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Abstract
The management of cerebral arteriovenous malformation (AVM) is discussed. A series of 231 cases of AVM was treated from 1961 to March 1984 in our department. The treatments of these cases are classified as total removal 169, partial removal 8, feeder clipping 14, embolization 4 and conservative 36. Results at discharge and at follow-up are analyzed and the treatments evaluated. At follow-up, no rebleeding is reported in the patients who had undergone extirpation. Cases treated with other methods showed rebleedings and either their condition worsened due to hemorrhages or they died. On the basis of these results, it is suggested that AVM should be extirpated totally. Our surgical procedure consisted of temporary occlusion of feeders using cerebral protective substances, so called "Sendai Cocktail" (mannitol, Vitamin E, steroid). This procedure makes complete surgery safe. Surgical results of the cases which were totally extirpated were better than those reported in previous reports: the mortality rate was 3.6%, and the morbidity rate was 5.4%. Because of this, surgical treatment was preferred, that is when the location, size of AVM, age, patient’s circumstances and the surgeon’s experience allow. However, there are still cases which must be treated with other therapy. These patients are withheld surgery because they have inaccessible AVM or large AVM etc., whose operation would cause neurological deficits. For the treatment of these cases we have recently attempt the chemical embolization method with conjugated estrogen. This produced good outcomes. These non-surgical treatments such as embolization and irradiation have still some unsolved problems and progress in the future is anticipated.

Keywords: Arteriovenous malformation, cerebral protective substances, chemical embolization, Sendai Cocktail, surgical treatment.

1 Introduction
Cerebral arteriovenous malformation is, together with intracranial aneurysm, an important cause of subarachnoid hemorrhage especially in the case of young people [2, 4, 9, 19]. However, cerebral arteriovenous malformations rupture less frequently and generally have lighter symptoms at the time of rupture than intracranial aneurysms. On the other hand, cerebral arteriovenous malformations often grow into cerebral parenchyma, and so, in case of total extirpation, injury the cerebral parenchyma is sometimes unavoidable. It therefore still has to be resolved whether this lesion should be excised surgically or controlled conservatively.

Surgeons are apt to think that, if a lesion exists, it must be removed, and neurosurgeons tend to think that cerebral arteriovenous malformation will lead to a poor outcome if left unattended. Before deciding to operate on cerebral arteriovenous malformations, it is important to study the site of occurrence, size, afferent and efferent arteries, etc., in order to fully recognize, considering the neurosurgeon’s experience and ability, in which part and to what extent a lesion may be excised, and in which cases this may be risky.

In the following, the techniques and results of both operations on cerebral arteriovenous malformations and chemical embolizations with conjugated estrogen [8, 24, 25, 26] are described based on cases in the Department of Neurosurgery, Institute of Brain Diseases, Tohoku University School of Medicine.

2 Operative method
Direct operations on cerebral arteriovenous malformations are performed, in principle, under a temporary interruption of the blood flow of the afferent artery [14, 16, 18, 21, 22, 23, 26, 28]. Before 1972
operations were performed under hypothermic anesthesia for prolonging the interruption of the blood flow. At present cerebral protective substances (Sendai Cocktail – 20% mannitol 500 ml, vitamin E 300 mg, dexamethasone 50 mg) [18, 20, 21, 22, 23], which were developed by the Department of Neurosurgery, Institute of Brain Diseases, Tohoku University are used. They are administered intravenously, and an operation is performed under anesthesia at normothermia and normotension. This method for prolonging the interruption of the cerebral blood flow has been reported in detail in separate papers [14–16, 18–23, 26, 28], and will not be gone into here. The effective time for 20% mannitol 500 ml which was first used permitted a 40-minute-long interruption of any main brain artery within 100 minutes after administration. The effective time of the Sendai Cocktail, developed later, is considered to be longer, but for the present it was considered to be nearly the same.

After preparation, the cerebrospinal fluid is aspirated from the subarachnoid space in the part of chiasma opticus or basis cerebri in an attempt to reduce the cerebral volume. Then the afferent arteries of the cerebral arteriovenous malformation or their sources, the main cerebral arteries of the basis cerebri, are exposed and secured. By this time, the Sendai Cocktail has been administered over a period of about 30 minutes. A clip with a blade pressure of about 50 g low enough to avoid damage to the vascular wall [15] is applied to this part in order to temporarily interrupt the blood flow. The operation removing the cerebral arteriovenous malformation is then performed. By this method it is possible to prevent dangerous hemorrhaging and to perform the operation safely, while minimizing injury to the cerebral parenchyma. Therefore, preparation can be extensive enough to include stripping and full removal of the cerebral arteriovenous malformation, and exposure of the afferent arteries, or main blood vessels, at the basis cerebri. If the middle or posterior cerebral artery is an afferent artery, it should first be entered in the direction of the basis cerebri, while if the anterior cerebral artery is an afferent artery, the anterior cerebral artery should be reached from the front, when possible by anterior part of the falx cerebri and the brain. These afferent arteries are temporarily interrupted, and then the cerebral arteriovenous malformation is treated [13, 19, 26]. This method makes an operative manipulation in the “dry field” possible. Therefore total extirpation in a relatively short time, without unnecessary injury to the cerebral parenchyma is possible (Figure 1).

Stripping of the cerebral arteriovenous malformation is performed so as to separate the blood vessels from the cerebral parenchyma. If an afferent artery is a small blood vessel, hemostasis with a bipolar coagulator is sufficient. In case of a large afferent artery, it is important to cut it after it has been securely interrupted with a silver clip. Hemostatic manipulation is relatively easy, particularly in an operation under temporary interruption of the blood flow. Even in a fairly thick artery, the bleeding apparently is simply stopped by coagulation. However, since postoperative hemorrhages from this site have caused fatalities, thick afferent blood vessels should always be blocked with silver clips [19, 26].

Furthermore, cerebral arteriovenous malformations are abnormal blood vessels in themselves and, at the