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Angiographic Assessment of the Transverse Sinus and Vein of Labbé to Avoid Complications in Skull Base Surgery

Abstract—Advances in the field of skull base surgery have dramatically reduced the mortality and morbidity of operations on the skull base. Nevertheless, cerebral ischemic events from compromised blood supply to areas of the brain still occur. Although arterial compromise is responsible for a majority of these events, the venous side of the circulation can also play a role in producing cerebral infarctions. A key area of cerebral venous drainage is at the junction of the transverse sinus, sigmoid sinus, and vein of Labbé. Absence of the transverse sinus with the outflow of the vein of Labbé limited to the sigmoid sinus puts these patients at an increased risk for venous infarcts when this area is manipulated during skull base surgery. We have studied 100 consecutive carotid angiograms performed on 50 individuals for carotid artery disease or to rule out aneurysms. We have found that 16.7% of individuals have one atretic transverse sinus. We discuss our results and the implications that they have in skull base surgery. It is our hope that a better understanding of the cerebral venous drainage patterns will help skull base surgeons avoid complications in the future. (*Skull Base Surgery, 3(4):217–222, 1993*)

The extirpation of skull base tumors often requires involved, lengthy, multiteam operations. Advancement in surgical and radiographic techniques has allowed these operations to be performed more frequently and with less morbidity and mortality. Nevertheless, complication rates for skull base operations remain high. Perhaps the most feared complication of skull base surgery is compromised blood supply to areas of the brain and resultant cerebral ischemic events. A significant volume of work has focused on the management of the carotid artery and the arterial side of the cerebral circulation, whereas much less work has been devoted to understanding the often more complex and variable venous drainage of the brain.

We present a case of dominant temporal lobe venous infarct after a total temporal bone resection. We then study the major venous drainage patterns of the brain using the venous phase of angiography in an attempt to describe more accurately specific situations in which manipulation or ligation of veins or sinuses may produce cerebral compromise or stroke.

CASE REPORT

A 64-year-old man with a history of chronic otitis media was found to have squamous cell carcinoma of the left temporal bone (Fig. 1). There was involvement of the middle ear, mastoid, and middle fossa dura but no par-

Skull Base Surgery, Volume 3, Number 4, October 1993 The Department of Otorhinolaryngology: Head and Neck Surgery and the Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, and Midwest Otologic Group, St. Johns Mercy Medical Center, St. Louis, Missouri Presented in part at the 1993 North American Skull Base Meeting, February 12–14, 1993, Scottsdale, Arizona Reprint requests: Dr. Bigelow, Department of Otorhinolaryngology: Head and Neck Surgery, 5 Silverstein, Hospital of the University of Pennsylvania, 3400 Spruce St., Philadelphia, PA 19104

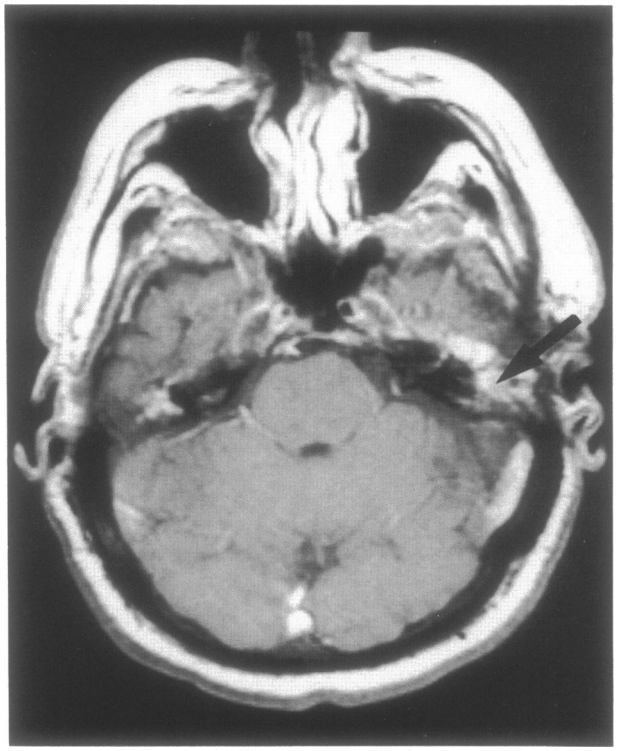

Figure 1. Preoperative magnetic resonance image demonstrating squamous cell carcinoma of the temporal bone.

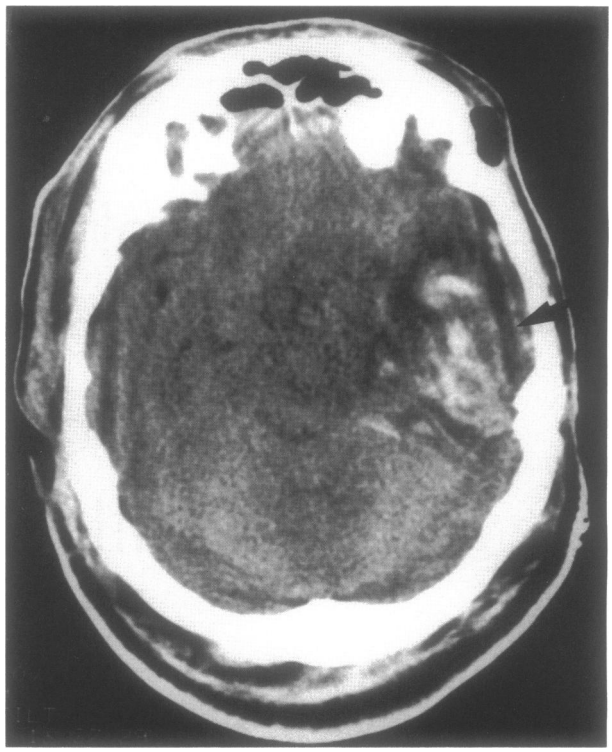

Figure 2. Postoperative computerized tomography scan demonstrating a temporal lobe venous infarct.

enchymal involvement of the brain. The patient underwent preoperative angiographic assessment to evaluate the feasibility of carotid resection. He had a carotid balloon occlusion study showing good cerebral cross-flow and no adverse effects after 30 minutes of occlusion. Two days later, the patient underwent a left radical temporal bone resection with ligation of the petrous carotid artery and the sigmoid sinus just distal to its junction with the transverse sinus.

Postoperatively the patient remained obtunded and evaluation by computed tomography scan (Fig. 2) revealed a diffuse hemorrhagic venous infarct in the left temporal lobe. Long-term, the patient's recovery was slow and incomplete with an altered mental status and severe expressive aphasia. Review of the angiographic study subsequently revealed an absent left transverse sinus and an excessively anteriorly placed vein of Labbé (Fig. 3), which had not been appreciated preoperatively.

MATERIAL AND METHODS

The vascular anatomy was assessed on the venous phase of 100 consecutive carotid arteriograms performed on 50 patients receiving clinical studies for evaluation of carotid artery atherosclerotic disease or to exclude aneurysms. Internal carotid artery injections were performed in the aneurysm cases and common carotid artery injections were performed for the carotid evaluations. The arteriograms were reviewed by two neuroradiologists and a consensus was reached as to the presence of a patent vein of Labbé, transverse sinus, sigmoid sinus, and jugular vein on each side. All studies were performed on a Toshiba 1024 × 1024 matrix digital biplane angiographic system

Figure 3. Preoperative angiographic study. Small arrow indicates the vein of Labbé and large arrow indicates the sigmoid sinus.

(Toshiba American Medical Systems, Tustin, CA 92680). The standard injection rates were 6 ml/sec for a total of 8 ml for the internal carotid injections and 7 ml/sec for a total of 11 ml for the common carotid injections.

RESULTS

The venous phase of 100 consecutive carotid angiograms on 50 patients undergoing angiography for carotid artery atherosclerotic disease or evaluation of aneurysms were analyzed. One or both sides of eight patients were not adequate studies to evaluate the entire venous phase and these patients were dropped from the study. On the remaining 42 patients, both sides could be adequately reviewed for a total of 84 angiograms. Particular attention was focused on the area of the transverse sinus, vein of Labbé, and sigmoid sinus. The only significant anomalies observed in this area related to unilateral atresia of the transverse sinus with outflow of the vein of Labbé limited to the sigmoid sinus on the affected side (Table 1). Seven of 42 patients (16.7%) had an absence or atresia of one of the transverse sinuses. The anomaly was significantly more common on the left side than on the right side. The anomaly was only present in one of the 42 right-sided studies (2.4%), but was present in 6 of the 42 left sided studies (14.3%).

In individuals with an absent or atretic transverse sinus the vein of Labbé was found to drain predominantly into the sigmoid sinus (Fig. 4). No other anomalies were noted in these patients or in the other angiograms that were reviewed.

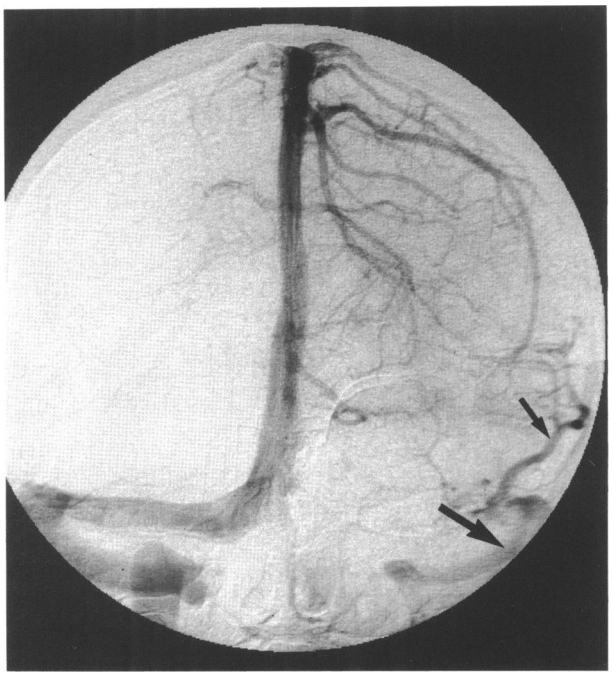

Figure 4. Angiogram demonstrating absence of the transverse sinus. Small arrow indicates the vein of Labbé and large arrow indicates the sigmoid sinus.

DISCUSSION

The incidence of cerebral vascular events during skull base surgery, has been reported to occur in between 5 and 18% of cases.[1–3] The majority of events occur as a result of disruption of arterial flow or cerebral edema. The literature is replete with information discussing the management of the carotid artery and the arterial circulation; however, there is far less literature discussing the venous side of the circulation.

The anatomy of the cerebral venous system, although complex, must be understood by the skull base team, since many skull base procedures involve working with or ligating part of this system. The superior sagittal sinus extends from the foramen cecum to the internal occipital protuberance. It runs posteriorly, grooving the inner surface of the frontal lobe. It receives drainage from the superficial cerebral veins and drains the cortex and subcortical medullary substance of the brain.[4] The straight sinus formed by the union of the inferior sagittal sinus and the vein of Galen courses posteriorly and inferiorly in the junction of the falx cerebri and tentorium cerebelli. At the confluence of sinuses, the superior sagittal sinus usually turns to drain into the right transverse sinus and the straight sinus continues as the left transverse sinus. The small, usually unpaired, occipital sinus, which most often runs in the junction of the falx cerebelli and the dura of the posterior fossa, also drains into this area.[4] The transverse sinuses pass laterally and anteriorly through the petrous part of the temporal bone where they continue as the sigmoid sinuses, which turn downward and medially to form the jugular bulbs (Fig. 5).[4] Several other veins and sinuses should be mentioned. The superior petrosal sinuses drain the cavernous sinus into the sigmoid sinus and the inferior petrosal sinus drains the cavernous sinus into the internal jugular bulb. The mastoid emissary vein unites the sigmoid sinus with the posterior auricular or occipital vein. The superficial middle cerebral vein drains the lateral surface of each hemisphere and terminates in the cavernous sinus. The posterior anastomic vein, or vein of Labbé connects the superficial middle cerebral vein with the superior sagittal and transverse sinuses (Fig. 6).[4] This is an important route of venous drainage from the temporal lobe. Finally, one must remember that the nature of cerebral venous outflow is highly variable and influ-

Table 1. Frequency of Transverse Sinus Atresia

	Number Studied	*Atretic Transverse Sinus*	*Percentage*
Patients	42	7	16.7
Right side	42	1	2.4
Left side	42	6	14.3

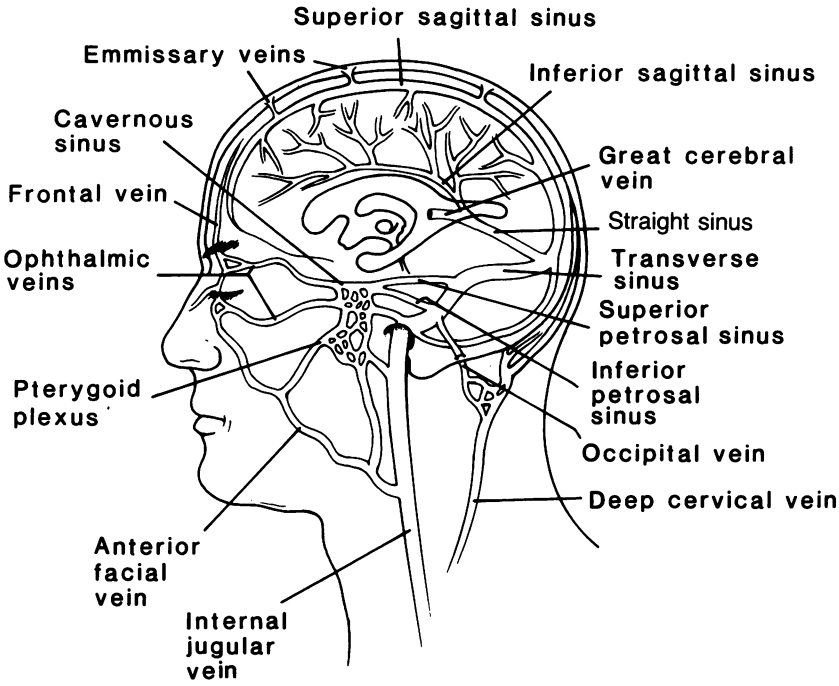

Figure 5.

enced by the presence of collateral flow. The importance of any one vein for supplying primary drainage of a portion of the brain must be establish for each patient independent of the "typical" patterns.

In approaching a skull base procedure the surgical team must be aware of which venous structures can be manipulated without producing venous drainage problems of cerebral edema or infarct. To the skull base team, the area of the transverse sinus, sigmoid sinus, and vein of Labbé is particularly important.

Many authors have stated that the sigmoid sinus can be safely ligated,[6–10] but complications from this area are known to exist.[7,9] Al-Mefty has been an active proponent of modifying the surgical approach selected to preserve the sigmoid sinus,[11] or reconstructing the sinus with a venous graft.[12]

Our study indicates that Al-Mefty's caution may well be advised because we found a 16.7% incidence of an absent, atretic, or hypoplastic transverse sinus based on carotid angiographic studies, with 14.3% of the patients

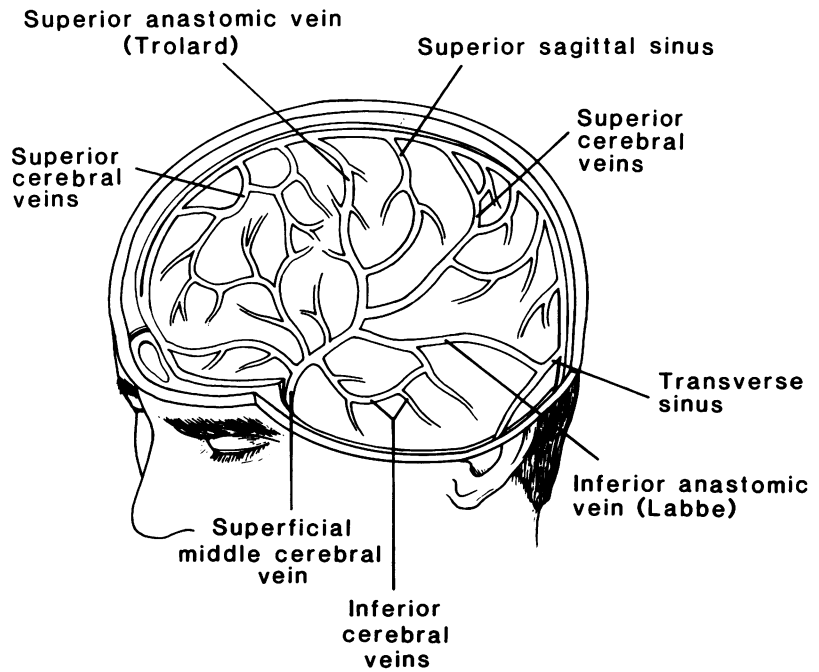

Figure 6.

having this anomaly of the left transverse sinus and a 2.3% incidence in the right transverse sinus. We do not have a reason for the significant difference between the two sides. Our figures, however, agree very closely with those of Hacker,[13] who showed a 14% incidence of an absent left transverse sinus and a 3.3% incidence of an absent right transverse sinus. Our data do not agree with that of Kaplan et al,[14] who found a 6% incidence of a narrowed or atretic transverse venous sinus in their study of 422 autopsy specimens with approximately equal distribution of right- and left-sided lesions. There are several reasons why our data differ from that of Kaplan et al. Our study is based on carotid angiographic studies. It is possible that these studies "missed" transverse sinuses that were present but could only be visualized with vertebral injections or with intraoperative techniques. In addition, in 57% of the autopsies, Kaplan et al only analyzed the anatomy up to the confluence of sinuses. If the transverse sinus was narrowed or atretic distal to this point, they would not have discovered the anomaly. If we rework their data, examining only the patients in whom they followed the transverse sinus all the way out, we find that 24 of 182 patients had atresia or narrowing of at least one transverse sinus. This 13.2% figure is in close agreement with our study. In addition, one must remember that Kaplan et al's study is an anatomic rather than a functional study. The presence of a transverse sinus at autopsy does not prove that there was adequate flow through the sinus.

The consequences of this anomaly can be significant to the patient undergoing skull base surgery. In cases in which there is an ipsilateral (operative side) atretic transverse sinus the only drainage for the vein of Labbé is through the sigmoid sinus, since outflow through the transverse sinus is nonexistent. Sacrificing or manipulating the sigmoid sinus on this side risks leaving the vein of Labbé with nowhere to drain and producing a venous infarct in the distribution of the vein of Labbé, as in our index case. In the case of a contralateral (nonoperative side) atretic transverse sinus a majority of the venous drainage of the brain may be channeled through the transverse sinus and then through the sigmoid sinus on the operative side, since there may be little outflow on the contralateral side because an atretic transverse sinus. Sacrificing or manipulating the sigmoid in these individuals risks leaving a large portion of the brain with the potential for compromised venous outflow and could produce a venous infarct. Although collateral circulation may exist, it is risky to rely on it, since its role is difficult to predict.

Since many skull base cases include an angiographic assessment for carotid occlusion tests, it is very straightforward to study the venous phase of the angiogram and analyze the venous drainage pattern, with particular attention given to the transverse sinuses and the vein of Labbé. Our study predicts that 16.7% of individuals will have an atretic or absent transverse sinus based on these studies. It is probably true that some of these individuals have functioning transverse sinuses on both sides that simply could not be visualized on the carotid injections. The carotid angiograms will then allow the neuroradiologist and skull base surgeon to identify an "at risk" group of patients who require other techniques to establish the presence of functioning transverse sinuses or the nature of collateral cerebral venous outflow. If, after further study, an anomaly is present, one should consider altering the surgical approach to preserve the sigmoid sinus or attempt to establish the significance of the collateral flow intraoperatively.

Certainly, as skull base surgery advances, we must continue to study both the arterial and venous circulation patterns. The nature of the collateral circulation is an important piece of information for the skull base team. We have already begun to study the use of magnetic resonance imaging angiography as a way to examine venous circulation patterns and to study collateral flow.

CONCLUSION

Based on carotid angiographic studies, 16.7% of individuals have an atretic or absent transverse sinus. This anomaly is more common on the left side than on the right side. In these individuals the vein of Labbé can drain predominantly through the proximal sigmoid sinus. Sacrificing the sigmoid sinus may leave portions of the temporal lobe, with venous outflow supplied by the vein of Labbé with nowhere to drain and risk a venous infarct. By studying the venous phase of the carotid angiographic studies preoperatively, the skull base surgeon can identify patients in which other studies or an altered surgical approach are required. In this way the mortality and morbidity of skull base procedures may be reduced.

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