenchymal tissue receives metabolic waste from the parenchyma by passive diffusion.[20] The dural field is induced by arborization of the neural tube as waste removal by passive diffusion is exceeded.[16-18,20,21] The supratentorial mesenchyme develops through intramembranous ossification into the meninges and bone in a gradient-dependent fashion due to neural tube induction, whereas the infratentorial skull base forms by somite migration.[21,22] The venous channels organize within the dural fields and BVs migrate toward the parenchyma through the developing arachnoid plane to penetrate as medullary veins as shown by Huang.[23,24]

Lateral head veins, which give rise to the cavernous sinus anteriorly, initially bound the dural venous field; a central vein courses through the field.[25] Plexiform channels connect these.[16,17,20,26] The tentorial venous field moves inferolaterally with 1) disproportionate posterior fossa growth incurred by proximity to the isthmic organizer and 2) inferolateral somite migration.[17,18] An increase in the tentorial pitch leads to drainage of venous blood laterally, whereas continued gradient differentiation of mesenchyme adjacent to developing calvarium leads to the obliteration of the endothelium, forming the major dural sinuses.[16,17] The tentorium is thus attached medially to the 1) falx, which develops as the median vein of the prosencephalon arises from the superior sagittal sinus and divides the hemispheres,[27] and 2) the inferomedially migrating petrous bone[28] and developing dural sinuses.[17,24]

Flow Considerations

Perfusion of the observed tentorial veins in the studies performed suggests that they are patent. The orientation of these vessels

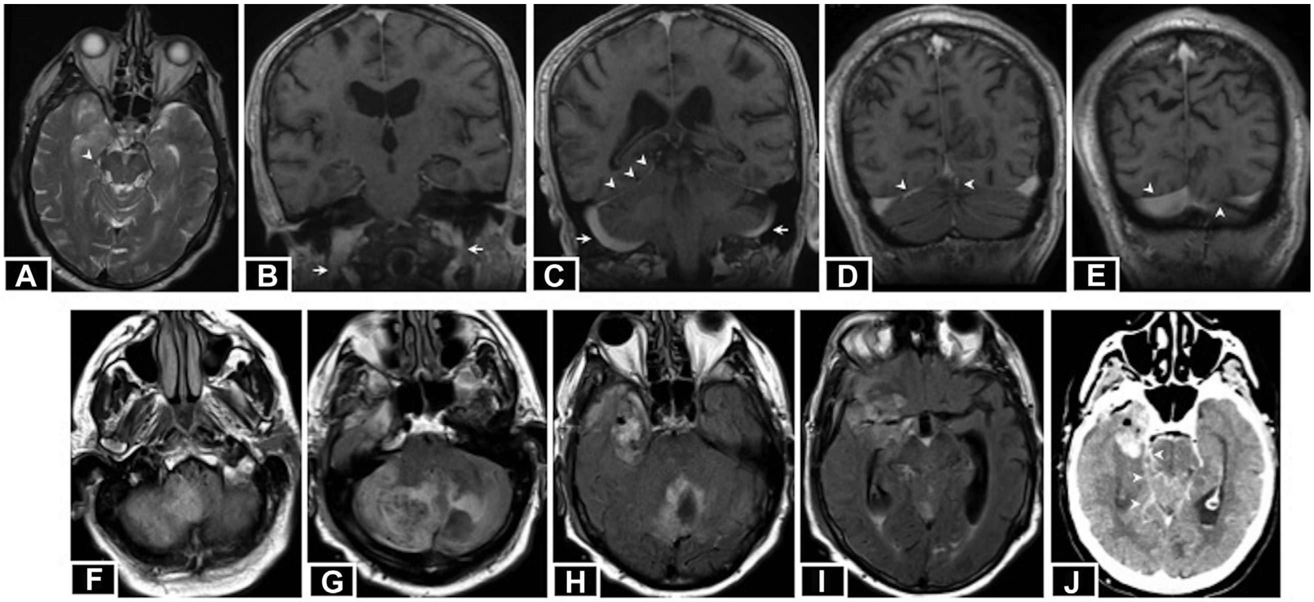

Figure 4. Magnetic resonance imaging (MRI) and computed tomography studies of temporal lobe glioma with remote cerebellar and brainstem infarct after resection. (**A**—**E**) Preoperative MRI. The bridging vein of the inferior temporal lobe to the tentorium is seen on the axial T2 FLAIR sequence in (**A**) (*arrowhead*). A difference in caliber of the jugular bulb is seen in the coronal T1 postcontrast sequence in (**B**); the right is narrowed distally with dilation proximally, whereas the left is narrowed proximally (*arrows*). Dilation of the right sigmoid sinus compared with the left is seen on the coronal T1 postcontrast sequence in **C** (*arrows*). In the same slice, tentorial vessels are seen in the plane of the tentorium (*arrowheads*). More posteriorly, the cerebellar bridging veins, right more lateral than left, are seen draining into the tentorium (*arrowheads*) in the coronal T1 postcontrast sequence in (**D**). Stenosis of the left transverse sinus and dilation of the right is seen on the coronal T1 postcontrast sequence in (**E**). The extent of the postoperative remote cerebellar and brainstem infarct is appreciated on the axial T2 FLAIR in (**F**)—(**H**); venous hemorrhage in the resection cavity is also seen. Extension of the resection cavity hemorrhage and intraventricular blood is appreciated in (**I**). A contrast filling channel, the medial tentorial vein, is seen coursing from the resection cavity to the straight sinus medially along the right tentorial free edge with draining into a channel belonging to the cerebellar bridging vein (*arrowheads*) on the delayed phase CTA in (**J**); a mesencephalic bridging vein is also seen in continuity with this channel of the free edge. CTA, computed tomography angiography; FLAIR, fluid-attenuated inversion recovery.

parallel to the slope of the tentorium provides insight into the conditions under which these fill.

The tentorium is situated at the interface of dural venous sinuses, the parenchyma, and the cerebrospinal fluid (CSF) subarachnoid compartment. The impact of change to these components is related to the size and the rate of change of each compartment.[29] The arterial supply and venous outflow have the fastest rate of change, whereas the CSF rate of change is minimal, 0.35 cc per minute; parenchyma is constant until relative positioning is changed.[29,30] This is particularly relevant when examining flow-related changes in the dural sinuses and tentorial veins at the interface of the 3 components.

Studies examining TS manometry related to TS stenosis have defined pathologic pressures as those above 0—10 cm H_2O, the same as intracranial pressure.[31] This suggests that the direction of flow through the venous sinuses and channels identified herein is imposed by positioning, path of least resistance, and dynamic factors of the surrounding system both in development and later physiology.[30] Anterograde flow in the venous system through the BVs to the tentorial channels and into the major sinuses is maintained by pulsatile pressure and transdural movement of CSF, parenchymal pressure on the veins, and arachnoid tethering.[30-32]

Anatomy and Physiology of Intracranial Venous Channels

Drainage to the major dural sinuses is a phenomenon of completed development.[16,17] The lateral head veins, which rotate with the tentorium, give rise to the TS, the sigmoid sinus, the SPS and inferior petrosal sinus, and the cavernous sinus, the medial venous channel of which is in continuity with the circular sinus, as demonstrated by Streeter[17] and later by Browder.[25,33] Initial disproportionate posterior fossa growth leads to increased venous drainage to the TS by an increase in the lateral pitch of the tentorium.[17] However, in fetal development and through childhood, the jugular foramen has a narrow caliber due to the incomplete medial migration of the petrous pyramid to the clivus.[24,28] The resultant venous pooling in the TS is thought to lead to retrograde flow and outpouchings of the dural sinuses and formation of the MTS and LTS.[24,26,34] This is consistent with the major dural sinuses as distensible spaces capable of receiving stagnant flow.

The histologic study of the dural sinuses found that the degree of separation of endothelium within the sinus to form a separate vein is related to the amount of muscular, elastic, and collagenous differentiation of the surrounding dura.[35] The venous plexuses in the tentorium organize to form the BVs and separate channels. The degree of venous architecture present appears to be a result of gradient-dependent development. The differing properties of

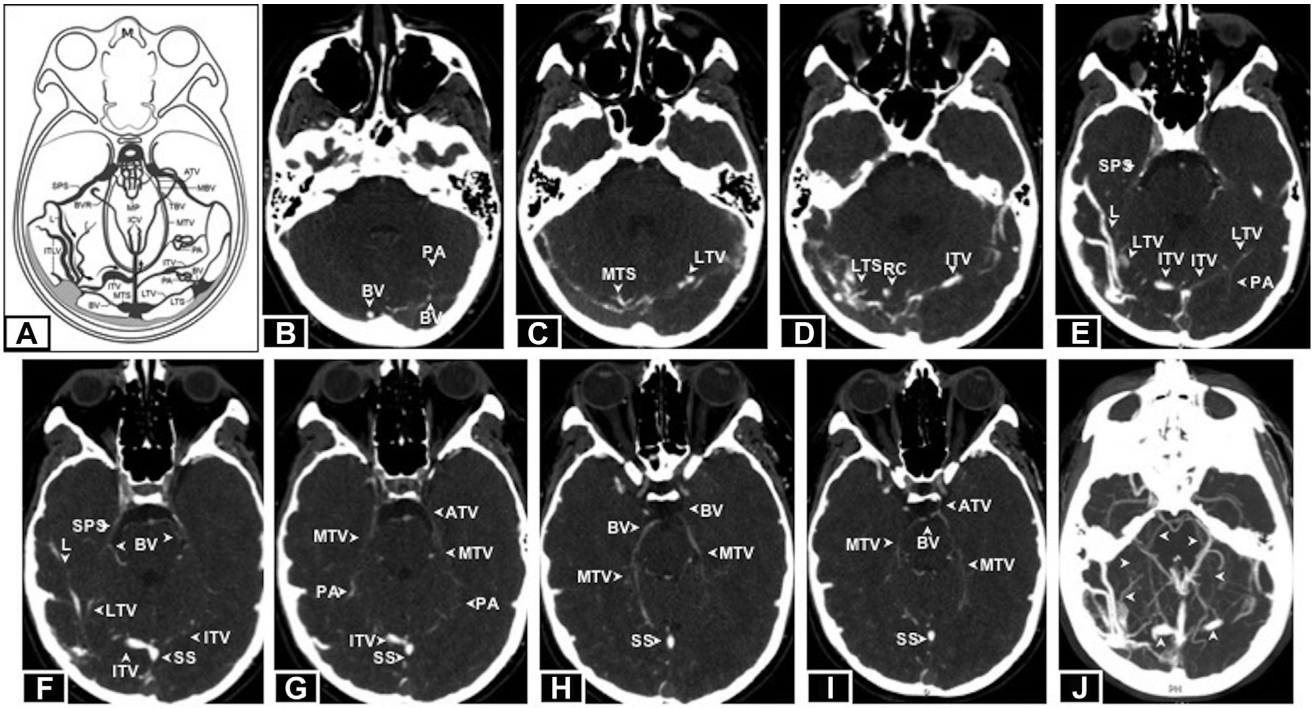

Figure 5. CTV studies of tentorial sinuses and veins in the setting of thrombosis of the straight, transverse, and sigmoid sinuses. A schematic of the venous architecture in this patient is seen in (**A**); the shaded regions represent clotting. Cerebellar bridging veins (BVs) are seen in (**B**), with the left draining to the tentorial veins at a plexiform anastomosis (PA). In (**C**), the medial tentorial sinus (MTS) is seen on the right arising from the transverse sinus (TS) near the confluens; the lateral tentorial vein (LTV) is seen in continuity with the PA on the left. The ring configuration (RC) connection from the MTS to the lateral tentorial sinus (LTS) is seen on the right in (**D**), and the intermediate tentorial vein (ITV) is seen arising from the straight sinus (SS) on the left. The vein of Labbé (L) is seen draining into the LTS on the right in (**E**). The LTV is also seen arising from the LTS; both ITV are seen arising from the SS. A PA is appreciated between the LTS, LTV, and ITV on the left in the same image. In (**F**), L, the ITV bilaterally, and the LTV on the right are again visualized. The superior petrosal sinus (SPS) is seen in continuity with mesencephalic BV bilaterally. The PA between the ITV and the medial tentorial vein (MTV) is appreciated bilaterally in (**G**); the apical tentorial vein (ATV) is also appreciated bilaterally. The MTV is seen bilaterally giving rise to mesencephalic BVs in (**H**) and continuing on to the ATV preceding the cavernous sinus in (**I**). The MIP sequence in (**J**) demonstrates all of these sinuses and tentorial veins. (**J**) Of note, the right BVR was incomplete and did not drain the anterior mesencephalon in this patient. BVR, basal vein of Rosenthal; CTV, computed tomographic venography; MIP, maximum intensity projection.

these structures impact flow dynamics. The dural sinuses have a compliance; the degree of distension of the sinuses is detected by the recurrent tentorial nerve, which shares its branching pattern with the venous channels identified in this study and regulates cerebral vasodilation.[36-38] The tentorial veins may remain patent because of positional and compliance-dependent flow and their connections to drainage through the sylvian veins, the cavernous and circular sinuses, the mesencephalic plexus, and the cerebellar veins.

Relationship to Venous Pathways and Surgical Considerations

Consequences of interruption of the tentorial venous system and BVs to the tentorium should be considered in surgical planning. In supine or sitting positions, blood flow through the BVs may be toward the tentorium because tentorial pressure is reduced by the loss of CSF and head elevation. It may be beneficial to ligate supratentorial BVs at the entrance to the tentorium to avoid formation of a clot in the supratentorial BV that propagates through the tentorium to a cerebellar BV, resulting in hemorrhagic infarction. It may be beneficial to ligate cerebellar BVs at the parenchyma to prevent propagation of a clot from the free BV into the cerebellar parenchymal vein. The venous system does not share the anterograde pressure of the arterial system.[29,32] Thus, venous flow through the tentorial channels may be directionally altered as the surrounding system is manipulated and may depend on the position of the patient.

In case 1, the patient underwent right frontotemporal, transsylvian resection of a mass. The venous architecture in this patient may have increased transtentorial drainage when the head was placed the right side up. We postulate that when the BV to the inferior temporal lobe was compromised during mass resection, the sylvian and bilateral cerebellar venous drainage into the TS may have been redistributed through the MTV to the mesencephalic and cerebellar BVs, resulting in the bilateral cerebellar and mesencephalic hemorrhagic infarction, as shown in **Figure 6D**.

Case 2 demonstrates how the transtentorial venous system can serve as an accessory drainage pathway. Contrast filled the tentorial veins and sinuses bilaterally from the vein of Labbé drained

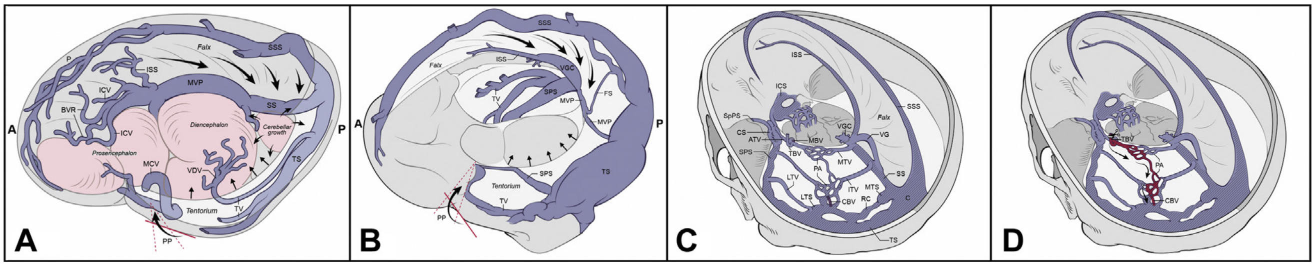

Figure 6. Development of the dural venous system. (**A**) Week 12, adopted from Dr. Huang's embryologic work. The superior sagittal sinus (SSS) is seen plexiform anteriorly and coalesced posteriorly. At this stage, the tentorium is narrow and lacks incline. Thus, drainage of the diencephalon occurs through the ventral diencephalic vein (VDV) into the tentorial veins (TVs). The prosencephalon is drained by the median vein of the prosencephalon (MVP) of Markowski. As the *arrows* indicate, the continued development of the cerebellum will result in an increase in posterior fossa size and an increase in the incline of the tentorium, which will also continue to grow medially. The petrous pyramid will also begin anteromedial growth and rotation. The falx will continue to develop inferoposteriorly and the MVP will form the falcine sinus (FS) and the straight sinus (SS) intradurally and the vein of Galen confluens (VGC) in the subarachnoid space, as seen in (**B**) at week 17 of development. The stems of the MVP give rise to the BVRs, internal cerebral veins (ICVs), and inferior sagittal sinus (ISS). At this stage, the jugular foramen is narrowed because of continued petrous pyramid development and rotation; thus, the transverse sinus (TS) is dilated, whereas the posterior aspect of the SSS has not yet converged. This maintains flow through the FS and TVs. The adult configuration is shown in (**C**) as observed in the present study. The SSS is seen completely coalesced. The ISS drains into the junction of the VGC and SS and the VG continues in the falx as a separate structure as observed. The medial tentorial vein (MTV) is seen originating from the SS on the tentorial free edge and continuing to the CS while giving off the mesencephalic bridging vein (MBV) and temporal lobe bridging vein (TBV) to transition to the apical tentorial vein (ATV). The intermediate tentorial vein (ITV) is seen from the SS to superior petrosal sinus (SPS) in plexiform anastomosis (PA) with the MTV and lateral tentorial vein (LTV), a continuation of the ring configuration (RC) and lateral tentorial sinus (LTS). (**D**) Propagation of venous thromboembolism after ligation of the TBV, as seen in case 1 with resultant infarction and hemorrhagic conversion. BVR, basal vein of Rosenthal; CS, cavernous sinus; SpPS, sphenoparietal sinus.

into the LTS in retrograde. Drainage through the mesencephalic plexus continued to the anterior cervical epidural plexus to the radicular veins that drain to the jugular veins, returning to the right atrium. Cerebellar drainage was maintained through the tentorial veins via BVs into the PAs. The right MTV in this case was important due to the incomplete development of the right basal vein of Rosenthal to meet the mesencephalic plexus anteriorly. This case may serve as an explanation for observation of asymptomatic postoperative thrombosis of the TS.[39]

These cases highlight the importance of recognizing normal and anomalous tentorial drainage. Before complete development of the transcerebral venous system arising from the VG, the diencephalon and mesencephalon BVs arise from a tentorial sinus.[24,26,40] The medullary veins arise from BVs, which arise from the prosencephalic, tentorial, and myelencephalic plexuses.[17,23,24] Although it was originally thought that completed rotation of the tentorium obliterates the tentorial veins,[17] this study supports the concept that the transtentorial venous system persists. We hypothesize that the volume dependence of pressure in the dural venous system maintains directionality of flow and patency of the tentorial veins. Furthermore, Huang[24] demonstrated that the right jugular bulb and dural sinuses are larger in caliber and flow due to retrograde pulsations of the heart. Cases 1 and 2 accentuate the normal development with dominant right dural sinuses and incomplete development of basal vein of Rosenthal,[40] respectively.

The transtentorial venous system was identified in both cases on T1-weighted postcontrast MRI and delayed-phase computed tomography angiography. The outcomes of these cases suggest the importance of preoperative evaluation of this venous system, possibly to include magnetic resonance venography and computed tomographic venography in cases where the tentorium or BVs may need to be manipulated.

Limitations of the Study

Although in this study we have identified a consistent configuration of the transtentorial venous network in 2 cadaver heads and 2 clinical cases with related outcomes, further cadaveric or radiographic study is warranted to determine generalizability of this framework and how it is affected by developmental and pathologic processes.

CONCLUSIONS

The cadaveric study of the tentorium elaborated on a transtentorial venous system connecting venous drainage of parenchyma within the anterior, middle, and posterior fossae. These veins, thought to obliterate in completed development of the tentorium, remain patent. This tentorial vein configuration was found in a case of remote cerebellar and brainstem venous infarction after resection of a medial temporal lobe glioblastoma. In the other case presented, bilateral transverse sinus thrombosis did not result in damage to the brain parenchyma because venous channels in the tentorium may have acted as an accessory venous drainage pathway. The cases presented emphasize the importance of the transtentorial venous system physiologically and in surgical approaches.

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