Neurol Med Chir (Tokyo) 30, 738~743, 1990

Cerebellar Hemorrhage After Supratentorial Craniotomy
—Report of Three Cases—

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Abstract

We report on three cases of remote cerebellar hemorrhage after supratentorial craniotomy, which had much in common in their computed tomographic, operative, and clinical findings. We speculate that, when the patient is in the supine position, displacement of the cerebellum causes stretching of the superior vermian veins and their tributaries, resulting in tearing of these vessels. Postoperative cerebrospinal fluid overdrainage or massive air reflux into the cranial cavity through the drainage tube may accelerate this process. Meticulous management of the drainage system is necessary to prevent this postoperative complication.

Key words: cerebellar hemorrhage, supratentorial craniotomy, operative complication, superior vermian vein

Introduction

Postoperative intracerebral hemorrhages usually result from surgical procedures and most often occur in the operative field, although they sometimes develop at sites other than the initial operative field. Several such hemorrhages have been reported in the literature,[1-5,8,9,12-14] but its mechanism is poorly understood.

In this study, we report on three cases of remote cerebellar hemorrhage after supratentorial craniotomy, all of which had similar computed tomographic (CT), operative, and clinical findings. We also discuss the mechanism and preventive means of hemorrhage.

Case Reports

Case 1: A 54-year-old male was admitted to our hospital on June 30, 1987, complaining of transient weakness of his left lower extremity. Angiograms revealed a saccular aneurysm of the anterior communicating artery. He was referred to our department for surgery.

On July 17, 1987, aneurysmal neck was clipped through a right frontotemporal craniotomy, without problems in anesthetic and surgical procedures. His brain was somewhat atrophic and considerable space was left between the brain surface and the dura mater at the time of dural closure. A drainage tube was placed in the epidural space.

In the operating room, negative pressure was applied to the epidural tube, connecting it with a portable continuous suction apparatus (SB Bag®, Sumibe Medical Co., Tokyo). A large quantity of fluid mixed with cerebrospinal fluid (CSF), more than 100 ml, then drained through the tube in a short time.

On returning to the intensive care unit, he was half responsive. Thereafter, the draining fluid turned bloody and increased in volume. Meanwhile, he became comatose, with abnormal ocular movements

Received November 30, 1989; Accepted May 14, 1990
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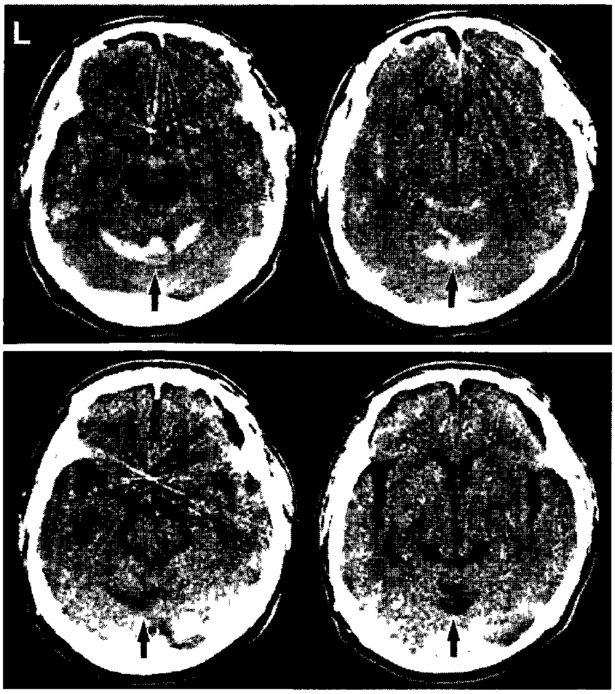

Fig. 1 Case 1. *upper*: Postoperative CT scans, showing a high-density area (*arrow*) in the upper vermis and on the tentorial surface of the cerebellar hemisphere. Subarachnoid hemorrhage, severe in the ambient and quadrigeminal cisterns, is also recognized. *lower*: CT scans taken about 1 month after surgery, demonstrating a low-density area (*arrow*) in the vermis and on the tentorial surface of the cerebellar hemisphere.

such as vertical nystagmus, and his blood pressure rose. A CT scan revealed subarachnoid hemorrhage, most striking in the posterior fossa, and a high-density area in the upper cerebellar vermis (Fig. 1 *upper*). A vertebral angiogram, which had not been obtained before surgery, showed no vascular lesion. On a follow-up CT scan, a low-density area appeared in the region where the cerebellar hemorrhage had occurred (Fig. 1 *lower*). Although a ventriculoperitoneal (VP) shunt had to be installed for subsequent hydrocephalus, his consciousness level gradually improved. He was discharged on October 16, with slight truncal ataxia. He has now returned to his previous occupation.

Case 2: A 43-year-old male had sudden onset of severe headache on January 21, 1988, and subarachnoid hemorrhage was diagnosed by CT in a nearby hospital. He was referred to our hospital on the following day, for further examination and surgical treatment.

He was alert without neurological deficit. A CT scan revealed moderate subarachnoid hemorrhage, localized mainly on the left side of the suprasellar cistern and in the left Sylvian fissure (Fig. 2 *upper*). Angiograms disclosed an internal carotid-posterior communicating artery aneurysm.

On the day of admission, the aneurysm was clipped through a left frontotemporal craniotomy, without problems, including the anesthetic course. The subarachnoid clot was thin, and CSF outflow from the subarachnoid space was good. In our hospital, postoperative cisternal drainage is routinely performed to prevent vasospasm in cases of subarachnoid hemorrhage, so one drainage tube was inserted into the basal cistern, in addition to the one placed in the epidural space. His brain was slack at the end of the intradural procedure, and there was considerable space between the brain and the dura mater.

After surgery, recovery from the anesthesia was slow, but his condition gradually improved. Con-

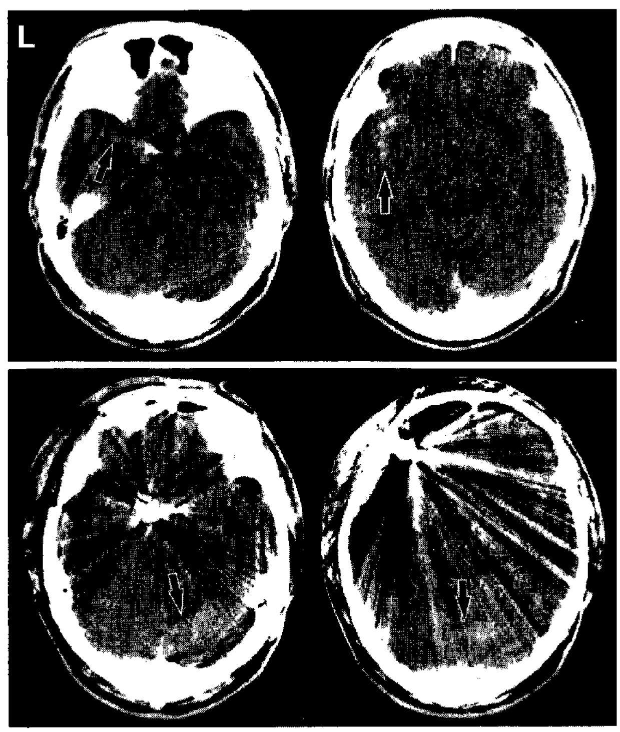

Fig. 2 Case 2. *upper*: CT scans on admission, showing moderate subarachnoid hemorrhage (*arrow*), mainly localized in the left Sylvian fissure and on the left side of the supresellar cistern. *lower*: Postoperative CT scans, demonstrating a high-density area (*arrow*) on the cerebellar tentorial surface.

tinuous drainage was performed through the epidural tube with application of negative pressure, using the SB Bag mentioned above. The draining fluid was slightly bloody and mixed with CSF. A total of 190 ml of fluid was drained during the first 10 hours after surgery.

At about 10 hours after surgery, he suddenly sat up in his bed in a confused state, and a large amount of fluid was drained through the epidural tube over a short time. After a while, he became comatose and his eyes diverged. The drainage tube was immediately occluded, and an emergency CT scan revealed more extensive subarachnoid hemorrhage than before surgery and a high-density area in the cerebellum (Fig. 2 *lower*). Follow-up angiograms showed complete obliteration of the aneurysm and no other vascular lesions. Later, his consciousness level and neurological symptoms gradually improved, and he was discharged on March 7, with slight dysorientation.

Case 3: A 59-year-old male was referred to us on the 2nd day after the onset of subarachnoid hemorrhage. He was fully alert without neurological deficits. A CT scan revealed minimum subarachnoid hemorrhage (Fig. 3 *upper*). Angiograms disclosed two saccular aneurysms, one of the left internal carotid artery and the other of the right middle cerebral artery.

On the day of admission, those two aneurysms were clipped through bilateral frontotemporal craniotomies, without problems. Blood in the subarachnoid space was scarce, and CSF outflow was good. We inserted two tubes, one into the basal cistern and the other into the epidural space. His brain became slack at the end of the intradural procedure, and considerable space was left between the brain surface and the dura mater.

In the operating room, he opened his eyes to verbal command. After returning to the intensive care unit, the epidural tube was opened and suctioned with application of negative pressure, using an SB Bag. However, the cisternal drainage tube remained open, so a considerable amount of air refluxed into the cranial cavity through the cisternal drainage tube.

His blood pressure rose, his neurological state deteriorated, and his eyes diverged. An emergency CT scan revealed more extensive subarachnoid hemorrhage than before surgery and a high-density area on the superior surface of the cerebellum (Fig. 3 *lower*). Afterwards, a VP shunt was placed for obstructive hydrocephalus. His consciousness level gradually improved to be alert, however, dysarthric speech, swallowing disturbance, and truncal ataxia persisted. He was discharged on March 3, in a dependent state.

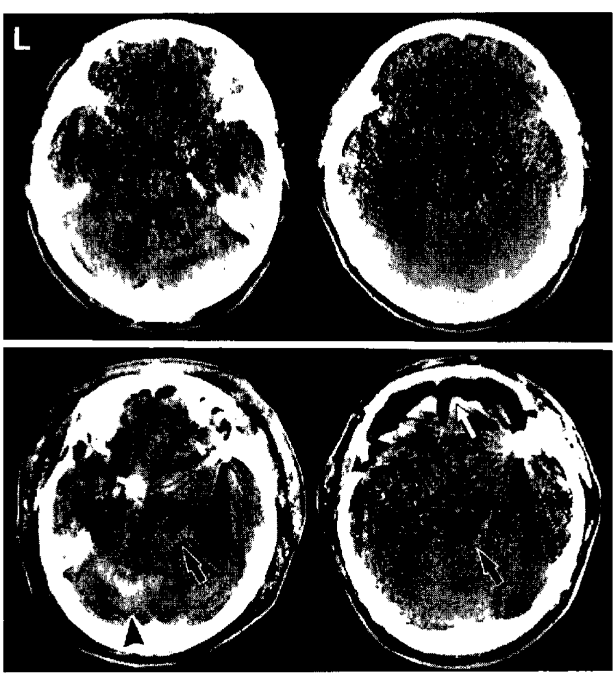

Fig. 3 Case 3. *upper*: CT scans on admission, showing minimum subarachnoid hemorrhage. *lower*: Postoperative CT scans, demonstraing a high-density area (*arrowhead*) in the upper cerebellum and subarachnoid hemorrhage (*arrow*), more severe than before surgery. A large quantity of air (*white arrow*) is seen intracranially.

Discussion

Several reports concerning the development of intracranial hematomas remote from the initial operative site have appeared in the literature.[1-6,8-14] There are relatively many reports concerning epidural hematomas, in which rapid decompression caused by surgery displaces the brain, so that dissection between the dura mater and the skull results in tearing and leakage of small vessels in the epidural space.[6,11] Subdural hematomas also appear after shunting procedures. Moussa and Sharma[10] suggest that rapid collapse of the brain parenchyma after ventricular CSF drainage stretches and tears bridging veins. On the other hand, intracerebral hemorrhage remote from the surgical site, with no relation to the operative procedure, is extremely rare. We have found only 19 such cases reported in the literature. Excluding five cases of supratentorial

Table 1 Postoperative remote cerebellar hematomas

Author (Year)	Age/Sex	Primary disease	Operation
Yasargil and Yonekawa (1977)[14]	?	?	STA-MCA anastomosis
	?	?	STA-MCA anastomosis
Heros and Nelson (1980)[3]	?	?	STA-MCA anastomosis
	?	?	STA-MCA anastomosis
Chadduck (1981)[1]	59/M	cervical disc	laminectomy
Modesti *et al.* (1982)[9]	12/M	lt subdural hygroma	trephination
Waga *et al.* (1983)[13]	42/M	AcomA aneurysm	rt craniotomy
Miyamoto *et al.* (1985)[8]	56/M	craniopharyngioma	rt craniotomy
Ikakura *et al.* (1988)[4]	50/M	rt ICA aneurysm	rt craniotomy
Present Case 1	54/M	AcomA aneurysm	rt craniotomy
Present Case 2	43/M	lt ICA aneurysm	lt craniotomy
Present Case 3	59/M	lt ICA aneurysm, rt MCA aneurysm	bil craniotomy

AcomA: anterior communicating artery, ICA: internal carotid artery, MCA: middle cerebral artery, STA: superficial temporal artery.

hematoma after posterior fossa surgery,[2] nine of 14 (64%) were cerebellar hemorrhages.[1,3,4,8,9,13,14]

Table 1 shows these nine and our three cases of postoperative remote cerebellar hematomas. Spontaneous cerebellar hemorrhage is said to occur in about 10% of all spontaneous intracerebral hemorrhages. Even if we consider the possibility that there are some more unreported postoperative supratentorial hematomas, the incidence of postoperative remote cerebellar hemorrhage seems to be extremely high compared with that of spontaneous cerebellar hemorrhage. This high incidence appears very important, when considering the mechanism of remote hematoma development.

Three mechanisms for the occurrence of postoperative remote intracerebral hematoma can be found in the literature. The first theory stresses a role of brain movement during surgery. Modesti *et al.*[9] speculated that intraparenchymal vessels might be injured with rapid displacement of the midline structure after decompression. Chadduck[1] argued on a case of cerebellar hematoma after cervical laminectomy in a sitting position that stretching and tearing of cerebral vessels due to collapse and displacement of the brain, accompanying a rapid decrease of CSF pressure, might be responsible for the hemorrhage. The second theory involves the so-called "normal pressure breakthrough phenomenon." Solomon and Michelson[12] used this breakthrough mechanism to explain the hematoma development in the head of the caudate nucleus after removal of a contralateral arteriovenous malformation. Heros and Nelson[3] suggested that an intracerebral hematoma in the recipient artery territory after extracranial-intracranial bypass might develop in the same manner, that is, the already dilated vessels in the hypoperfused brain may easily tear after recirculation. The last theory focuses on transient hypertension during surgery or the perioperative period, accompanying such procedures as endotracheal intubation or extubation.[13]

Our three cases were alike in several respects. First, their CT findings were similar: all hematomas in the cerebellar parenchyma were very small and were mostly located in the upper vermis. These features were clearly different from typical spontaneous cerebellar hematomas, which are usually located in the cerebellar hemisphere, generally near the dentate nucleus. All our cases also had subarachnoid hemorrhage, typically distributed over the superior or tentorial surface of the cerebellum. These findings suggest that the bleeding point involved the vessels lying on the tentorial surface of the cerebellum or near the surface and running near the midline.

The second similarity among our three cases was in operative findings. All our cases underwent aneurysm surgery, one without previous hemorrhage and others with subarachnoid hemorrhage. In two cases with subarachnoid hemorrhage, however, the amount of subarachnoid bleeding was very small, and the CSF outflow during surgery was very good. At the end of surgery, the brain surface was depressed and slack, and there was considerable space between the dura and the brain in all cases. We performed no additional procedures to drain CSF, such as spinal drainage, and paid attention to replacing the subdural space with saline solution as much as possible at dural closure.

Finally, their postoperative courses were similar. Hemorrhages probably occurred not during but after surgery, since all patients gradually recovered from the anesthesia and then deteriorated. Drainage tubes seem to be related to this deterioration. An epidural tube was placed in all cases, and a cisternal drainage tube was added in two cases with subarachnoid hemorrhage (Cases 2 and 3). In all cases, the epidural tubes were continuously suctioned under negative pressure, using portable equipment (SB Bag). A large amount of fluid mixed with CSF was drained, accompanying neurological deterioration in Cases 1 and 2. In Case 3, a considerable amount of air refluxed into the cranial cavity, when the epidural tube was opened under negative pressure, leaving the cisternal drainage tube open.

Considering the common features mentioned above, we speculated on the mechanism of hemorrhage in our cases as follows: In the postoperative supine position, the cerebellum is supposed to lie floating in CSF, since fluid stays in the bottom of the cranial cavity, namely, the posterior fossa, while air occupies the upper area, that is, the frontal region. In Cases 1 and 2, a large quantity of CSF was drained through the epidural tube postoperatively, and this massive loss of CSF may have caused downward displacement of the cerebellum. Excessive negative pressure applied on the tube seems to be responsible for the overdrainage in Case 1 and the sudden sitting up in the confused state in Case 2. In Case 3, air reflux into the cranial cavity through the cisternal drainage tube, which had been left open, may have caused downward displacement of the cerebellum. In all cases, the brain was slack and subsided at the end of operation, and the CSF space was apparently occupying a relatively large part of the intracranial cavity compared to the normal state. This postoperative intracranial environment probably accerelated downward displacement of the cerebellum. We believe that cerebellar displacement stretched the superior vermian veins and their tributaries, which run on the cerebellar tentorial surface near the midline.[7] In the supine position, these veins run in an almost perpendicular plane, as in Fig. 4, so may be stretched as if suspended from the vein of Galen. In this way, these veins may easily tear.

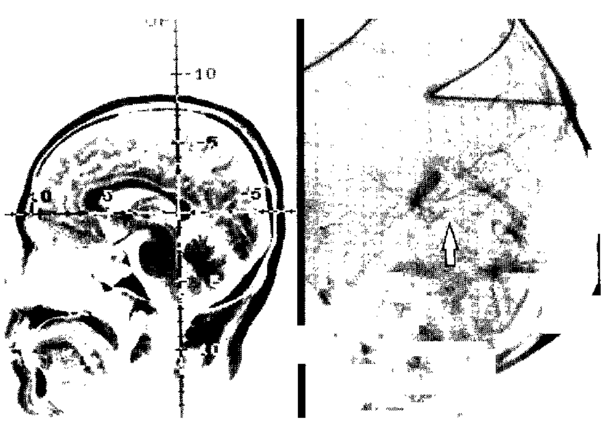

Fig. 4 Case 1. Preoperative sagittal magnetic resonance image (*left*) and venous phase of postoperative vertebral angiogram (*right*), obtained with the patient in a supine position. The superior vermian veins (*arrow*) are appeared to run on the cerebellar tentorial surface in an almost perpendicular plane.

Of course, all postoperative cerebellar hematomas are not necessarily caused in the above-mentioned way. Some postoperative hematomas may spontaneously develop with accompanying hypertension. However, we do believe that the epidural drainage tube was most responsible for the occurrence of hemorrhage in our cases. Furthermore, it is possible that such complications can be prevented if close attention is paid to the drains. From our experience, postoperative overdrainage is thought to be dangerous, especially when the brain is loose and considerable subdural dead space is created during surgery. In such cases, it is reasonable to place the drainage tube over the bone flap, not in the epidural space, and to perform postoperative drainage without application of negative pressure. Rather, the drainage tube should be open to atmospheric pressure, and suction should be controlled with hydrostatic pressure, using the distance between the patient's head and the sample bag.

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