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Radiotherapy for Small Cerebral Arteriovenous Malformation

Tetsuo Yamashita, Yasushi Kurokawa, Shiro Kashiwagi, Seisho Abiko, Yujiro Shiroyama, Toshifumi Kamiryo, Shigeki Nakano, Yuuki Eguchi, Toru Tsurutani and Haruhide Ito

Department of Neurosurgery, Yamaguchi University School of Medicine, Ube, Yamaguchi 755 Japan
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Summary The results of two types of radiation therapy for small cerebral arteriovenous malformations (AVM) were analyzed, and the indications and limitations of radiation therapy for small AVMs discussed.

Four patients with small AVMs received radiation therapy. There were three males and one female, ranging in age from 7 to 44 years with an average of 29 years. One cerebral AVM was located in the right thalamus, two were in the left central sulcus and one was in the left parietal lobe.

Three AVMs were subjected to conventional radiation therapy with 30 Gy of X-rays from a linear accelerator. The other AVM was subjected to stereotaxic radiosurgery with 27.5 Gy of gamma rays.

The conventional radiation therapy did not obliterate the AVMs, but radiosurgery successfully obliterated the AVM in the central sulcus. These results suggest that conventional radiation is not effective for small cerebral AVMs, and that stereotaxic radiosurgery is preferable.

Key words : AVM, Radiation therapy, Stereotaxic radiosurgery

Introduction

Most cerebral arteriovenous malformations (AVMs) can be safely resected using microsurgical techniques. However, some AVMs are difficult to resect because they are located in important areas of the cortex or in deep areas. [1)2)] For these AVMs, conventional radiation therapies have been applied since 1914, but their effectiveness for AVM is still controversial.[3)4)] Stereotaxic radiation therapy, "radiosurgery", for AVM was conducted by Steiner et al. in 1970, and since then it has been reported to be effective for AVM.[5)] The purpose of this study was to compare conventional radiation therapy with radiosurgery therapy for small cerebral AVMs.

Material and Methods

Four patients who were admitted to Yamaguchi University Hospital between 1973 and 1990 were studied (Table 1). There were three males and one female, ranging in age from 7 to 44 years with an average of 29 years. One cerebral AVM was located in the right thalamus, two were in the left central sulcus and one was in the left parietal lobe. All of the AVMs were small, measuring less than 25 mm. One was classified

Table 1. Summary of cases

Case No	Age	Sex	Site	Size	Grading*	Radiation Dose (Gy)	Adjunct therapy	Follow-up Period (y)	Follow-up Method	Result
1	32	F	thalamus	small	III*	30	hemostatic hypotension	7	angio	rebled
2	32	M	parietal	small	III*	30	hemostatic hypotension, op	6	angio	unchanged
3	7	M	parietal	small	III*	30	hemostatic, op	3	CT	unchanged
4	44	M	parietal	small	II*	27.5***	op	2	angio	nearly obliterated

*Spetzler's grading, ***stereotaxic radiosurgery, op : operation, angio : angiography
AVM : arteriovenous malformation, CT : computed tomography

as group II according to Spetzler's classification, and three were group III.

The thalamic AVM was treated by conventional radiation without surgery. The other three were subjected to radiation for the residual nidus after partial surgical resection.

Three AVMs were subjected to conventional radiation of 30 Gy using X-rays from a linear accelerator at Yamaguchi University. One residual AVM was subjected to 27.5 Gy of gamma rays by stereotaxic radiosurgery in Del Sol Hospital, Buenos Aires.

Follow-up study was done by cerebral angiography or X-ray computed tomography. The follow-up period was from 3 to 7 years, with a mean of 4.5 years. No cerebral angiography was performed in a case whose CT revealed apparent AVM.

Results

The AVMs treated with conventional radiation therapy were not obliterated after 3 to 7 years. The patient with the thalamic AVM had recurrent bleeding in 1991 (Table 1).

The radiosurgery had obliterated 50% of the nidus one year after radiation and almost all of the nidus after two years, as revealed by cerebral angiography.

Case presentation

(Case 1) A 32-year-old woman suffered sudden consciousness disturbance on March 26, 1984. She was transferred to Sanyo Central Hospital, where CT scan revealed left thalamic hemorrhage. Her consciousness disturbance and hemiparesis improved gradually, and she was admitted to our hospital on April 10, 1984. Neurological examination showed right hemiparesis and right hemihypesthesia.

Cerebral angiography showed a small AVM in the left thalamus (Fig. 1a). The AVM was subjected to conventional radiation 2 Gy x 15, total 30 Gy. The patient was discharged from hospital on May 26, 1984, at which time she was able to walk unaided. She did well until January 7, 1991, when she suffered consciousness disturbance due to rebleeding and fell into a vegetative state. Follow-up angiography revealed AVM of the same size as that before radiation therapy (Fig. 1b).

(Case 2) A 32-year-old male suffered from consciousness disturbance and left hemiparesis on October 31, 1982. CT scan revealed an intracerebral hematoma in the right parietal lobe. Cerebral angiography showed a right parietal AVM. He underwent partial removal of the AVM and evacuation of the hematoma on November 1, 1982, and was discharged from hospital in good condition on January 10, 1983. On March 3, 1984 he suffered rebleeding and an emergency operation was performed. In this operation, the abnormal vascular lesion could not be removed. Postoperative angiography showed a small vascular network and early filling of the thalamostriate vein (Fig. 2a). So conventional radiation of 30 Gy was carried out for the residual AVM. Follow-up angiogra-

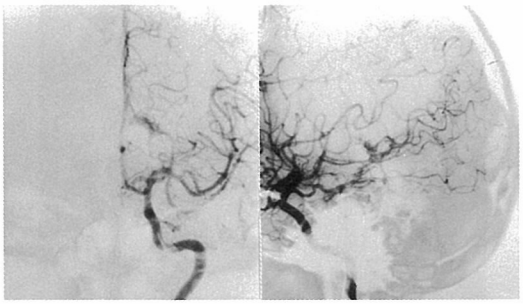

Fig. 1a Case 1. Cerebral angiography showing a small AVM in the left thalamus.

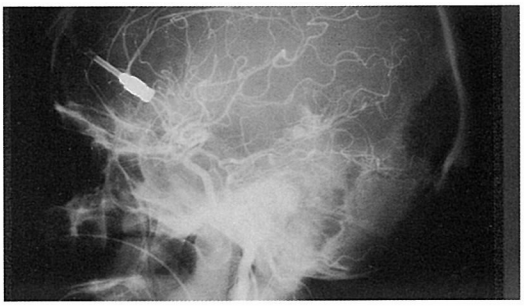

Fig. 1b Seven-year follow-up angiography revealed AVM of the same size as that before radiation therapy.

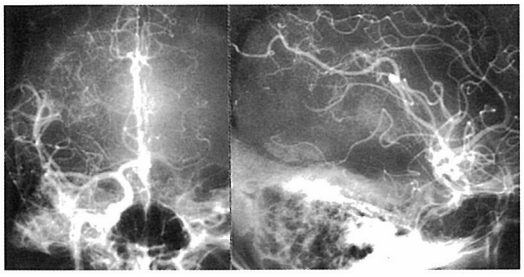

Fig. 2a Case 2. Cerebral angiography showing a small vascular network and early venous filling of the thalamostriate vein.

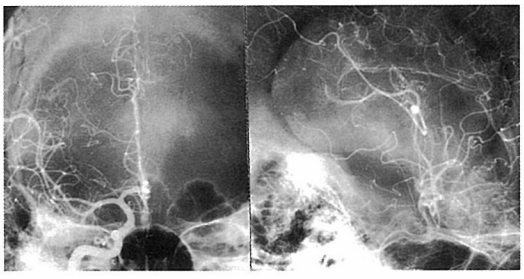

Fig. 2b Six-year follow-up angiography showing the presence of the AVM.

phy on August 21, 1990 showed the presence of the AVM (Fig. 2b).

(Case 3) A 7-year-old boy suffered from sudden onset of headache and loss of consciousness on September 16, 1984. CT revealed a left parietal intracerebral hematoma. Angiography showed a cerebral AVM in the left central sulcus. The hematoma and the AVM were removed, leaving part of the AVM in the motor cortex. Postoperative angiography showed a small vascular stain and early venous filling in the motor cortex. The patient underwent irradiation with a total dose of 30 Gy. He had right hemiparesis, but was discharged as an ambulatory patient on December 21, 1984. Three year after the irradiation, CT showed a small enhanced lesion in the left frontal region.

(Case 4) A 44-year-old male suffered from headache on July 13, 1979. He was admitted to our hospital on August 4, 1979. He had no neurological deficits. Cerebral angiography revealed a small AVM in the left central region, which was classified as Spetzler group II. The AVM was partially removed by left frontoparietal craniotomy on August 13, 1979. In the postoperative course, transient speech disturbance occurred, but the patient recovered well and was discharged as an ambulatory patient on September 22, 1979. He had a normal life until August 2, 1986, when he had another attack of headache. At this time, he had no neurological deficits. On August 22, 1986, cerebral angiography revealed a residual AVM in

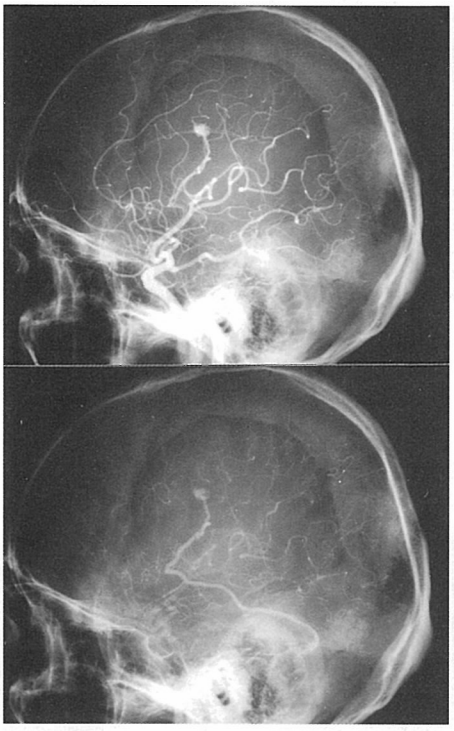

Fig. 3a Case 4. Cerebral angiography showing a small AVM in the left central region.

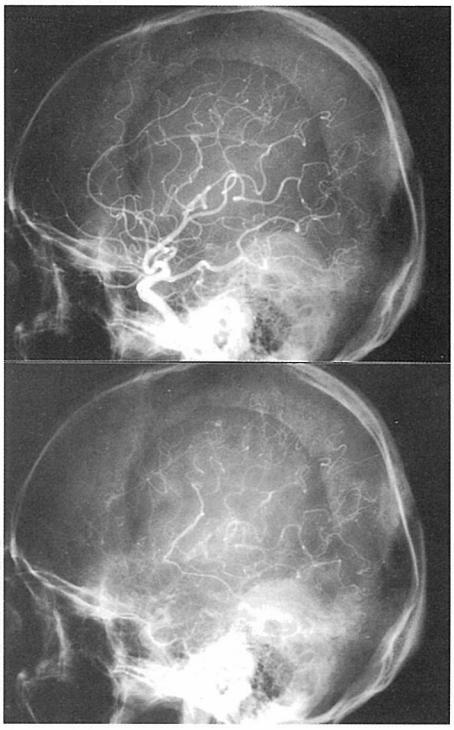

Fig. 3b One-year follow-up angiography showing 50% reduction of the nidus size.

the central sulcus. The size of the nidus was 6 x 7 x 9 mm (Fig. 3a), which was the same size as that 8 years previously. He was recommended to have radiosurgery for the AVM. Stereotaxic radiosurgery was performed in Del Sol Hospital, Buenos Aires, on February 24, 1987. The radiosurgery was performed using ^{60}Co gamma rays, with a radiation field of 14 mm, a total radiation dose of 27.5 Gy, and an irradiation time of 10 min. One year after the radiosurgery (March 1, 1988), cerebral angiography showed 50% reduction of the nidus size (Fig. 3b). Two-year follow-up angiography showed almost complete obliteration of the nidus and fair staining due to early venous filling, on April 14, 1989 (Fig. 3c).

Discussion

The aims of radiation therapy for AVMs are gradual vascular obliteration due to endothelial proliferation, thickening of the vascular wall and thrombosis formation with endovasculitis.[6)7)] There are two main methods of radiation; one is conventional radiation, and the other is stereotaxic radiation (radiosurgery).[4)5)] The effectiveness of conventional radiation for cerebral AVM is still controversial. This type of radiation had already been tried before 1960, and the method was concluded to be ineffective at that time. However, Johnson et al., in 1975, reported 100 cases treated with 45-50 Gy of radiation, 20 of which were followed up by angiography, which revealed that 9 were obliterated.[4)] On the other hand, in 1978, Glanzman et al. reported that none of 13 large AVMs irradiated by 40-60 Gy disappeared angiographically.[8)] In our three cases treated in this way, there was no obliteration of the AVM during the 4.5-year mean follow-up period. One AVM rebled 7 years after therapy and the patient became vegeta-

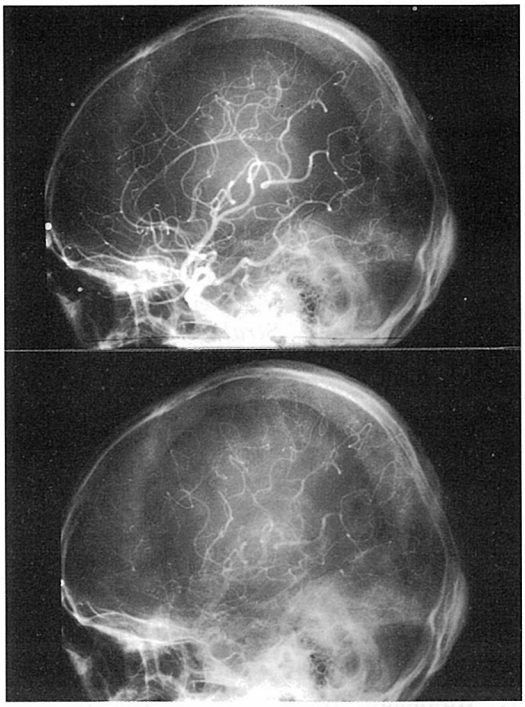

Fig. 3c Two-year follow-up angiography showing almost complete obliteration of the nidus and fair staining of due to early venous filling.

tive.

According to reports between 1960 and 1989, disappearance of AVM was evaluated by follow-up angiography, and 18 of 73 cases (24.6% disappearance rate) showed unequivocal obliteration of the AVM (Table 2).[9-17] This disappearance rate is better than that of the natural course, 6%, reported by Luessenhop,[18] but it is so low that conventional radiation therapy cannot be considered an adequate therapy for cerebral AVMs. According to the report by Johnson et al., AVMs for which treatment was effective were mainly deep-seated. However, in our cases, this type of radiation therapy was not effective for the thalamic AVM. Hereafter, therefore, a combination of radiation therapy with some other form of treatment, for example interventional embolization, may be recommendable.

Stereotaxic radiosurgery for cerebral

Table 2. Result of conventional radiation for AVM

Author	Year	No. of cases*	No. of AVM obliteration
total		74	18(24.3%)
Svien	1960	1	1
Johnson	1975	20	9
Miyazaki	1978	4	1
Glanzman	1978	13	0
Kuwahara	1979	4	1
Higashi	1984	3	0
Tognetti	1985	1	1
Poulsen	1987	6	1
Kurokawa	1987	12	3
Walkov	1987	5	1
Morgan	1988	3	0
Our	1991	2	0

*Follw-up cases with angiography

AVM was first reported by Steiner et al. in 1970.[5] The main characteristics of radiosurgery are stereotaxic determination of the AVM site and delivery of high energy in a short time to the AVM focus. The reported effectiveness of radiosurgery for obliteration of AVM two years after the therapy is 12 out of 62 cases (19%) using a Bragg-peak proton beam as the radiation source (Kjellberg et al.)[19] 90 of 104 cases (86.5%) using ^{60}Co gamma-rays (Steiner et al.)[20] and 26 of 28 cases (92.8%) using high-energy X-rays (Betti et al.)[21] (Table 3). Our patient whose AVM was unchanged after 8 years, showed obliteration of the nidus within two years after ^{60}Co gamma-ray radiosurgery, showing the effectiveness of this therapy.

One of the reasons for the superiority of radiosurgeny to conventional radiation is that the former irradiates the AVM more accurately than conventional treatment (Shiogai et al.).[22] In conventional radiation using many separate small doses, the treatment time is long, so that the irradiated area may be missed, or imprecisely or inadequately irradiated. On the other hand, in radiosurgery, the head is fixed by a stereotaxic frame, and the irradiated area can be precisely pinpointed. Radiosurgery can deliver a high dose of radiation over a very short time in a single session, so that the irradiated area

Table 3. Result of radiosurgery for cerebral AVM*

Author	Year	No. of cases	No. of AVM obliteration
Kjellberg	1983	62	12(19.5%)
Steiner	1985	104	90(86.5%)
Betti	1989	28	26(92.8%)

*Two years follow-up cases with angiography.

is not moved, or missed.

One problem of radiosurgery is that it can be applied only to AVMs of limited size because of the risk of radiation necrosis. Steiner et al. reported that the size of AVMs for which this treatment is indicated is less than 25 mm in diameter.[23] Also, with radiosurgery, obliteration of the AVM takes time, with a risk of rebleeding before complete obliteration is accomplished. However, radiosurgery is the most reliable method of radiation therapy for small AVMs at the present time.

Conclusion

Conventional radiation therapy has limited effects for cerebral AVM. Stereotaxic radiosurgery is the most reliable method of radiation therapy for small cerebral AVMs.

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