T. Kanno, A. Kasama, and H. Suzuki

Safety of Ablation of the Sigmoid and Transverse Sinuses: An Experimental Study

Abstract—If the sigmoid and transverse sinuses could be divided safely, surgeons could broaden their access during skull base surgery without retracting the brain extensively. We undertook this study in monkeys to assess the risk of sacrificing these sinuses. We learned that when bilateral transverse sinuses were occluded, the sinus pressure measured in the superior sagittal sinus increased significantly as blood was purged from sinus venules. Unilateral sacrifice of sigmoid and transverse sinuses, however, did not change proximal sinus pressure in any ipsilateral or contralateral sinus. Furthermore, no change in regional cerebral blood flow or motor evoked potentials was seen in the parietal lobe nor did auditory brainstem response change significantly with sinus ablation. We conclude that, unilaterally, sigmoid and transverse sinuses may be ablated safely because collateral circulation via the vein of Labbé, superior petrosal sinus, petrosal vein, and backflow from the transverse sinus to the contralateral sinus may be established. (*Skull Base Surgery, 3(3):146–151, 1993*)

Various techniques and approaches have been developed to minimize invasion in skull base surgery. If the sigmoid and transverse sinuses could be divided safely, surgeons could have better surgical access without much retraction of the brain. However, it is currently believed that these sinuses contain important routes of venous drainage from the brain and that, if they are sacrificed, severe brain swelling would follow.

Recently, surgical techniques were reported by which the sigmoid and transverse sinuses could be divided.[1–3] The authors found it safe to divide the sigmoid sinus and proposed that the divided transverse sinus be closed on completion of the operation. Generally, however, it is still considered risky to ablate these sinuses to provide access to skull base and brain.

We performed the present study to establish the safety of sacrificing these sinuses experimentally in monkeys, since it is well known that the venous drainage of the monkey's brain is quite similar to that in humans. The purpose of the present study was to measure the effect of sacrificing the sigmoid and transverse sinuses on sinus pressure, regional cerebral blood flow (rCBF), and cortical motor evoked potentials(MEP).

MATERIALS AND METHODS

Japanese monkeys (*Macaca fascata*) weighing 5 to 6 kg were used for the experiments described. After induction with ketamine and atropine at doses of 5 and 0.2 mg/kg, respectively, general anesthesia was established with thiamylal (10 mg/kg) given intravenously, and an endotracheal tube was inserted. Serial blood gas measurements were taken throughout the surgery and partial arterial carbon dioxide pressure was kept within the normal physiologic range (35 to 40 mmHg) by giving room air or oxygen (2 ml/min). Blood pressure (femoral artery, A line) was also maintained around the level of 90 to 105 mmHg. While in the prone position, suboccipital craniectomy was performed after a linear skin incision was made. The craniectomy extended across the transverse and sigmoid sinuses. A parietal craniectomy was also performed and a part of the dura was opened to measure MEP and rCBF at the prefrontal motor cortex. This craniectomy also allowed inspection of the brain surface for venous congestion. In two monkeys in which bilateral transverse sinuses are occluded and the pressure was measured in the

Skull Base Surgery, Volume 3, Number 3, July 1993 Department of Neurosurgery, School of Medicine, Fujita Health University, Aichi, Japan
Reprint requests: Dr. Kanno, 1-98, Dengakugakubo, Kutsukake-cho, Toyoake, Aichi, Japan

superior sagittal sinus, wide bilateral parietal craniectomy was performed to observe the congestion of the bridging veins to the superior sagittal sinus.

The rCBF and MEP were continuously evaluated throughout the experiment. A DISA/1500 electromyographic system (Manson Co.) was used to record MEP. Evoked potentials by an electric stimulation on the right motor area was measured at the C2 epidural space.

The rCBF was measured with an ALF 2100 (Advance Co.) and sinus pressure was measured before and after occlusion of the sinus by using uniflow (Baxter). The subjects were divided into five groups as follows:

Group 1 (n = 2): The bilateral transverse sinuses were occluded (using the Yasargil temporary clip) and the pressure was measured in the superior sagittal sinus.

Group 2 (n = 3): The sigmoid sinus was occluded and pressure was measured proximal to the occlusion in the ipsilateral sigmoid sinus.

Group 3 (n = 3): The sigmoid sinus was occluded and pressure was measured in the contralateral transverse sinus.

Group 4 (n = 3): The transverse sinus was occluded and pressure was measured proximal to the occlusion in the ipsilateral transverse sinus.

Group 5 (n = 3): The transverse sinus was occluded and pressure was measured in the contralateral transverse sinus.

In each group, sinus pressure, rCBF, and MEP were examined before and after the occluding the sinus.

RESULTS

Occlusion of the Bilateral Transverse Sinus (Group 1)

The pressure in the superior sagittal sinus increased significantly, 15 mmHg and 46 mmHg, in each monkey within 2 to 3 minutes after they were occluded. At the same time, much congestion in the small veins was observed bilaterally at the prefrontal motor areas. However, the auditory brainstem response (ABR), rCBF in the motor area, and MEP did not change significantly in the following 15 minutes (Fig. 1).

Occlusion of the Sigmoid Sinus (Groups 2 and 3)

Sinus pressure proximal to the occlusion point in the sigmoid sinus varied (Fig. 2). Two of three monkeys experienced no change in pressure with occlusion of the sigmoid sinus. In one monkey, however, the pressure decreased suddenly after the occlusion. In this case, a postoperative pathologic study showed no abnormality, such as sinus thrombosis or hypoplasia of the transverse sinus (Fig. 3). In no subject did ABR, MEP, or rCBF in the motor areas change.

The pressure in the contralateral transverse sinus did

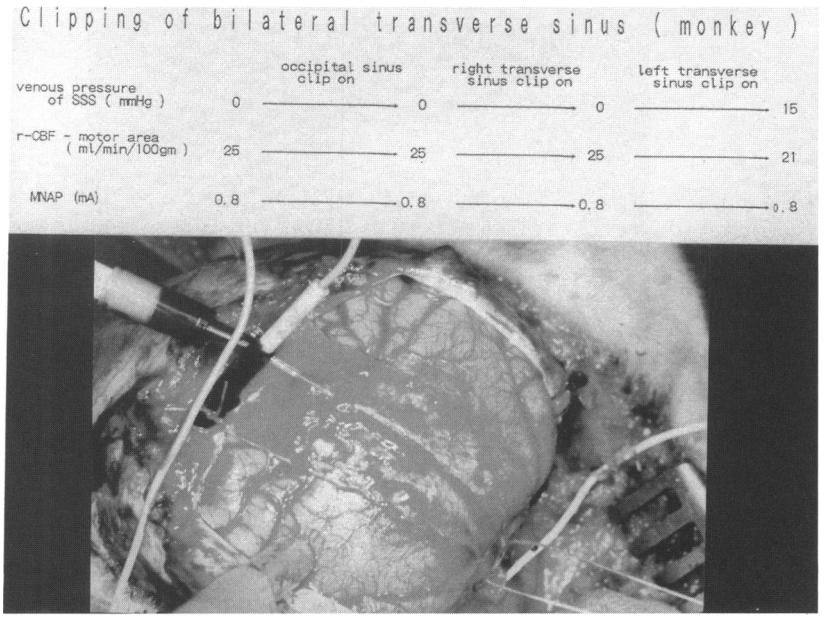

Figure 1. Superior sagittal sinus pressure increases significantly when the transverse sinuses are occluded bilaterally. Although rCBF and MEP do not change, marked venous congestion is observed in both hemispheres.

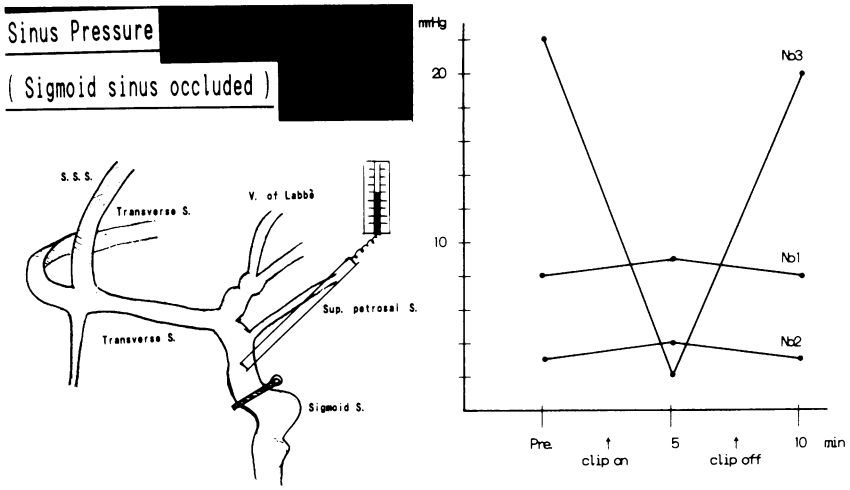

Figure 2. Sigmoid sinus pressure proximal to the occlusion site decreases remarkably in one case. However, no other parameters such as ABR, rCBF, or MEP were abnormal.

not change when the sigmoid sinus was occluded (Fig. 4). Again, ABR, rCBF in the motor area, MEP, and pathologic study revealed no abnormal changes.

Occlusion of the Transverse Sinus (Groups 4 and 5)

Sinus pressure proximal to the occluded transverse sinus did not change significantly with occlusion (Fig. 5). Furthermore, no significant change was seen in ABR, rCBF, or MEP, and no pathologic abnormality was seen. When the ipsilateral transverse sinus was occluded, the pressure in the contralateral transverse sinus (Fig. 6), ABR, rCBF, MEP, and pathologic features did not change significantly.

DISCUSSION

It is thought to be very risky to ablate the sigmoid or transverse sinuses. Such ablation is thought to compromise the brain's venous drainage and result in severe brain swelling.

Recently, Spetzler et al[3] and Sekher and Goel[2] reported that is may be safe, in some cases, to divide the sigmoid or transverse sinus. If these sinuses could be sacrificed safely, neurosurgeons could improve the surgical access in skull base surgery. We sought to determine in the present study the safety of dividing these sinuses. Our results confirm our hypothesis that sacrifice of the sigmoid or transverse sinus causes no serious problem, as is evident from the lack of significant increase in sinus pressure.

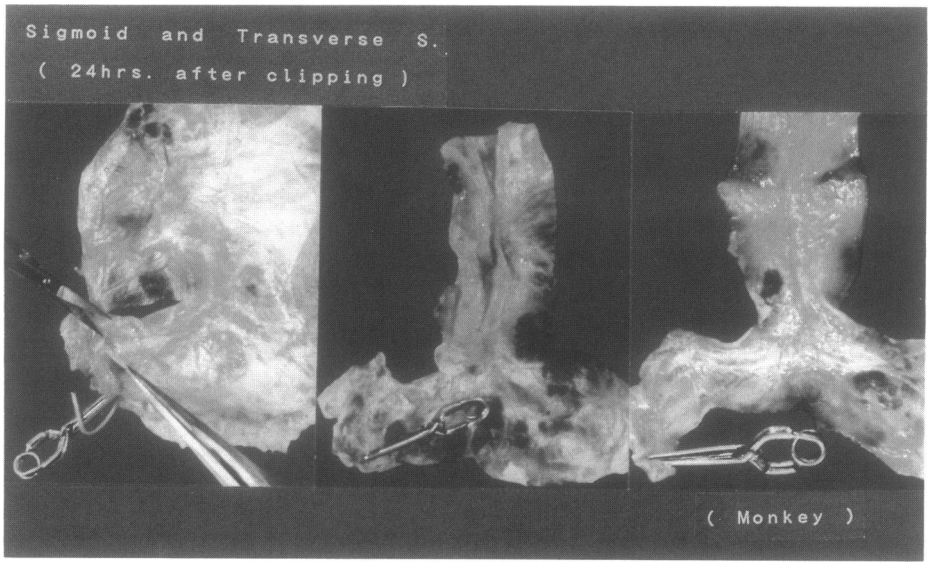

Figure 3. Pathologic study reveals no abnormality such as sinus thrombosis.

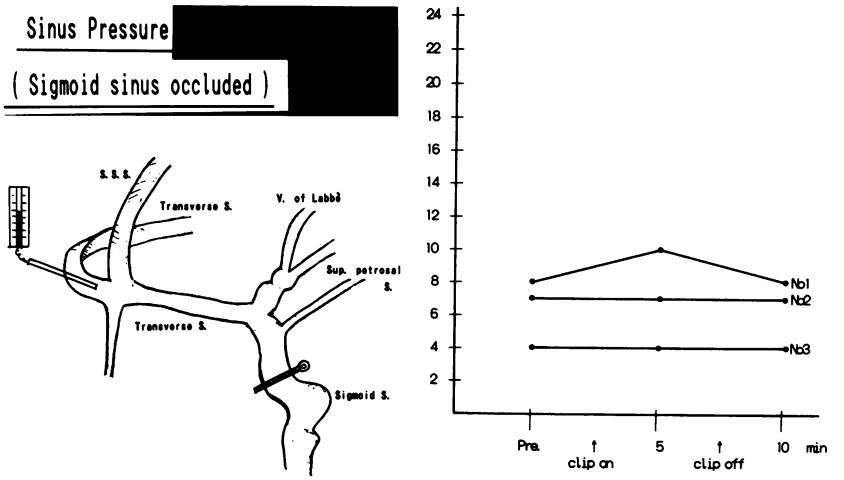

Figure 4. Sinus pressure in the contralateral transverse sinus when the sigmoid sinus is occluded does not change significantly.

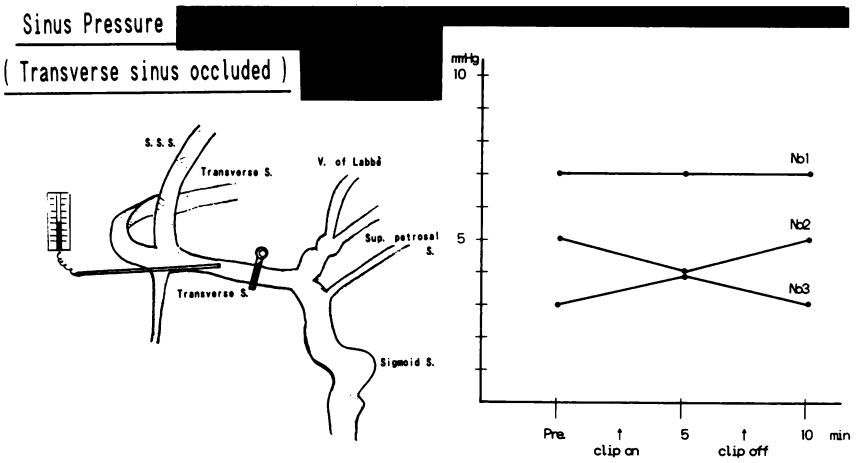

Figure 5. Sinus pressure proximal to the transverse sinus does not change significantly.

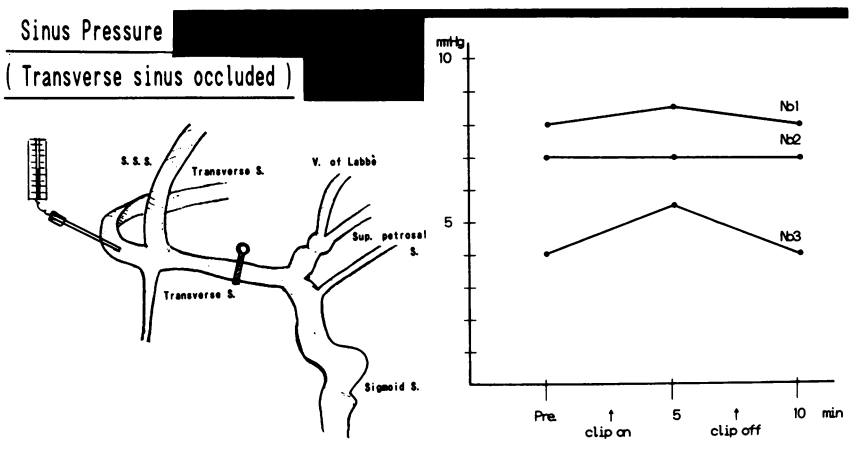

Figure 6. Contralateral transverse sinus pressure does not change significantly when the transverse sinus is occluded.

To determine why no significant change in sinus pressure, rCBF, or MEP was seen with sinus ablation, we evaluated blood flow through the sinus by angiograms. We learned that blood did not always flow in one direction. When the sigmoid sinus is occluded, blood from the vein of Labbé and the superior petrosal sinus flows from the transverse sinus to the contralateral transverse sinus (Fig. 7). This phenomenon was also reported by Spetzler et al.[3] Thus, by changing the direction of flow, any flow disturbance caused by the sinus occlusion or ablation may be compensated for. Furthermore, bypass flow may also compensate for a disturbance in blood flow. For example, when the transverse sinus is occluded, more blood drains through the vein of Labbé and the superior petrosal sinus to the sigmoid sinus (Fig. 8). Therefore it is essential that the vein of Labbé, the superior petrosal sinus, and the bilateral transverse sinuses be visible on a preoperative angiogram. If not, ablation of the sigmoid or transverse sinus may increase sinus pressure, thereby causing much venous congestion and brain swelling.

There remain, however, a few questions to be answered. First, are these findings also true in humans? Although recent reports[1–3] suggest that this is so, the experience with sinus ablation in humans remains limited. The result of our serial angiographic study revealed that there was no definite difference of venous system between man and monkey (Fig. 9).

Second, is it safe to sacrifice the so-called dominant sigmoid or transverse sinus? The answer is not yet known. The concept of the "dominant sinus" was proposed on the basis of angiographic evidence. In some cases, there is only a laminar flow, because it is not so rare that the dominant sinus on carotid angiograms appears nondominant on vertebral angiograms in the same patient. In such a case, intraoperative measurement of sinus pressure would clarify the decision to ablate the sinus.

Third, is sinus ablation safe even when the brain is retracted? Kanno and colleagues[4,5] have reported that sacrifice of any of the cerebral venous system would make it more likely that a subcortical hematoma would develop if retraction is applied over the area affected by the venous sacrifice.

Fourth, although resuturing of the sinus after brain surgery would seems to be beneficial, the significance of resuturing is unclear and should be studied further.

We conclude that it is safe to divide unilaterally the sigmoid or transverse sinus provided that the vein of Labbé, superior petrosal sinus, and bilateral transverse sinuses are readily visible on preoperative angiograms and that sinus pressure does not increase intraoperatively.

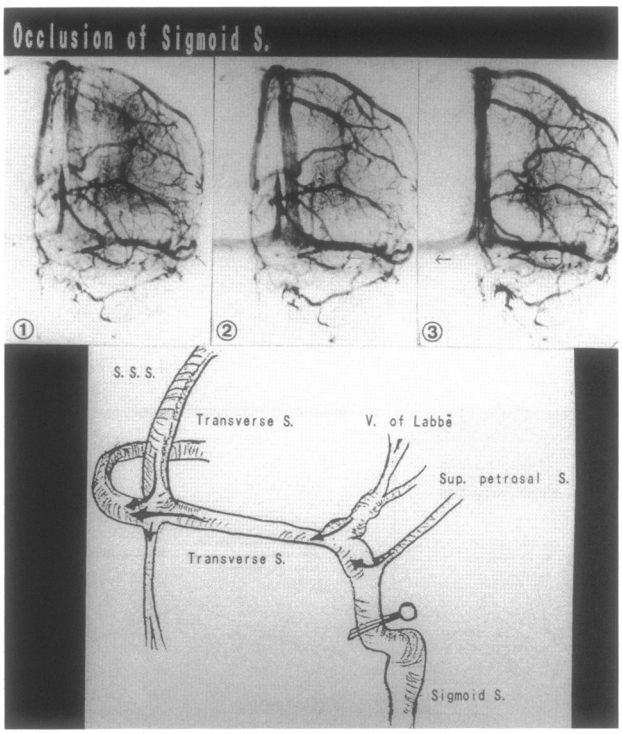

Figure 7. When the sigmoid sinus is occluded, blood flows from the vein of Labbé and the superior petrosal sinus to the ipsilateral transverse sinus and to the contralateral transverse sinus.

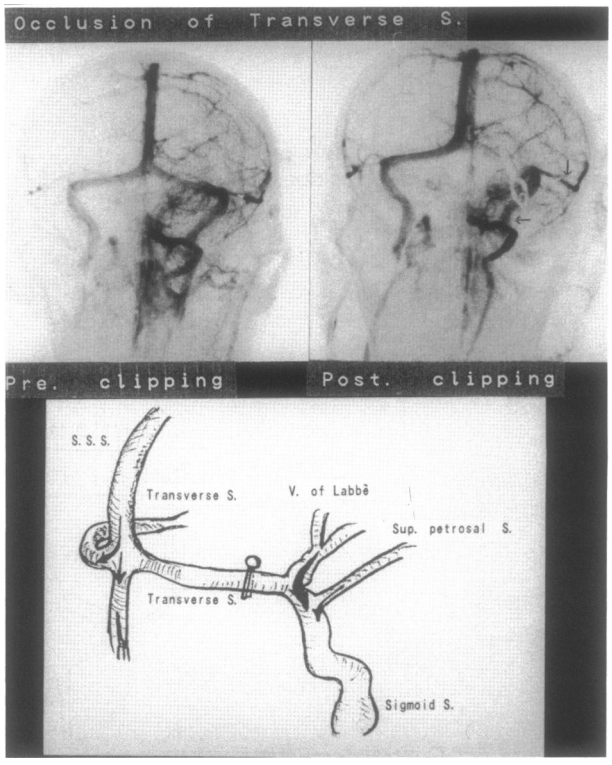

Figure 8. When the transverse sinus is occluded, blood flows from the vein of Labbé and the superior petrosal sinus to the sigmoid sinus.

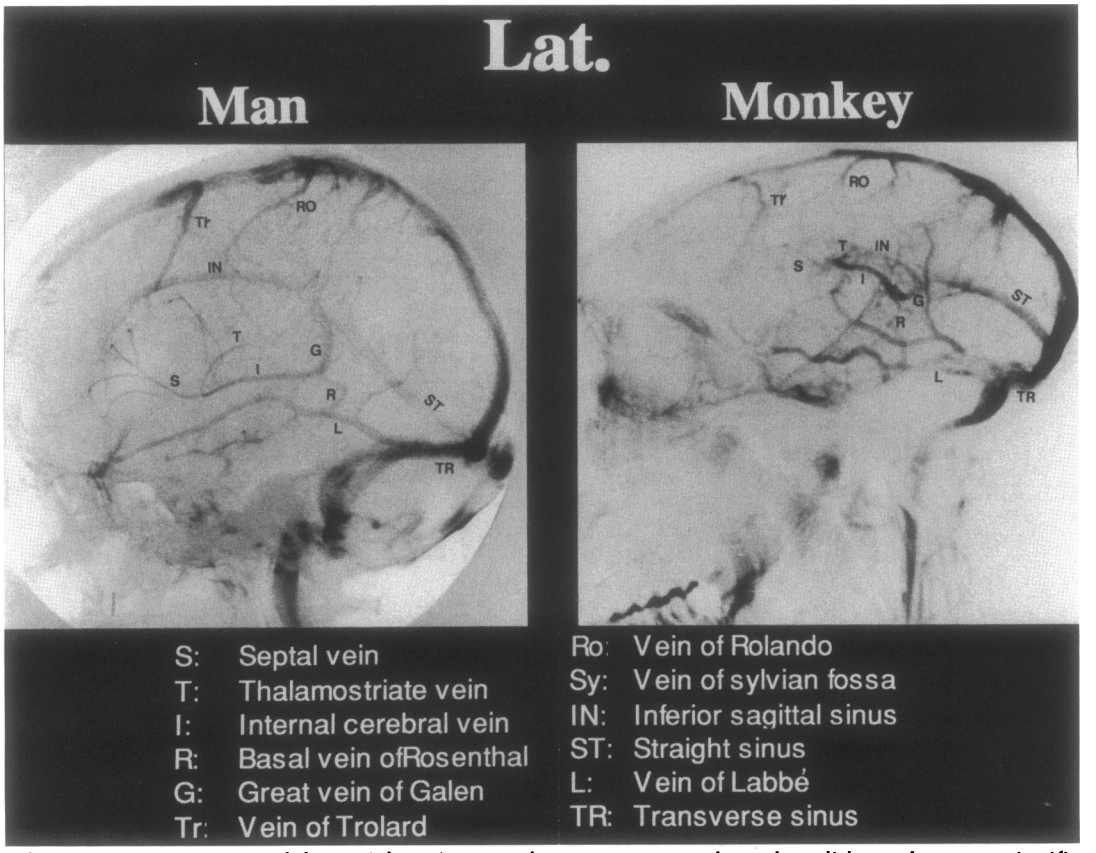

Figure 9. Comparison of the serial angiograms between man and monkey did not show any significant difference.

REFERENCES

1. Malis LT: Surgical resection of tumors of the skull base. In Wilkins RH, Rengachary SS (eds): Neurosurgery, Vol. 1. New York: McGraw-Hill, 1985, pp 1011–1021
2. Sekhar LN, Goel A: Combined supratentorial and infratentorial approach to large pineal-region meningioma. Surg Neurol 37: 197–201, 1992
3. Spetzler, RF, Daspit CP, Pappas CTE: The combined supra- and infra-tentorial approach for lesions of the petrous and clival regions: Experience with 46 cases. J Neurosurg 76:558–599, 1992
4. Kanno T, Kasama A, Shoda M, et al: A pitfall in the interhemispheric translamina terminalis approach for the removal of a craniopharyngioma. Significance of preserving draining veins. Part I. Clinical study. Surg Neurol 32:111–115, 1989
5. Kasama A, Kanno T: A pitfall in the interhemispheric translamina terminalis approach for the removal of a craniopharyngioma: Significance of preserving draining veins. Part II. Experimental study. Surg Neurol 32:116–120, 1989