The Vulnerability of the Vein of Labbé During Combined Craniotomies of the Middle and Posterior Fossae

ABSTRACT—During combined middle and posterior cranial fossae (“petrosal”) approaches to the skull base, the anastomotic vein of Labbé, which bridges between the inferior surface of the temporal lobe and the transverse sinus is placed at risk. Occlusion of this vein, which may drain a large section of the temporal and parietal lobes, may lead to speech, memory, and/or other cognitive disorders. Labbé may be injured along its course on the inferior aspect of the temporal lobe where it may be lacerated during dural incision or thrombosed due to prolonged or overly vigorous retraction. The anastomotic segment of the vein, which bridges between the temporal lobe and transverse sinus, may be avulsed during elevation of the temporal lobe or injured during tentorial division. Labbé may course in close proximity to the upper surface of the tentorium or even travel within it for a short segment of its course en route to the transverse sinus. This article reviews the anatomy of the vein of Labbé, discusses its clinical significance, and highlights the technical points relevant to the preservation of this important structure.

During combined craniotomies of the posterior and middle fossae (“petrosal” approaches), the anastomotic vein of Labbé, which bridges the inferior surface of the temporal lobe and the transverse sinus is placed at risk. Occlusion of this vein, which may constitute the sole venous drainage for a large section of the temporal and parietal lobes, may lead to devastating neurological injury. Prominent among these potential sequelae are disturbances of speech and memory, with contralateral motor deficits occasionally being seen. Nevertheless, very little has been written on avoidance of the Labbé injuries during intracranial surgery.

The vein of Labbé may be injured along its course on the inferior aspect of the temporal lobe where it may become thrombosed because of prolonged or overly vigorous retraction. The anastomotic segment of the vein, which bridges the temporal lobe and transverse sinus, may be avulsed during elevation of the temporal lobe. The vein of Labbé may course in close proximity to the upper surface of the tentorium or even travel within it for a short segment en route to the transverse sinus. Here it lies vulnerable to injury during tentorial division, a key technical maneuver which joins together the posterior and middle fossa exposures. This report re-

views the anatomy of the vein of Labbé, discusses its clinical significance, and highlights the technical points relevant to the preservation of this important structure.

ANATOMY OF THE SUPERFICIAL CEREBRAL VENOUS SYSTEM

The vein of Labbé is an integral part of the superficial cerebral venous system. The cerebral venous system has been classified by a variety of criteria, including its embryological development, organizational pattern, vascular hemodynamics, and angiographic patterns. Most commonly, though, this venous system is subdivided into two broad groups; a superficial group of veins and a deep group.¹ The deep venous cerebral system drains blood centripetally away from the deep white matter, basal ganglia, and diencephalon, ultimately emptying into the great vein of Galen. The superficial venous system is responsible for draining blood from the outer 2 cm of cortex and the underlying white matter, ultimately terminating in one of the several dural sinuses. As a general rule, the superficial cortical veins are named according to the lobe of the cerebrum that they drain (frontal, parietal, etc.), the surface drained (lateral, medial, or basal/inferior), and direction of travel (ascending or descending). With respect to the temporal lobe, the veins are classified into those groups draining the lateral surface, and those draining the inferior surface.²

There are a series of anastomotic veins which lie along the lateral surface of the brain which connect the superficial cortical venous system to the major venous sinuses. The three largest of these veins are the vein of Labbé, the vein of Trolard, and the superficial sylvian vein. Together, these three veins drain the region around the lateral sulcus and temporal lobe. The vein of Labbé (or inferior anastomotic vein) crosses the temporal lobe between the sylvian fissure and the transverse sinus (Figs. 1–3). It generally arises at the midpoint of the sylvian fissure, then travels posterior and inferior towards the transverse sinus. The vein of Trolard (or superior anastomotic vein) crosses the cortical surface of the frontal and parietal lobes, traveling between the superior sagittal sinus and the sylvian fissure. The superficial sylvian vein (also known as the superficial middle cerebral vein) arises at the posterior end of the sylvian fissure, coursing anteroinferiorly along the fissure. It receives contributions from veins along the sylvian fissure before commonly anastomosing with the veins of Trolard and Labbé.²

The vein of Labbé drains blood from the lateral surface of the temporal lobe and from the region adjacent to the sylvian fissure, emptying nearly always into the transverse sinus (Figs. 1–3). (Rarely, Labbé has been noted to run backward on the undersurface of the temporo-occipital lobe to drain into the posterior portion of the superior sagittal sinus after coursing upward on the convex side of the occipital lobe.) In Koperna's anatomical studies, the vein was clearly defined in 82%

Figure 1. Inferior anastomotic vein of Labbé (arrows) as seen from a lateral perspective after elevation of the temporal lobe (Modified after Oka et al²). In many cases, it represents the primary venous drainage of the temporo-parietal region. While Labbé is usually the dominant vein bridging between the cortical surface and the transverse-sigmoid system, other more variable anastomotic veins may egress the inferior surface of the temporal lobe and enter the tentorium. These travel as a tentorial sinus and ultimately enter the transverse sinus either directly or after joining Labbé en route.

Figure 2. The terminal segment of the vein of Labbé (V) may follow several different courses. It may remain intradural until shortly before entering the medial aspect of the transverse sinus (TS) (*upper left*). It may also penetrate the dura to join the tentorial sinus (*upper right*) or travel by itself within the leaves of the tentorium (*lower*).

of cadavers, while in the remaining 18% there were two equal caliber veins along the temporal lobe.³ This finding has been noted by other authors as well.^{2,4}

The vein of Labbé varies in size relative to the vein of Trolard and the superficial sylvian vein. Di Chiro has noted that while occasionally these three vessels draining the lateral sulcus have the same size, in the majority of cases one or two will predominate.⁴ In his study of 180 radiographic cases, Labbé represented the predominate superficial drainage pathway in 40% while Trolard predominated in 32% of the cases. The superficial sylvian vein was dominant in only 8%, while codominance of both Labbé and Trolard was seen in 11% of cases. Di Chiro also noted that Labbé tended to predominate on the left (dominant hemisphere), while Trolard tended to predominate on the right (nondominant hemisphere), a finding that has been substantiated by other authors as well.² Moreover, there is an inverse relationship between the veins of Trolard and Labbé. When one predominates, the other anastomotic vein on that side is generally small or absent.² Thus, in these cases of a single dominant vessel, either Trolard or Labbé may be responsible for draining a majority of the lateral surface of a cerebral hemisphere.

The segment of Labbé which travels on the brain surface is susceptible to injury during maneuvers such as prolonged compression with subsequent venous thrombosis, or laceration of the vein directly by the retractor. In contrast, the bridging segment, as Labbé turns under the temporal lobe, may be subject to avulsion or torsion injury, while the intradural segment may be

placed at risk during tentoriotomy or electrocoagulation. While the anatomy of the bridging and intradural segments of Labbé may be quite variable, there are some clear relationships which the surgeon can use to avoid intraoperative injuries to Labbé (Fig. 3). In Koperna's study, the vein was noted to reach the transverse sinus via one of the tentorial sinuses (73% of cases) or through a lacuna in the dura of the lateral skull wall (23% of cases).³ Typically, there was a distance of at least 7 mm between the entry of Labbé and the entry of the superior petrosal sinus into the transverse sinus. Moreover, the authors noted that the vein was adherent to the tentorium over a varying length of 3 to 23 mm. The distance from the entry into the tentorium to the medial border of the transverse sinus measured up to 11 mm, and from the entry into the dura of the skull wall to the edge of the sinus up to 15 mm.³ Typically, the vein entered the dura together with other superficial cerebral veins forming a "vein star" which then drained into the transverse sinus via a tentorial sinus.

Because of the abundant number of anastomotic venous channels within the cortex, intraoperative sacrifice of a vein does not inevitably lead to a postoperative neural deficit. However, as this anatomical review of the vein of Labbé alludes to, occasionally Labbé may be the single dominant vessel draining a majority of the temporal lobe or lateral cerebral hemisphere. In these cases, sacrifice of the vein may cause significant postoperative morbidity. One such case was recently encountered at our own institution, which was the impetus for the current report.

Figure 3. As the vein of Labbé (L) courses inferiorly from its lateral position of the temporal cortex, it sweeps medially a short distance underneath the temporal lobe. In its terminal course, it returns to a lateral position where it joins the transverse sinus. During this lateral course it parallels the tentorium. In a variable portion of this segment the veins travel within the tentorium. In data derived from a study of Koperna et al,³ the vein of Labbé lies adherent to the upper surface of the tentorium for up to 23 mm and within it for up to 11 mm. They also observed that the vein entered the transverse sinus at least 7 mm posterior to its junction with the superior petrosal sinus (SPS).

ILLUSTRATIVE CASE

A 55-year-old woman presented with a 6 week history of left parietal headaches, left hemisensory disturbances (tingling) and a slowly progressive left hemiparesis which became acutely worse 4 weeks prior to presentation. The patient denied diplopia, vertigo, or change in hearing. On examination, the left hemiparesis was evident, however, her cranial nerve exam, including Vth nerve, was normal. An MRI demonstrated a 6 cm transtentorial, petroclival meningioma, extending anteriorly to displace the medial temporal lobe. The mass encased the left internal carotid artery, with deviation of the pons and fourth ventricle.

The patient subsequently underwent a combined petrosal middle fossa/posterior fossa approach for tumor resection. Intraoperatively, several small bridging

veins were bipolar cauterized during elevation of the temporal lobe from the upper tentorial surface. Later in the case, during tentoriotomy, a prominent venous channel was noted between the leaves of the tentorium. It bled briskly during tentorial division and was also controlled with bipolar cautery. Subsequently, a large vein of Labbé was identified entering the tentorium from above, and was noted to be contiguous with the disrupted sinus. The remainder of the tumor resection went without incident, with a small amount of tumor left over the cavernous sinus and adjacent to Meckel's cave. Some temporal lobe discoloration was noted at the end of the procedure.

Postoperatively the patient was minimally responsive and was noted to have a right hemiparesis. A CT scan obtained on the first postoperative day demonstrated a 1.5×1.5 cm venous infarct in the left temporal lobe. The patient was managed conservatively with steroids and fluid restriction, and demonstrated slow improvement in her mental status, with a persistent right hemiparesis and aphasia. On postoperative day 3 the patient's mental status worsened and an MRI was obtained, demonstrating a slight increase in the venous infarct with some mass effect, but without hydrocephalus (Fig. 4). She subsequently had an intracranial pressure monitor placed. Over the following week, her neurologic status dramatically improved. By the time of her discharge on postoperative day 11, she was fully ambulatory with a mild speech dysphasia. On her most recent

Figure 4. MRI demonstrating a Labbé infarct (arrows).

follow-up visit, 1 year postoperatively, her dysphagia was completely resolved.

CLINICAL MANIFESTATIONS OF VEIN OF LABBÉ INFARCTION: REVIEW OF THE LITERATURE

While intraoperative sacrifice of individual cortical veins rarely leads to venous infarction, hemorrhage, or postoperative neural deficits, as the above case report demonstrates, in some instances a dominant vein of Labbé or Trolard may be responsible for draining most of the lateral hemisphere. Inadvertent sacrifice of one of these bridging anastomotic veins can thus lead to serious neurologic sequelae from venous infarction.

There are several previous case reports in the literature highlighting the potential danger of vein of Labbé infarction. Sasaki et al reported a patient who developed aphasia and disorientation immediately after a middle fossa craniectomy for squamous cell carcinoma of the temporal bone. Postoperative angiography demonstrated hemoclips adjacent to the vein of Labbé, with a presumed vein of Labbé infarction. The patient's condition progressed, leading to a hemiparesis, loss of consciousness, and ultimately, death.⁵ Dorndorf reported a case of aseptic thrombosis of the vein of Labbé in a young woman.⁶ The patient presented with headaches, nausea, vomiting, a central facial paresis, unilateral arm weakness and sensory loss, and pyramidal signs. Her symptoms eventually resolved with anticoagulation. Yokota et al described a case of a 56-year-old Japanese male with a pure agraphia of kanji (the Japanese morphograms) due to a hemorrhagic infarction of the left temporal lobe caused by the thrombosis of the vein of Labbé.⁷ Cambria reported a case of spontaneous vein of Labbé thrombosis marked by contralateral hemiparesis and motor aphasia.⁸ Kawase reported a case of vein of Labbé infarction heralded by nausea, vomiting, photophobia, and aphasia.⁹

AVOIDING INJURY TO THE VEIN OF LABBÉ: REVIEW OF THE LITERATURE

It is widely known that vein of Labbé injury is a potential danger in many neurosurgical procedures as a result of the need for prolonged temporal lobe retraction. However, during combined middle fossa/posterior fossa craniotomies, tentoriotomy also places the vein of Labbé in jeopardy, particularly if Labbé is directly adherent to the tentorium or travels through it as a tentorial sinus. As a result, a variety of methods have been described over the years to avoid injury to the vein of Labbé during this critical portion of the petrosal approach. Most skull base centers now routinely employ a

tentoriotomy during the petrosal approach, enabling greater exposure of the petroclival region. There is wide variability, however, in the method of tentorial division and whether the sigmoid and other major venous channels are preserved or transected.

In some instances, the surgeon approaches the petroclival region by working both above and below the tentorium through two operative fields. For example, Al-Mefty et al¹⁰ described opening the dura of the temporal and posterior fossa along either side of the sigmoid sinus. The supratentorial incision was then continued along the floor of the temporal fossa while extending the infratentorial incision to the jugular bulb. After gently retracting the posterior temporal lobe, they dissected the vein of Labbé from the cortical surface, enabling temporal lobe retraction without tension on the venous wall. The authors did note, however, that when more lateral and shorter access to the petrous apex was needed, the posterior fossa dural incision could be extended onto the tentorium parallel to the pyramid through the incisura. Out of 13 patients reported, only 1 developed a hemiparesis postoperatively, none had aphasia, and there were no deaths in the authors' series.

Malis¹¹ described a similar transtentorial approach, except his method involved transecting the sigmoid sinus. Malis also stressed the importance of preserving the vein of Labbé by ligating the transverse sinus between the entrance of Labbé posteriorly and the sigmoid sinus and petrosal sinus anteriorly. After dividing the sinus, the tentorium could then be divided along the petrous apex. This allowed upward retraction of the tentorium, transverse sinus, temporal lobe, and vein of Labbé with resulting exposure of the clivus to the foramen magnum.

Ammirati and Samii^{12,13} described a petrosal approach to the petroclival region which preserved the major venous structures in the field. After a posterior temporal craniotomy and a lateral suboccipital craniectomy, the supratentorial dura is opened horizontally above the transverse sinus and the infratentorial dura is opened vertically in front of the sigmoid sinus. The distal superior petrosal sinus is ligated and the tentorium is cut in a posteroanterior direction a few mm medial to the superior petrosal sinus as well as in a lateromedial direction to develop a medially based triangular tentorial flap. The temporal lobe and tentorial flap with preserved vein of Labbé are then retracted superiorly while cerebellum and sigmoid are retracted medially. In the five reported cases using this method, there was no mortality or neurologic sequelae attributed to venous infarction.

Kinney et al¹⁴ described a petrosal approach to lesions of the anterior cerebellopontine angle, also preserving the sigmoid sinus. By advocating a relaxation incision of the middle fossa dura and tentorium (with careful preservation of the vein of Labbé) in addition to wide decompression of the sigmoid, an additional 1 to

Figure 5. View of the dural incisions used in combined posterior and middle fossa craniotomy (retrolabyrinthine-subtemporal) which have been modified to reduce the risk of injury to the vein of Labbé (L). Note that the division of the superior petrosal sinus (SPS) is carried out considerably medial to its entry into the junction of the transverse sinus (TS) and sigmoid sinus (SS).

1.5 cm posterior retraction could be obtained without additional cerebellar retraction. The authors noted, however, that despite preservation of the vein of Labbé, they still encountered temporal lobe edema with transient aphasia after indiscriminate sacrifice of other temporal lobe veins. The authors thus advocated gentle temporal lobe retraction and preservation of venous

structures whenever possible. None of the 18 patients in their report, however, were noted to have long-term neurological deficits from the procedure related to the venous reservoir of the vein of Labbé.

Canalis et al¹⁵ also advocated preservation of the sigmoid during the petrosal approach. In their modification, the superior petrosal sinus is transected and

Figure 6. Initially, the dura of both the posterior and middle fossae are opened separately. Gentle retraction of the temporal lobe (TL) brings the vein of Labbé (L) into view. It may follow a surgically favorable course well superior to the tentorium (1). When it courses either along the upper surface the tentorium or within its leaves (2) it is in peril during tentoriotomy. Reconnaissance of the course of Labbé from above prior to tentoriotomy assists with planing a safer line of tentorial division. SS = sigmoid sinus; TS = transverse sinus; C = cerebellum.

Figure 7. Following division of the superior petrosal sinus in proximity to the labyrinth, the tentorium (T) is divided. It is important that the tentoriotomy be directed medially in order to reach the incisural notch. It is tempting to divide the tentorium along a line parallel to the petrous bone, but this is an error as it directs the incision towards the roof of Meckel's cave and the cavernous sinus rather than the free edge of the tentorium.

the tentorium divided along its insertion in the superior petrosal ridge. The tentorial incision is then extended medially to the tentorial notch, allowing exposure of the transverse sinus and early identification and preservation of the vein of Labbé. In one of the nine cases discussed, however, despite preservation of the vein of Labbé, there was an associated devascularization of the brainstem during tumor removal resulting in a prolonged coma and severe neurological deficits.

Spetzler et al¹⁶ described a petrosal approach where the sigmoid may be either preserved or transected. The dural incision begins over the temporal lobe at the anterior limit of the middle fossa craniotomy, extending it posteriorly to the superior petrosal sinus at least 1 cm below where it enters the sigmoid sinus. When preserving the sigmoid, the authors carry the incision across the superior petrosal sinus, joining with a dural incision in front of the sigmoid sinus. A second incision behind the sinus allows the surgeon to work both in front and in back of the sinus (as described above by Ammirati and Samii¹³). The authors cautioned that if the temporal lobe required elevation due to superior tumor extension, the vein of Labbé was at risk due to its tethering to the skull base by the preserved sigmoid sinus. The authors noted, however, that the sigmoid could be sacrificed in the presence of radiographic verification of predominance of the contralateral sigmoid drainage system, assuring drainage of the ipsilateral vein of Labbé to the dominant, contralateral side. The authors also stressed that the vein of Labbé could be protected maximally by cutting the superior petrosal sinus and the sig-

moid sinus, then elevating the cut tentorium along with the base of the temporal lobe. Out of the 30 patients who underwent this type of procedure in their report, two were complicated postoperatively by a hemiparesis and one had an aphasia.

Herzog et al¹⁷ advocated ligation of the sigmoid sinus for greater exposure in their modification of the petrosal approach. The authors temporarily clamped the sigmoid sinus distal to the vein of Labbé while continuous electroencephalography (EEG) and simultaneous angiography was performed. By demonstrating adequate collateral flow without EEG changes, the authors concluded it was safe to proceed with sacrifice of the sigmoid sinus. After the dural incision is extended trans-sigmoid, retrolabyrinthine, and up to the middle fossa dura, the tentorium is then incised to a point immediately lateral to the incisura to allow adequate temporal lobe retraction. Neither of the two patients who underwent the approach had any neurological sequelae relating to ligation of the sigmoid sinus.

The dinger et al¹⁸ described a transcochlear petrosal approach and actual excision of a large portion of tentorium to improve exposure and excision of the middle fossa component of the tumor. The authors advocated transection of the superior petrosal sinus with the middle fossa dura excised superior and parallel to the sinus. Posteriorly, the tentorium is divided to the incisura, preserving the trochlear nerve. Utilizing this method, only 1 of the 14 reported patients developed a postoperative hemiparesis, and none were noted to have an aphasia.

Figure 8. A more anteriorly placed line of tentorial division (*solid line*) better avoids the vein of Labbé than the earlier described more posterior technique (*dotted lines*).

MODIFICATION OF TENTORIOTOMY TECHNIQUE INTENDED TO REDUCE RISK TO THE VEIN OF LABBÉ

In many of the reports reviewed above describing the modifications of the petrosal approach, preservation of the vein of Labbé is appropriately stressed. Yet none of the reports specifically address the variability of Labbé's anatomy nor offer specific points on the tentoriotomy which take into account this variability and Labbé's intimate relationship with the tentorium. At UCSF, a method for preserving the vein of Labbé during combined craniotomies of the middle and posterior cranial fossa has been developed (Figs. 5–8). This was in part spurred by the finding of a tentorial sinus during tentoriotomy as described in the case report above, with a resulting temporoparietal infarct.

This modified petrosal approach begins with the standard retrolabyrinthine/posterior fossa and middle fossa bone removal.¹⁹ The posterior fossa dural incision is then begun, extending to the inferior edge of superior petrosal sinus (Fig. 5). The middle fossa dural incision

is then initiated, carried from above the transverse-sigmoid junction. The temporal lobe is then gently elevated from the inferior surface, as anteriorly as possible, to avoid the vein of Labbé as it courses back along the inferior surface of the temporal lobe. After elevation of the temporal lobe, the surgeon is able to gaze downward from above, identifying the course of Labbé and any other bridging veins between the inferior temporal lobe surface and the tentorium (Fig. 6).

These observations during temporal lobe elevation provide critical guidance in designing the safest possible incision which transects the superior petrosal sinus prior to the tentoriotomy. Because Labbé may course in close proximity with the upper service of the tentorium, or even course within its leaves, it is wise to initiate tentorial division at a point considerably medial to the junction of the superior petrosal sinus and the transverse sigmoid sinus junction (Fig. 7). The location of greatest vulnerability of Labbé is the section of tentorium which lies posterior and lateral. To avoid this region, the superior petrosal sinus is divided in proximity to the labyrinth with tentoriotomy commenced from this more medial location and carried deep and anterior to reach the incisural free margin (of the dural lamella). When the undivided tentorial remnant impedes confluence of the middle and posterior fossa openings, it can be reflected superiorly along with its attached veins utilizing a malleable retractor, attached to a Laighla arm.

The principle advantage of this modified petrosal approach includes direct visualization of the bridging and anastomotic veins during temporal lobe elevation in order to plan the tentoriotomy in a more precise fashion. Further, by beginning the tentoriotomy medial and deep in relation to the labyrinth, the surgeon can safely avoid injury to the vein of Labbé, either as it rides under the temporal lobe freely or within the leaves of the tentorium as a tentorial sinus. Additional intraoperative maneuvers such as broad gentle retraction with periodic releases, as anteriorly as possible on the temporal lobe, can assist in preserving the vein of Labbé, avoiding the potential for serious postoperative neurological sequelae.

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