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Preserving the cerebellar hemispheric tentorial bridging veins through a novel tentorial cut technique for supracerebellar approaches

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OBJECTIVE The objective of this study was to describe the distribution pattern of cerebellar hemispheric tentorial bridging (CHTB) veins on the tentorial surface in a case series of perimedian or paramedian supracerebellar approaches and to describe a novel technique to preserve these veins.

METHODS A series of 141 patients with various pathological processes in different locations was operated on via perimedian or paramedian supracerebellar approaches by the senior author from July 2006 through October 2022 and was retrospectively evaluated. During surgery, the number and locations of all CHTB veins were recorded to establish a distribution map on the tentorial surface, divided into nine zones. Patients were classified into four groups according to the surgical technique used to manage CHTB veins: 1) group 1 consisted of CHTB veins preserved without intervention during surgery or no CHTB veins found in the surgical route; 2) group 2 included CHTB veins coagulated during surgery; 3) group 3 included CHTB veins preserved with arachnoid and/or tentorial dissection from the cerebellar or tentorial surface, respectively; and 4) group 4 comprised CHTB veins preserved using a novel tentorial cut technique.

RESULTS Overall, 141 patients were included in the study. Of these 141 patients, 38 were in group 1 (27%), 32 in group 2 (22.7%), 47 in group 3 (33.3%), and 24 in group 4 (17%). The total number of CHTB veins encountered was 207 during surgeries on one side. According to the distribution zones of the tentorium, zone 5 had the highest density of CHTB veins, while zone 7 had the lowest. Of the patients in group 4, 6 underwent the perimedian supracerebellar approach and 18 had the paramedian supracerebellar approach. There were 39 CHTB veins on the surface of the 24 cerebellar hemispheres in group 4. The tentorial cut technique was performed for 27 of 39 CHTB veins. Twelve veins were not addressed because they did not present any obstacles during approaches. During surgery, no complications were observed due to the tentorial cut technique.

CONCLUSIONS Because there is no way to determine whether a CHTB vein can be sacrificed without complications, it is important to protect these veins in supracerebellar approaches. This new tentorial cut technique in perimedian or paramedian supracerebellar approaches makes it possible to preserve CHTB veins encountered during supracerebellar surgeries.

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KEYWORDS bridging vein; mediobasal temporal region; midbrain; pineal region; supracerebellar approach; tentorium; vein sacrifice; surgical technique

The classic midline supracerebellar approach to reach the pineal region was first described by Fedor Krause in 1913[1,2] and developed by Bennett Stein in 1971.[3] As a variation of the midline approach, the paramedian approach was developed by Yaşargil to reach the pineal region, tectum, and thalamus, as well as the posterior mediobasal temporal region with an additional tentorial incision.[4–6] The senior author of this paper (U.T.) has also demonstrated the possibility of reaching the entire length of the mediobasal temporal region with the para-

ABBREVIATIONS CHTB = cerebellar hemispheric tentorial bridging; ICG = indocyanine green.
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median supracerebellar approach.[7] In addition to the paramedian supracerebellar approach to access lesions in the posterior incisural space and related areas, including the pineal region, midbrain, and pulvinar, the perimedian supracerebellar approach can be used.[8] With either of these approaches, cerebellar hemispheric tentorial bridging (CHTB) veins are usually encountered between the tentorium and superior surface of the cerebellum and narrow the surgical corridor. Although preserving the infratentorial venous drainage is very important to ensure optimal postoperative outcomes, preserving the bridging veins remains a considerable and neglected issue in supracerebellar approaches.[9–11] Because all vermian bridging veins are unavoidably sacrificed during midline approaches,[12–14] decreasing the risk of infarction and hemorrhage is possible when the vermian bridging veins are preserved during perimedian or paramedian supracerebellar approaches.[6,7]

The anatomy and distribution pattern of the CHTB veins vary and choosing the best possible approach is not sufficient to preserve these veins; therefore, managing the CHTB veins may be challenging during surgery. As imaging methods to demonstrate the drainage pattern of CHTB veins are limited preoperatively, the importance of CHTB veins in venous drainage is underestimated. To obtain a wide operative corridor and decrease the risk of uncontrolled bleeding from rupture, sacrificing the bridging veins is considered safe by some neurosurgeons,[15] but the results of such sacrifice are unpredictable. Some case reports describe severe complications related to venous sacrifice.[11,16–21] Therefore, the consequences of sacrificing the CHTB veins should be considered for patients undergoing perimedian or paramedian supracerebellar approaches during which CHTB veins present common obstacles.[22]

To prevent complications related to sacrificing CHTB veins, our surgical techniques have evolved over time to protect all bridging veins. In this study, we describe a novel technique to preserve the CHTB veins and their distribution on the tentorial surface in our case series of patients undergoing perimedian or paramedian supracerebellar approaches.

Methods

Patient Data and Outcome Assessment

A series of 141 patients with various pathological processes in different locations was operated on via perimedian or paramedian supracerebellar approaches at the Yeditepe University Department of Neurosurgery by the senior author (U.T.) from July 2006 through October 2022 and was retrospectively evaluated. Of these 141 patients, 47 underwent perimedian supracerebellar approaches and 94 had paramedian supracerebellar approaches. The perimedian supracerebellar approach was performed only with the patient in the semisitting position. The paramedian supracerebellar approach was performed with the patient in the semisitting, semilateral, or prone oblique positions, as previously described.[7,8]

Preoperative, early postoperative (< 24 hours), and 3-month postoperative evaluations were conducted using MRI according to a standard imaging protocol. Preoperative and 3-month postoperative evaluations with tractography were also included in our protocol. Intraoperative MRI was introduced to our institution in January 2018. After this time point, intraoperative MRI was routinely used for patients placed in the semilateral or prone oblique positions. All patients underwent detailed neurological examinations at admission, after surgery, at discharge, and at follow-up.

During surgery, the number and locations of all CHTB veins were recorded. To establish a map for understanding the distribution pattern and concentration of CHTB veins, four edges of the tentorium were divided into three equal parts based on our surgical trajectories (perimedian, paramedian, and lateral) and deepness (posterior, middle, and anterior) of the veins. By merging and intersecting these parts at each border equally, the tentorial surface was divided into nine zones. CHTB veins were assigned to zones based on their positions on the cerebellar hemispheres.

Patients were classified into four groups according to the surgical techniques used for CHTB veins as follows: 1) in group 1, the CHTB veins were preserved without intervention during surgery, or no CHTB veins were found in the surgical route; 2) in group 2, CHTB veins were coagulated and sacrificed when encountered along the surgical route; 3) in group 3, CHTB veins were preserved through arachnoid dissection from the cerebellar or tentorial surface; and 4) in group 4, CHTB veins were preserved with a novel tentorial cut technique during surgery. Patients who were operated on from 2006 through 2015 were included in groups 1, 2, or 3. In 1 patient with a single large CHTB vein that did not relax after arachnoidal dissection, we decided to cut the tentorium surrounding the vein and the accompanying tentorial sinus to preserve this structure; thus, the tentorial cut technique was created. Consequently, since August of 2016, we have preserved all CHTB veins by using this technique.

Patient data are reported according to common descriptive statistics. Written informed consent was obtained for all patients, and the study was performed according to the ethical standards of the Declaration of Helsinki.

Surgical Technique

Opening and Defining the Venous System

The tentorial cut technique was performed in 24 patients, who constituted group 4. The semisitting position was used in 22 of these patients to facilitate visualizing the supracerebellar space and to create a wide surgical corridor that made use of gravity. The other 2 patients were placed in the semilateral position to accommodate intraoperative MRI.

In the perimedian supracerebellar approach, a linear median occipital incision is made. Then, a relatively large perimedian craniotomy is completed to encompass both sides of the midline; it extends asymmetrically on the side of the lesion[8] (Fig. 1A). In paramedian supracerebellar approaches, a paramedian vertical linear skin incision is made and a unilateral craniotomy is performed on the side of the lesion (Fig. 1B). After the craniotomy for either approach, two openings are made in the dura. The first opening is placed over the lower aspect of the craniotomy to release CSF from the cisterna magna to relax the pos-

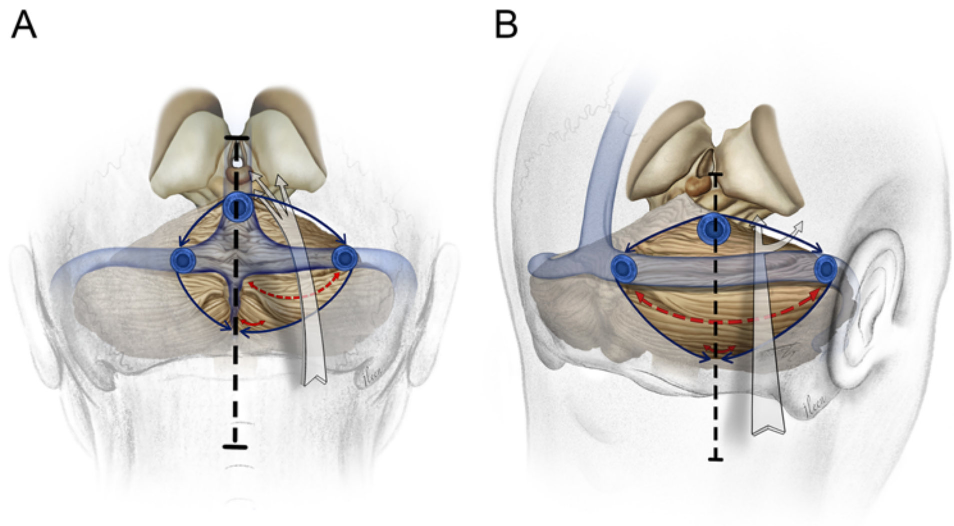

FIG. 1. Illustration of the perimedian and paramedian supracerebellar approaches. **A:** The perimedian supracerebellar approach. The *vertical dashed black line* demonstrates the midline skin incision. The *blue circular areas* indicate the optimal areas for the burr holes, allowing the craniotomy to extend asymmetrically on the side of the lesion. The *red dashed line* indicates the curvilinear dural incision. Note the small dural opening above the inferior border of the craniotomy, which facilitates access to the cisterna magna to release CSF, indicated by the *solid curved red line with arrows* on each end. The *white transparent arrows* indicate the operative routes to the posterior incisural space and related areas, including the pineal region, midbrain, and pulvinar, through the perimedian supracerebellar infratentorial approach and the perimedian supracerebellar transtentorial approach. **B:** The paramedian supracerebellar approach. The *vertical dashed black line* demonstrates the paramedian skin incision. The *blue circular areas* indicate the optimal regions for the burr holes. The *red dashed line* indicates the curvilinear dural incision. Note the small dural opening above the inferior border of the craniotomy, which facilitates access to the cisterna magna to release CSF, indicated by the *solid curved red line with arrows* on each end. The *white transparent arrows* indicate the operative routes to the tegmentum and the mediobasal temporal region through the paramedian supracerebellar transtentorial approach. © Uğur Türe, published with permission.

terior fossa. The second incision opens the dura approximately 15 mm below the transverse sinus, as previously described.[7,8] In the semisitting position, adequate exposure is obtained without rigid retractors through gravitational retraction of the cerebellum. The tentorial surface of the cerebellum is dissected from the tentorium, and the supracerebellar space is explored. The CHTB veins and accompanying tentorial sinuses are identified.

In patients who had no CHTB veins in the surgical corridor or veins that did not need to be managed to allow adequate exposure, surgery was performed to resect the lesion (group 1). For patients with CHTB veins that created obstacles to surgical exposure, the veins were dissected from their adhesions on cerebellar or tentorial surfaces to decrease tension and allow their lengthening to create adequate surgical exposure without causing injury. Sharp dissection of the arachnoid attachments is performed between the veins and the cerebellum to relax the CHTB veins. If such dissection does not adequately relax the veins, additional dissection of arachnoid attachments is conducted between the tentorium and the bridging vein (group 3). If a hemorrhage occurs during dissection, hemostatic agents are used to stop the bleeding. For patients in whom vein relaxation was not sufficient despite arachnoid dissection, we either sacrificed the vein with bipolar coagulation (before August 2016; group 2) or preserved the vein with the tentorial cut technique (after August 2016; group 4).

Vein-Preserving Technique

Our tentorial cut technique is used in patients with CHTB veins that impede surgical exposure and tend to rupture due to tension despite arachnoid dissection. To enlarge the supracerebellar space and prevent rupture of the veins, the tentorial dura surrounding the CHTB vein is incised. The direction of the incision is chosen based on the drainage route of the accompanying sinus, and the aperture of the cut is made to preserve the tentorial sinus (Fig. 2). The tentorial incision is made carefully to prevent injury to the temporal basal veins in the supratentorial area draining into the tentorial sinuses. At the end of surgery, patency of the CHTB veins is confirmed using micro-Doppler ultrasound (Mizuho America, Inc.), indocyanine green (ICG) video angiography, or both.

Results

Our study included 141 patients with no previous surgery. Of these 141 patients, 60 (42.6%) were male and 81 (57.4%) were female. The mean age of the patients was 29.7 (range 2–72) years. Thirty-eight patients were in group 1 (27%), 32 in group 2 (22.7%), 47 in group 3 (33.3%), and 24 in group 4 (17%). Before developing the tentorial cut technique, attempts to preserve the CHTB veins through arachnoid dissection had failed in 11 patients, resulting in sacrifice of the veins. The reasons for vein sacrifice were diverse, with 6 patients having insufficient exposure, 2

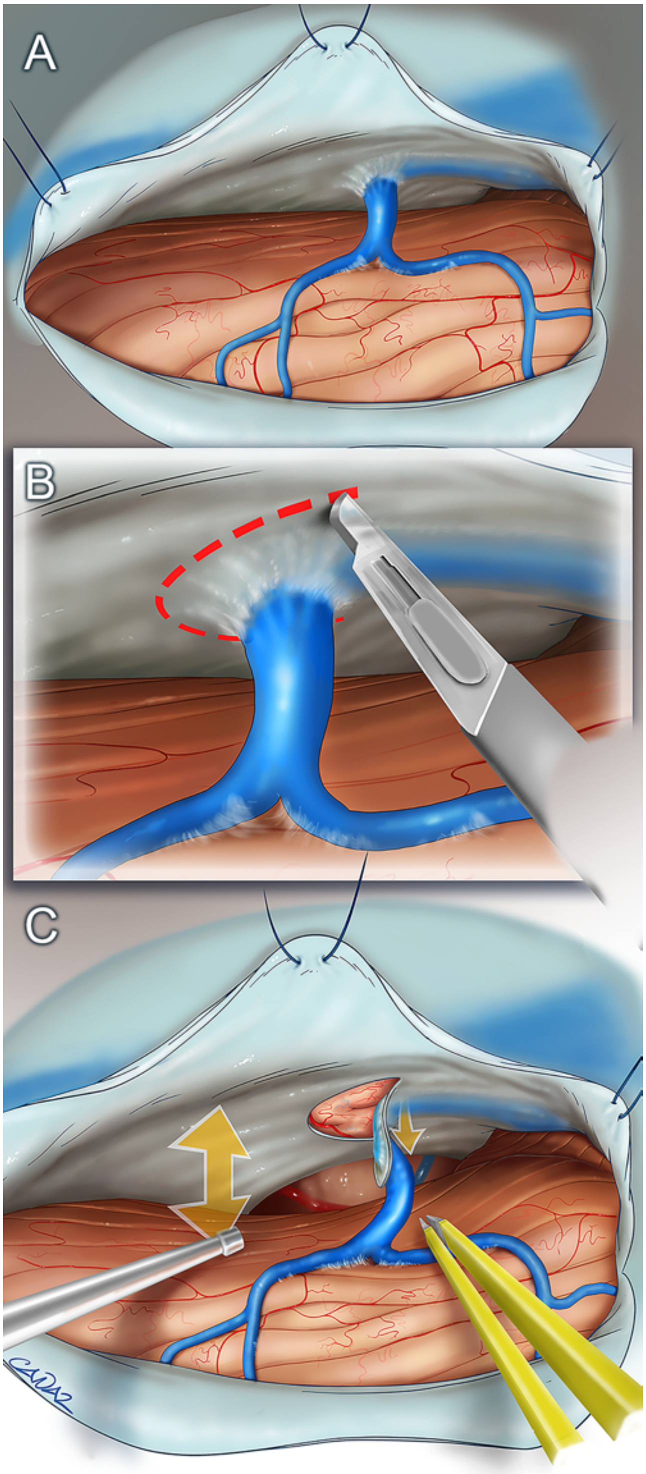

FIG. 2. Illustration of the tentorial cut technique in case 11. A left-sided perimedian supracerebellar transtentorial approach was performed. A major CHTB vein was preserved using the novel tentorial cut technique. **A:** Before application of the tentorial cut technique. **B:** The *dashed line* outlines the tentorial cut. The direction of the incision is chosen based on the drainage direction of the accompanying sinus, and the aperture of the tentorial cut shape is made to preserve the tentorial sinus. **C:** After the tentorial cut. The *small yellow arrow* demonstrates the relaxation of the tentorial flap and the CHTB vein. The CHTB vein and the tentorial sinus are preserved. **FIG. 2.** (*continued*)→

FIG. 2. Note the wide supracerebellar surgical space obtained by relaxation of the CHTB vein after the tentorial cut, as indicated by the *large yellow double-headed arrow.* © Gökhan Canaz, published with permission.

encountering bleeding during arachnoid dissection, and 3 encountering bleeding during resection. These patients are included in group 2. We did not observe any vein sacrifice-related complications in the group 2 patients during the postoperative period, but there were no large veins among the veins we coagulated. The perimedian supracerebellar approach was performed in 47 patients (28 on the right, 19 on the left) and the paramedian supracerebellar approach was performed in 94 (38 on the right, 56 on the left). The indications for surgery and approaches are summarized for 141 cases in Supplemental Table 1.

Distribution Pattern of the CHTB Veins

Of the 141 patients, 66 underwent a right-sided supracerebellar approach whereas 75 had a left-sided approach. Only the CHTB veins on the operated side were counted; petrosal veins and the vermian bridging veins were excluded. There were 89 CHTB veins (43%) in the right cerebellar hemisphere and 118 (57%) in the left, for a total of 207. CHTB veins were not encountered in 18 patients (12.8%), including 11 right-sided and 7 left-sided approaches. Of the CHTB veins encountered, there was 1 vein in 61 patients (43.3%), 2 veins in 46 (32.6%) patients, 3 veins in 11 (7.8%) patients, 4 veins in 4 (2.8%) patients, and 5 CHTB veins in 1 patient (0.7%; Table 1).

According to the CHTB vein distribution zones on the tentorium, 33 veins were observed in zone 1 (15.9%), 21 in zone 2 (10.1%), 18 in zone 3 (8.7%), 28 in zone 4 (13.5%), 60 in zone 5 (29%), 32 in zone 6 (15.5%), 2 in zone 7 (1%), 6 in zone 8 (2.9%), and 7 in zone 9 (3.4%). The distribution patterns and locations of the CHTB veins are illustrated in Fig. 3.

Zones 1, 4, and 7 represented the perimedian region of the tentorium; 2, 5, and 8 the paramedian; and 3, 6, and 9 the lateral region in the sagittal plane. Zones 1–3 also comprised the posterior part, 4–6 the middle part, and 7–9 the anterior part of the tentorium in the coronal plane (Fig. 3).

In zones 2–3 and 8–9, the CHTB veins were close to zones 5 and 6. Zone 1 also had two distinct distribution patterns located medially and laterally. Medially located

TABLE 1. Number and percentage of CHTB veins in 141 patient hemispheres

CHTB Veins in One Cerebellar Hemisphere	No. of Cerebellar Hemispheres	Percentage
0	18	12.8
1	61	43.3
2	46	32.6
3	11	7.8
4	4	2.8
5	1	0.7

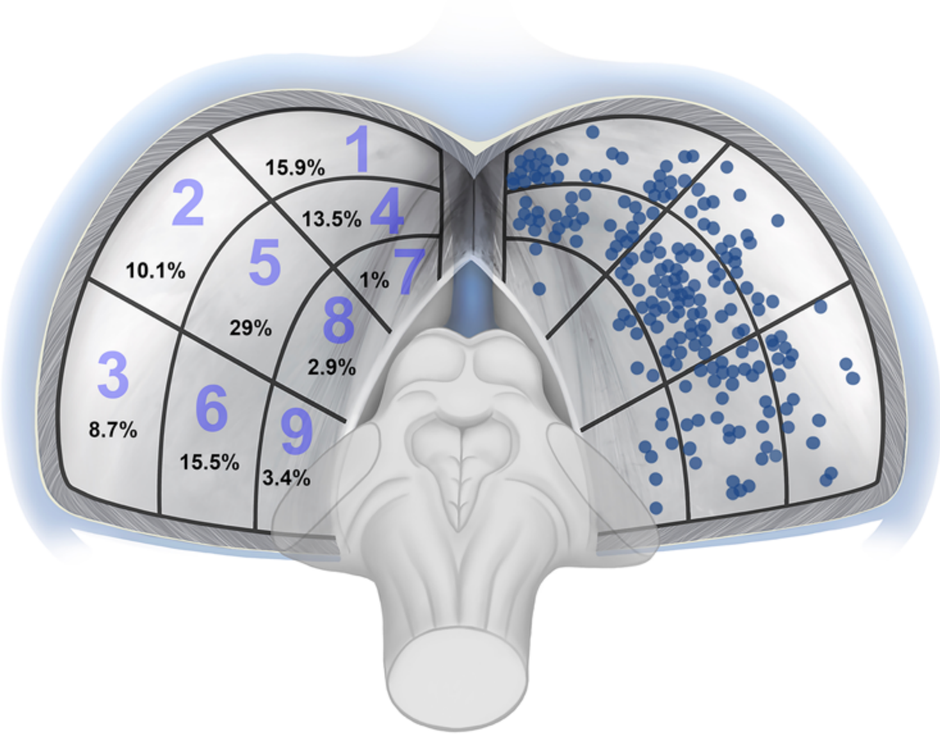

FIG. 3. The distribution pattern of CHTB veins according to tentorial zones. Overall, 33 CHTB veins were seen in zone 1 (15.9%), 21 (10.1%) in zone 2, 18 (8.7%) in zone 3, 28 (13.5%) in zone 4, 60 (29%) in zone 5, 32 (15.5%) in zone 6, 2 (1%) in zone 7, 6 (2.9%) in zone 8, and 7 (3.4%) in zone 9. Zones 1, 4, and 7 represent the perimedian; 2, 5, 8 the paramedian; and 3, 6, and 9 the lateral region of the tentorium in the sagittal plane. Zones 1–3 comprise the posterior part, 4–6 the medial part, and 7–9 the anterior part of the tentorium in the coronal plane, respectively. Only the CHTB veins are demonstrated; the petrosal veins and vermian bridging veins are not shown. © Uğur Türe, published with permission.

veins were close to the midline and zone 4 while laterally located veins were near the intersection of zones 2, 4, and 5. The region where the CHTB veins were most common in zones 2, 5, and 8 comprised the paramedian region of the tentorium, and zones 4, 5, and 6 constituted the middle part of the tentorium. Zones 2, 4, 5, 6, and 8 had the highest density of CHTB veins (Fig. 3).

Results of Group 4 Patients With the Tentorial Cut Technique

Patients operated on after August 2016 were included in groups 1, 3, and 4, and no patients were included in group 2 after August 2016. Of the 24 patients in group 4, 2 underwent the perimedian supracerebellar infratentorial approach, 4 had the perimedian supracerebellar transtentorial approach, and 18 underwent the paramedian supracerebellar transtentorial approach. The semisitting position was used for 22 patients, whereas 2 patients were operated on in the semilateral position to accommodate intraoperative MRI. Ten patients underwent right-sided supracerebellar approaches and 14 had left-sided supracerebellar approaches. Detailed information regarding the characteristics of patients in group 4 are summarized in Table 2.

During surgery, 39 CHTB veins were encountered on the surface of the cerebellar hemispheres of 24 patients. The tentorial cut technique was performed for 27 of these 39 veins. The remaining 12 veins were not managed because they did not obstruct the approach. After application of the tentorial cut, the patency of the CHTB vein was confirmed after surgery using micro-Doppler ultrasound, ICG video angiography, or both (Fig. 4). No surgical complications were observed from the tentorial cut technique. Intraoperative views of the tentorial cut in different patients are shown in Fig. 5 and illustrated in Fig. 6. Additionally, the tentorial cut technique is demonstrated for left-sided approaches in Video 1 and right-sided approaches in Video 2.

VIDEO 1. The tentorial cut technique as applied in left-sided supracerebellar approaches. The technique was successful and the CHTB veins were preserved. These cases are featured in Fig. 6A. © Uğur Türe and Gökhan Canaz, published with permission. Click here to view.

VIDEO 2. The tentorial cut technique as applied in right-sided supracerebellar approaches. The technique was successful and the CHTB veins were preserved. These cases are featured in Fig. 6B. © Uğur Türe, published with permission. Click here to view.

Discussion

To our knowledge, this is the first study of CHTB veins that details the variations and locations with direct observation in 141 patients intraoperatively. The posterior fossa veins have been classified according to their direction of drainage into three groups: the superior or galenic group,

TABLE 2. Characteristics of patients in group 4

Case No.	Age (yrs), Sex	Lesion Locations	Histopathology	Patient Position	Approach	No. of CHTB Veins	CHTB Vein Zones	Tentorial Cut Technique Application Zones
1	54, F	Rt tentorial hiatus	Fibroblastic meningioma grade 1	Semisitting	PaSCTT	1	4	4
2	12, F	Lt tegmentum	Diffuse glioma *IDH*–wild-type grade 2	Semilateral	PaSCTT	1	5	5
3	16, F	Rt posterior fusiform gyrus	Ganglioglioma grade 1	Semisitting	PaSCTT	2	7, 8	8
4	56, F	Lt tentorial incisura	Clear-cell meningioma grade 2	Semisitting	PaSCTT	2	4, 6	4, 6
5	13, M	Lt tegmentum	Low-grade neuroglial tumor	Semilateral	PaSCTT	1	5	5
6	14, M	Lt hippocampal region	Diffuse astrocytoma grade 2	Semisitting	PaSCTT	2	5, 6	5
7	41, F	Lt thalamus	Glioneuronal tumor grade 1	Semisitting	PeSCTT	1	6	6
8	24, M	Lt mesial temporal region	Dysembryoplastic neuroepithelial tumor	Semisitting	PaSCTT	2	5, 6	6
9	27, F	Rt hippocampal region	Arteriovenous malformation	Semisitting	PaSCTT	2	1, 5	5
10	22, M	Rt pineal region	Germinoma	Semisitting	PeSCIT	2	5, 6	6
11	37, F	Lt thalamus	Oligodendroglioma	Semisitting	PeSCTT	2	1, 3	1, 3
12	15, M	Rt midbrain	Pilocytic astrocytoma	Semisitting	PeSCIT	1	5	5
13	38, F	Rt tentorial hiatus	Hemangiopericytoma grade 2	Semisitting	PaSCTT	1	5	5
14	59, M	Lt thalamus	Cavernous angioma	Semisitting	PeSCTT	2	2, 6	2
15	59, M	Rt thalamic & hippocampal region	Mixed oligoastrocytoma grade 2	Semisitting	PaSCTT	2	5, 6	5
16	40, M	Rt thalamus	Mixed oligoastrocytoma grade 2	Semisitting	PeSCTT	1	5	5
17	25, F	Lt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	2	1, 5	5
18	54, F	Lt mesial temporal region	Diffuse astrocytoma grade 2	Semisitting	PaSCTT	3	4, 6, 6	4
19	31, F	Lt mesial temporal region	Oligoastrocytoma grade 2	Semisitting	PaSCTT	1	5	5
20	30, M	Lt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	2	5, 5	5, 5
21	36, M	Rt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	1	5	5
22	45, M	Rt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	1	5	5
23	32, F	Lt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	3	4, 5, 6	4, 5
24	20, F	Lt mesial temporal region	Hippocampal sclerosis	Semisitting	PaSCTT	1	2	2

PaSCTT = paramedian supracerebellar transtentorial; PeSCIT = perimedian supracerebellar infratentorial; PeSCTT = perimedian supracerebellar transtentorial.

the anterior or petrosal group, and the posterior or tentorial group.[23] The superficial veins draining the suboccipital surface are the inferior vermian and inferior hemispheric veins, and the superficial veins draining the posterior part of the tentorial surface are the superior hemispheric and superior vermian veins, respectively. These vermian and hemispheric superficial veins combine to form the bridging veins draining into the tentorial sinuses. The bridging veins on the vermis located in the midline are vermian bridging veins. Those located on cerebellar hemispheres are named hemispheric bridging veins and are described as CHTB veins in this study. All these venous structures and tentorial sinuses comprise the tentorial draining group of the posterior fossa.[10,24] To the best of our knowledge, no other study has defined a vein-preserving technique for this vein group.

The distribution of CHTB veins shows widespread variation. Matsushima and colleagues classified the CHTB veins in 10 cadaveric specimens as medial, middle, and lateral (20 sides) based on the location of the veins on hemispheric surfaces.[24] They found that CHTB veins were less frequently located in the lateral part of the hemisphere compared to the middle- and medial-thirds. Ueyama and associates classified the CHTB veins in 14 cadaveric specimens (26 sides) based on their draining location into the tentorium as medial, intermediate, and lateral with regard to the distance from the midline and posterior edge of the transverse sinus.[12] They reported that 59% of the CHTB veins were located in the intermediate-third, 18% in the lateral-third, and 23% in the medial-third. They also reported that no hemispheric bridging vein was found in 4% of their hemisphere specimens.[11] Our study divided the tentorium into 9 parts, and the locations of CHTB veins were classified with more detail. The zones were evaluated separately and the number of CHTB veins and their locations were recorded based on the zones. Zone 5, the central part of the tentorium, had 29% of the CHTB veins, the highest density. The possibility of encountering a CHTB vein is lower in the perimedian (1, 4, 7) or lateral (3, 6, 9) zones compared with the paramedian zones (2, 5, 8; Fig. 3). Furthermore, 12.8% of our patients had no CHTB veins on one side of their cerebellar hemispheres.

The midline supracerebellar infratentorial approach is associated with high rates of vein coagulation and the unavoidable sacrifice of vermian bridging veins.[25] Therefore, in our case series, we used only the perimedian or paramedian supracerebellar approaches. In addition to preserving veins with these approaches, the trajectory over the lateral

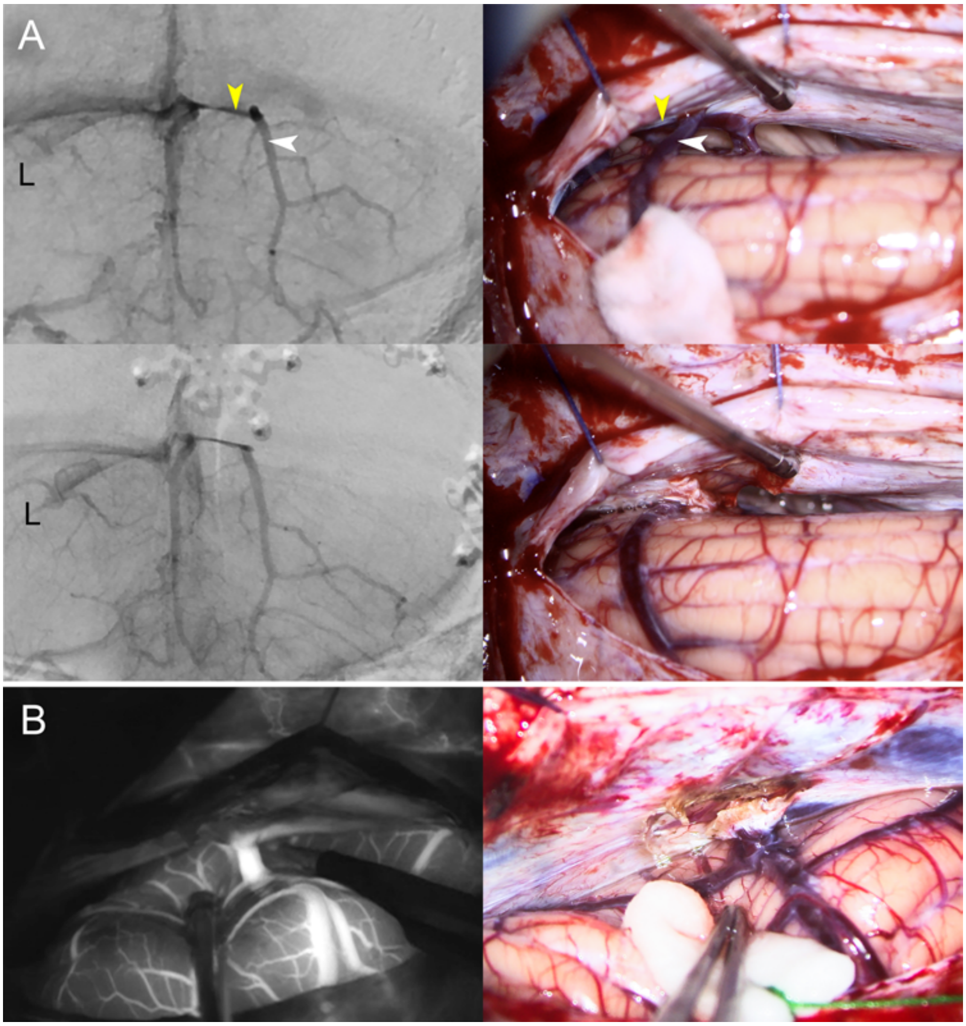

FIG. 4. Radiological and intraoperative demonstrations of the CHTB veins before and after the tentorial cut technique in different cases. **A:** In the *upper left* image, preoperative digital subtraction angiography (DSA) view of a CHTB vein in case 9 (right-sided medial temporal region arteriovenous malformation) is demonstrated. In the *upper right* image, the intraoperative view of the right-sided CHTB vein before applying the tentorial cut technique is shown. The *lower left* image demonstrates the postoperative DSA view of the preserved CHTB vein in case 9. The intraoperative view of the right-sided CHTB vein after applying the tentorial cut technique is shown in the *lower right* image. The *white arrowhead* indicates the CHTB vein. The *yellow arrowhead* indicates the tentorial sinus that drains the CHTB vein. **B:** ICG video angiographic and intraoperative views of the CHTB vein in case 2. After the tentorial cut, the patency of the CHTB vein was confirmed with ICG video angiography (*left*). An intraoperative view of the preserved CHTB vein is also shown (*right*). L = left.

cerebellum is more direct and less steep, enabling greater surgical exposure. In addition, aggressive retraction on the culmen, commonly used in midline approaches, is avoided with the paramedian or perimedian supracerebellar approaches.[12,14,26] Furthermore, the perimedian supracerebellar approach avoids CHTB vein–intense zones and works through the vermian bridging and CHTB veins without damaging them.[6,8] The paramedian supracerebellar approaches were performed with patients in semisitting, semilateral, or prone oblique positions, whereas the perimedian supracerebellar approaches were performed only with the patient in the semisitting position. Neurosurgeons who are inexperienced with the semisitting position or want to use intraoperative MRI during surgery might prefer the semilateral or prone oblique positions for paramedian supracerebellar approaches; however, the semisitting position has the advantages of providing a bloodless field from low venous pressure, gravity-aided cerebellar retraction, and better anatomical orientation.[7,8,27,28]

Sacrificing veins is common to obtain adequate surgical exposure.[29–31] In several case series, some authors claimed that no complications were found after the bridging veins were sacrificed.[18,32–35] Krogager and colleagues conducted a survey to evaluate the personal knowledge and experience of surgeons regarding venous sacrifice.[15] Based on reports by anonymous experienced surgeons answering the survey, these authors found that sacrificing one of several bridging veins, sacrificing one or two superior vermian veins, or sacrificing one internal occipital vein was considered safe. Although many complications caused by

FIG. 5. Intraoperative demonstrations of the tentorial cut technique in cases 5, 8, and 19. Images on the *left* are before application of the tentorial cut technique. Images on the *right* are after the technique. All CHTB veins were preserved. **A:** Case 5. A left-sided paramedian supracerebellar transtentorial approach was performed with the patient in the semilateral position. **B:** Case 8. A left-sided paramedian supracerebellar transtentorial approach was performed with the patient in the semisitting position. **C:** Case 19. A left-sided paramedian supracerebellar transtentorial approach was conducted with the patient in the semisitting position.

venous sacrifice are transient and infrequent,[30] sacrificing even a limited number of bridging veins may cause severe complications such as infarction, hemorrhage, or even death.[11,16,17,21,36,37] In a study with 13 case series and 578 patients operated on via supracerebellar infratentorial approaches, a venous infarction rate of only 0.345% caused by sacrifice was reported; however, case reports were not included in that study.[11] Furthermore, case series with transient or subclinical complications related to venous sacrifice may be underreported.[11,30,38] In this study, the 32 patients in group 2 did not experience any complications from vein sacrifice, but caution must be exercised as the major CHTB veins were not sacrificed and the sample size was small.

Because there is no method to predict whether a vein can be sacrificed without causing complications,[39,40] a surgeon should thoroughly consider whether to sacrifice a vein. Our opinion is that it is possible to preserve each CHTB vein. In our group 3 patients, we used arachnoid dissection to free the CHTB veins from the cerebellar hemisphere.[41–43] The vulnerable structure of veins with their thin walls restricts manipulation of the bridging veins to obtain an adequate exposure.[43] Some surgeons claim that coagulating the bridging veins prophylactically prevents ruptures that may cause uncontrolled bleeding or air embolisms,[19,34] but we demonstrated that all CHTB veins can be preserved with the tentorial cut technique without injuring the veins or accompanying tentorial sinuses, as achieved in group 4 patients. Nevertheless, surgeons should be aware that supratentorial cortical damage or temporal basal vein injury may occur if the tentorial incision is not made carefully when using the tentorial cut technique. In addition, undesirable bleeding or an air embolism may occur if the draining direction of the accompanying tentorial sinus is not noted during the tentorial incision.

Limitations of the Study

Our study has some limitations that need to be acknowledged. First, although we found the tentorial cut technique beneficial, we did not conduct a randomized controlled trial to compare it with the group in which the

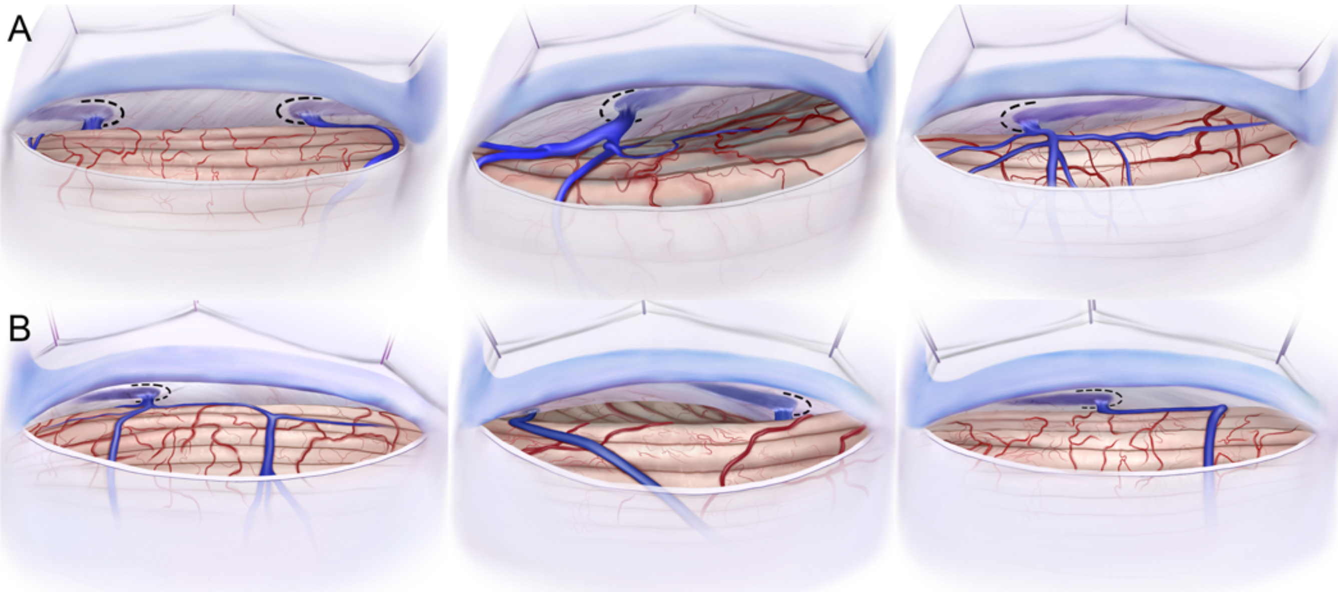

FIG. 6. Illustration of the CHTB veins and draining sinus structures of the cases in Video 1 (left-sided) and Video 2 (right-sided) before application of the tentorial cut technique. The *dashed lines* outline the tentorial cut. The aperture of the cut is made to preserve the tentorial sinus, which drains the CHTB veins. With the patient in the semisitting position, the cerebellar parenchyma is relaxed, and the space between the tentorium and cerebellar surface is opened and CSF released to create a wide operative corridor with the use of gravity. **A:** Left-sided cases in Video 1. Case 4 (*left*) involved the paramedian supracerebellar transtentorial approach with the patient in the semisitting position. Case 7 (*center*) used the perimedian supracerebellar transtentorial approach with the patient in the semisitting position. Case 2 (*right*) involved the paramedian supracerebellar transtentorial approach with the patient in the semilateral position. The image is rotated to facilitate comprehension. **B:** Right-sided cases in Video 2. Case 1 (*left*) comprised the paramedian supracerebellar transtentorial approach with the patient in the semisitting position. Case 3 (*center*) included the paramedian supracerebellar transtentorial approach with the patient in the semisitting position. Case 12 (*right*) used the perimedian supracerebellar infratentorial approach with the patient in the semisitting position. © Uğur Türe, published with permission.

technique was not applied, limiting our ability to evaluate its effectiveness. Second, to create a venous variation map and demonstrate the density of veins according to tentorial zones, we studied the anatomical variations of 141 patients; however, the observation of venous variations is limited to one side of the tentorium, and no data are available regarding bilateral venous variation in these patients. And third, while 32 patients in group 2 did not experience any complications from vein sacrifice, the small sample size and avoidance of sacrificing the major CHTB veins limit the generalizability of this finding.

Conclusions

Knowledge of the characteristics of the tentorial venous anatomy is essential for surgeons performing supracerebellar surgical procedures. As it is impossible to determine whether a CHTB vein can be sacrificed without complications, it is important to preserve these veins during supracerebellar approaches. Preserving the vermian bridging veins is possible with the perimedian or paramedian supracerebellar approaches, decreasing the risk of infarction and hemorrhage. Choosing these approaches, however, is not sufficient to preserve the CHTB veins. The tentorial cut technique described here makes it possible to preserve all CHTB veins encountered during supracerebellar approaches with no complications.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Conception and design: U Türe, Berker, Doğruel, Güngör, Karataş Okumuş. Acquisition of data: U Türe, Berker, Doğruel, H Türe. Analysis and interpretation of data: U Türe, Berker, Doğruel, Güngör, Karataş Okumuş. Drafting the article: U Türe, Berker, Doğruel, Güngör, Karataş Okumuş. Critically revising the article: U Türe, Berker, Doğruel, Güngör, Coşkun. Reviewed submitted version of manuscript: U Türe, Berker, Doğruel, Güngör, Coşkun, H Türe. Approved the final version of the manuscript on behalf of all authors: U Türe. Administrative/technical/material support: U Türe. Study supervision: U Türe, Güngör, H Türe.

Supplemental Information

Videos

Video 1. https://vimeo.com/829458130.
Video 2. https://vimeo.com/829460186.

Online-Only Content

Supplemental material is available with the online version of the article.

Supplemental Table 1. https://thejns.org/doi/suppl/10.3171/2023.5.JNS23657.

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