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Clinical Study

Delayed cyst formations and/or expanding hematomas developing after Gamma Knife surgery for cerebral arteriovenous malformations

Hideki Nakajima [a,*], Kazuhiro Yamanaka [b], Kenichi Ishibashi [a], Yoshiyasu Iwai [a]

[a] Department of Neurosurgery, Osaka City General Hospital, 2-13-22 Miyakojima-hondori Miyakojima-ku, Osaka 534-0021, Japan
[b] Department of Neurosurgery, Osaka City University Graduate School of Medicine, Osaka, Japan

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ABSTRACT

The authors retrospectively analyzed cyst formations and expanding haematomas (EHs) that developed after Gamma Knife surgery (GKS) for arteriovenous malformations (AVMs), and evaluated the treatment results of these lesions. Cyst formations and/or EHs which developed after GKS for AVMs were identified in 20 patients (5.0%) out of 404 patients who underwent this procedure. There were nine patients with cyst formations, two with EHs and nine with cyst formations with EHs. These lesions developed between 36 and 192 months (median 99 months) after GKS. The median nidus volume was 4.7 ml (range, 1.8–14.2 ml) and the median prescribed margin dose was 20 Gy (range, 15–23 Gy). The multivariate analysis showed no correlation between the appearance of cyst formations and/or EHs and the patients' age, sex, nidus volume, margin dose, repeated GKS, nidus obliteration, pre-GKS embolization and prior hemorrhage. Surgical treatment was required in nine patients. Eight patients had total removal of the angiomatous lesions (EHs or nodular lesions that were detected as enhancement part on MRI) via a craniotomy and one had a cyst aspiration. There was no recurrence of the lesions in all the patients that underwent a craniotomy. In the patient treated with a cyst aspiration, regrowth of the cyst formation occurred. Surgical treatment should be considered for symptomatic lesions and we recommend total removal of the angiomatous lesions to achieve a complete cure.

1. Introduction

Gamma Knife surgery (GKS) is widely accepted as an effective treatment for arteriovenous malformations (AVMs) [1–3]; however, various complications after this treatment such as brain edema, cyst formations and expanding hematomas (EHs) have been reported [4–14]. Cyst formations and EHs are well known delayed complications of GKS for AVMs, but the underlying etiology of them remains unclear. These delayed complications are clinically important since surgical treatment is required in some patients. In this study, we retrospectively analyzed our patients with cyst formations and/or EHs which developed after GKS for AVMs, and evaluated the treatment results of these lesions.

2. Methods

Between January 1994 and December 2013, 526 patients with AVMs were treated with GKS using a Leksell Gamma Unit (Elekta AB, Stockholm, Sweden) at Osaka City General Hospital. Out of the 526 patients, we selected 404 who we could obtain follow-up data on. The patients underwent application of an imaging-compatible stereotactic head frame. MRI coupled with biplane stereotactic angiography was then performed for dose planning. The median nidus volume was 4.4 ml (range, 0.03–27.0 ml) and the median prescribed margin dose was 19.1 Gy (range, 10–25 Gy). The patients were evaluated clinically and underwent MRI every 6 months after GKS until 36 months, and then every 12 months thereafter. Angiography was performed when obliteration was indicated the by MRI. We excluded 122 patients without exact follow-up data out of 526 patients. The median follow-up period was 58.9 months (range, 6–266 months). Out of 404 patients, 20 patients (5.0%) were identified as having cyst formations and/or EHs. Both symptomatic patients and asymptomatic patients with cyst formations and/or EHs revealed on the MRI were included. In our retrospective analysis, we examined the patients' age, sex, location, Spetzler–Martin (S–M) grade [15], prior hemorrhage, pre-GKS embolization, nidus volume, margin dose, repeat GKS, nidus obliteration and follow-up period. In addition, we evaluated the treatment results of these lesions, including the lesions that were treated at other hospitals.

* Corresponding author. Fax: +81 72 840 2266.
E-mail address: hikkinakajima@yahoo.co.jp (H. Nakajima).

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Statistical analysis was performed using JMP 9.0 software (SAS Institute, Cory, NC). The Kaplan–Meier method was performed to assess cyst formation or EH free survival. Univariate analyses were done using the log-rank method. Multivariate analyses were performed using the Cox proportional hazards model to assess the prognostic value of different variables to cyst formation or EH free survival.

3. Results

The characteristics of the 20 patients with cyst formations and/or EHs that developed after GKS for AVMs are summarized in Table 1. Ten men and 10 women were included and the median patient age was 37 years (range 8–71 years). The AVMs were located as follows: the frontal lobe in five patients, the temporal lobe in one, parietal lobe in three, occipital lobe in eight and basal ganglia in three patients. The S–M grade was diagnosed as follows: 1 in four patients, 2 in nine, 3 in five and 4 in two patients. Prior hemorrhage was observed in nine patients and pre-GKS embolization was performed in one patient. The median nidus volume was 4.7 ml (range, 1.8–14.2 ml) and the median prescribed margin dose was 20 Gy (range, 15–23 Gy). Repeat GKS for residual AVM was performed in two patients. One of those patients had GKS twice and the other had the treatment three times. There were nine cyst formations, two EHs and nine cyst formations with EHs. The angiomatous lesions (EHs or nodular lesions that were detected as enhancement part on MRI) were demonstrated in all patients (Fig. 1, 2). The nidus obliteration was incomplete in three patients when cyst formation or EH was detected. These lesions developed between 36 and 192 months (median, 99 months) after GKS. In the univariate analysis, no significant relationship was shown between the appearance of cyst formations or EHs and the patients' age, sex, margin dose, repeat GKS, nidus obliteration, pre-GKS embolization and prior hemorrhage; however, nidus volume was found to be statistically significant regarding the appearance of cyst formations and/or EHs. The multivariate analysis showed no correlation between the appearance of cyst formations and/or EHs and the patients' age, sex, nidus volume, margin dose, repeat GKS, nidus obliteration, pre-GKS embolization and prior hemorrhage (Table 2).

Table 1
Summary of characteristics of 20 patients with cyst formation and EH developed after GKS for AVMs

Characteristic	Value
Mean age (years)	37 (8–71)
Male/female	10/10
Median nidus volume (ml)	4.7 (1.8–14.2)
Median margin dose (Gy)	20 (15–23)
Duration (months)	99 (36–192)
Prior hemorrhage	9 (45%)
Pre-GKS embolization	1 (5%)
Repeat GKS	2 (10%)
Incomplete nidus obliteration	3 (15%)
Location	
Frontal lobe	5 (25%)
Temporal lobe	1 (5%)
Parietal lobe	3 (15%)
Occipital lobe	8 (40%)
Basal ganglia	3 (15%)
S–M grade	
1	4 (20%)
2	9 (45%)
3	5 (25%)
4	2 (10%)
5	0 (0%)

AVM = arteriovenous malformation, EH = expanding haematoma, GKS = Gamma Knife surgery, S–M = Spetzler Martin.

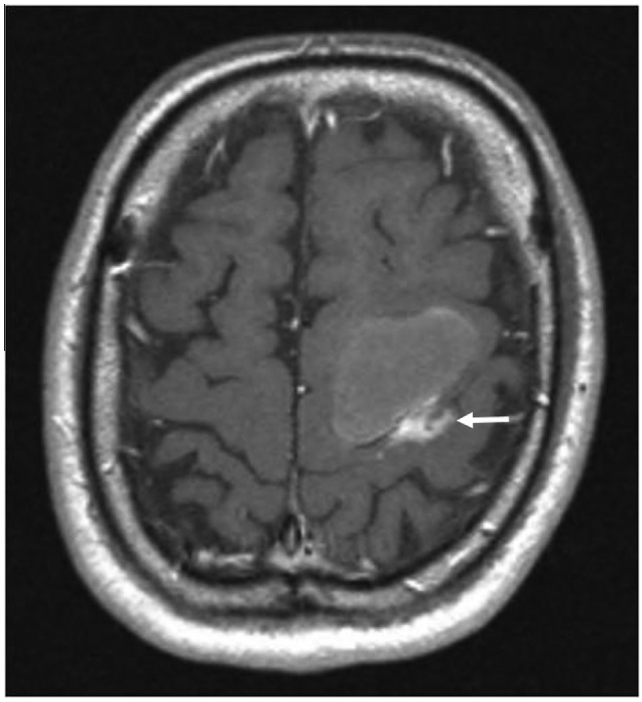

Fig. 1. A 39-year-old man. A Gd-DTPA-enhanced MRI obtained 180 months after Gamma Knife surgery for arteriovenous malformationm (nidus volume 4.6 ml, margin dose 21 Gy) shows cyst formation with a nodular lesion (arrow).

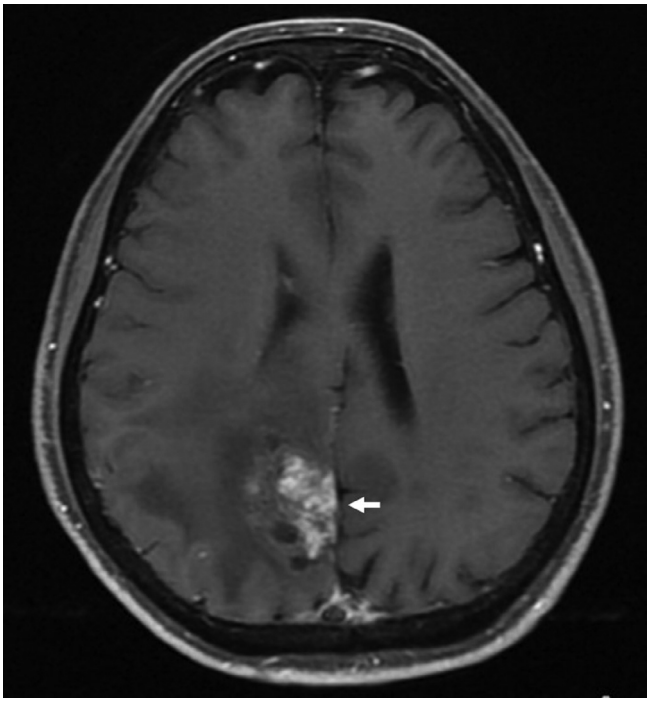

Fig. 2. A 71-year-old female. A Gd-DTPA-enhanced MRI obtained 120 months after Gamma Knife surgery for arteriovenous malformationm (nidus volume 3.6 ml, margin dose 20 Gy) shows expanding hematoma (short arrow).

In 11 patients with asymptomatic or mild symptomatic lesions, serial imaging follow-up was performed. Spontaneous regression of the EH was observed in one patient. In nine patients with moderate or severe symptomatic lesions, eight underwent a craniotomy (one cyst formation, one EH and six cyst formations with