Original Article

Gamma Knife Radiosurgery for Intracerebral Arteriovenous Malformations

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ARTICLE INFO

ABSTRACT

Background: The goal of stereotactic radiosurgery for cerebral arteriovenous malformations (AVMs) is to obliterate the AVM nidus, decrease the risk of future hemorrhage, and improve seizure severity, headache, or other neurological deficits. Objectives: evaluation of gamma knife radiosurgery as a modality of treatment of intracranial arteriovenous malformation. Patients and Methods: this study was conducted on 108 patients of intracranial AVMs between 2002 and 2010. All cases of AVMs were included in the study with exception of those had previous conventional radiotherapy for their intracranial AVMs or those with AVMs requiring staged volume treatment. Results: Complete obliteration of AVMs was documented by MR imaging and cerebral angiography in 94 patients (87%). Only 5 patients (4.6%) showed bleeding from their treated AVMs. Permanent residual deficit was observed in 4 of the 5 patients with hemorrhage. In 23 patients (21.3%), symptomatic adverse radiation effects (AREs) (edema) developed after Gamma knife treatment. In 4 patients (3.7%), a persistent clinical deterioration developed (one of them suffered hemiparesis and 3 patients suffered a visual field defect but no total loss of vision). In the other 19 (17.5%) patients AREs were successfully managed with a short course of corticosteroids. Follow up of patients who presented with seizures showed that 27 patients (67.5%) became seizure free (Engel grade 1), 9 patients (29.7%) had rare seizures (Engel grade 2) and only one patient (2.7%) showed no improvement (Engel grade 4). Conclusion: Gamma knife radiosurgery for AVMs is an effective treatment modality. We were able to treat all patients with both ruptured and unruptured malformations and reached excellent or good clinical outcome in 96% of our patients, with a 87% angiographic obliteration. Larger or deeply located AVMs showed less favourable outcomes in terms of lower obliteration rates and more adverse radiation effects.

INTRODUCTION

Following the advent of noninvasive imaging techniques, including the widespread availability of CT and MR imaging, there has been a significant increase in the incidental detection of unruptured BAVMs. In patients with untreated BAVMs the annual hemorrhage rates of 2–4% (major morbidity 1.7%, mortality 1%, and combined morbidity and mortality 2.7% per year); however, the vast majority (71%) of these BAVMs had ruptured at initial presentation 1.

Controversy exists regarding the optimal treatment of cerebral arteriovenous malformations. Current management guidelines are based on case series and cohort studies, as there is yet to be a randomized trial assessing treatment modalities according to patient and AVM characteristics. Nonetheless, it is generally accepted that patients referred to radiosurgery constitute a unique AVM population 40.  

Stereotactic radiosurgery (SRS) has been one of the most significant advances in the field of neurosurgery and is now available to both large and small neurosurgical practices.

The goal of stereotactic radiosurgery for cerebral AVMs is to obliterate the AVM nidus, decrease the risk of future hemorrhage, and improve seizure severity, headache, or other neurological deficits. Complete AVM obliteration following radiosurgery generally takes 1–3 years and the risk of hemorrhage during this latency period remains essentially unchanged from untreated patients. Obliteration rates following radiosurgery range from 54 to 92% 40. The aim of this study is evaluation of Gamma knife radiosurgery as a modality of treatment of intracranial arteriovenous malformation.

PATIENTS AND METHODS

This study was conducted on 108 patients with intracranial arteriovenous malformations. All patients with intracranial arteriovenous malformations (AVMs) are included in this study except those having one or both of the following exclusion criteria

- Patients previously treated with conventional radiotherapy for their intracranial AVMs.
- Patients having intracranial AVMs necessitating staged volume gamma knife treatment.

Between March 2002 and April 2010, out of patients with intracranial AVM who underwent gamma knife
treatment, 108 patients were fulfilling the inclusion criteria of our study.

All cases were diagnosed using MRI with and without Intravenous contrast, 3D C-T angiography and 4 vessels direct angiography.

**Radiosurgery technique**

**Target delineation**

After fixing the Leksell frame to the head, MR images were obtained in each case (1.6-mm slice thickness, no gap). T1-weighted fast spoiled gradient with Gd and T2-weighted sequences were done. The images were transferred to the dose planning computer GammaPlan (Elekt Instrument AB, Stockholm, Sweden). On the day of treatment AVM delineation was done on the stereotactic MRI scans with preoperative non-stereotactic angiography images as guidance throughout the planning. In most cases the target was drawn on T2 series except when there was embolization material that would confuse with the traditional void signal appearance. In this instance target delineation was done on contrasted T1 series. After completing delineation the target was superimposed on the T2 images to ensure inclusion of whole the nidus (Fig. 1).

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**Fig. 1:** This 26 year old female patient presented with hemorrhage. The cerebral angiography showed a left thalamic AVM (a (anteroposterior view), b (lateral view)) 5.1 cc in volume treated by gamma knife radiosurgery with a prescription dose of 20 Gy to 50 % isodose with a 95 % cover (c (coronal reconstruction), d (sagittal reconstruction)). The cerebral angiography images (a, b) were used as a guide throughout the target delineation process. A final angiography (e (anteroposterior view), f (lateral view)) done 38 months after treatment showed complete AVM obliteration.
Dose selection

The targeted prescription dose was 25 Gy. This was reduced to protect critical structures or eloquent areas such as visual pathway, brainstem, internal capsule and motor strip. The dose to the visual pathway was kept below 9 Gy. The dose to the brainstem was restricted so that no more than 1 cm³ received 12 Gy. The integral dose was also used as a guide to make adjustments to the prescription dose as described in an earlier paper. The maximum acceptable integral dose used after the first few cases was around 220 mJ for cases with bleeding and 175 mJ for other cases. The modified Pollock-Flickinger AVM grading score (AVM score) was used \((= (0.1) \text{ (volume in cm}^3\text{)} + (0.02) \text{ (age in years)} + (0.5) \text{ (location: basal ganglia, thalamus, or brainstem= 1, others = 0)})\). The effect of the AVM score on the occlusion and complication rate was assessed.

The patients’ Pollock-Flickinger score ranged from 0.4 to 2.1 with median value of 1. The AVM volume among patients ranged from 0.4 cc to 14 cc with median value of 2.8 cc. The treatment prescription dose ranged from 16 to 35 Gy, isodose ranged from 40% to 65%, integral dose from 13.4 to 289.7 mJ and a cover ranged from 80% to 100%.

Follow up

Patients were followed up after the treatment at 6, 12 months and 24 month by clinical assessment and gadolinium-enhanced MRI. Once there was no longer an AVM nidus visualized by gadolinium-enhanced MRI, a four vessel angiography or CT angiography, was done to confirm complete obliteration of the arteriovenous malformation.

RESULTS

The series included 70 male and 38 female patients, whose median age was 31 years (range 5–72 years). One hundred and six patients had their AVMs located supratentorially and only 2 patients had their AVMs located infratentorially. Twenty seven of them were located in the parietal lobe, 25 temporal, 16 frontal, 12 occipital, 9 intraventricular, 2 cerebellar, and 17 were deeply seated (11 thalamic, 4 corpus callosum and 2 basal ganglia).

Symptoms leading to the diagnosis were hemorrhage in 70 patients (64.8%), seizures in 37 (34%), headaches in 28 (25.9%), motor deficit in 23 (21.3%), Steal symptoms in 3 patients (2.7%), venous hypertension (headache, vomiting and blurring of vision) in 3 patients (2.7%) and it was an incidental discovery in 3 patients (2.7%). Nineteen patients underwent prior embolization and 1 patient underwent prior partial AVM resection.

AVM obliteration

Complete obliteration of AVMs was documented by MR imaging and cerebral angiography in 94 patients (87%). Factors associated with a higher rate of total AVM obliteration included (Table 1)

- Low Pittsburgh Scale (highly significant/p value= 0.019)
- Small AVM volume (highly significant/p value= 0.052)
- Frontal, ventricular and cerebellar location (highly significant/p value= <0.001)
- No previous embolization (highly significant/p value= <0.001) (Table 2)

<table>
<thead>
<tr>
<th>Table (1): Relation between incidence of AVM occlusion to all parameter.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Items</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Pittsburgh Scale</td>
</tr>
<tr>
<td>Treatment Volume</td>
</tr>
<tr>
<td>Treatment Prescription Dose</td>
</tr>
<tr>
<td>Treatment Isodose</td>
</tr>
<tr>
<td>Treatment Integral dose</td>
</tr>
<tr>
<td>Treatment Cover</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table (2): Relation between incidence of AVM occlusion and previous embolization.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td>No embolization</td>
</tr>
<tr>
<td>Previous embolization</td>
</tr>
<tr>
<td><strong>p-value</strong></td>
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</table>
Hemorrhage after gamma knife

Only 5 patients (4.6%) showed bleeding from their treated AVMs, four of them occurred in the first year and only one occurred in the second year after treatment. From those 5 patients 4 of them occluded later on and one of them needed a second treatment. Permanent residual deficit was observed in 4 of the 5 patients with hemorrhage. Also 4 patients had initially bled before gamma knife treatment.

The preradiosurgical annual hemorrhage rate was calculated as the number of preradisurgical hemorrhages divided by the all patient-years at risk. Because AVM are generally considered as congenital anomalies, we assumed that patients were at risk for hemorrhage from their dates of birth.

\[
\text{The preradiosurgical annual hemorrhage rate} = \frac{\text{number of hemorrhages}}{\text{patients' years at risk}}
\]

To calculate the preradiosurgical annual rebleeding rate, the number of preradiosurgical recurrent hemorrhages was divided by the total number of risk years (for patients presented by hemorrhage) from the dates of initial hemorrhage to the dates of GKS.

\[
\text{The preradiosurgical annual rebleeding rate} = \frac{\text{number of recurrent hemorrhages}}{\text{number of risk years}}
\]

Postradiosurgical Annual bleeding rate = postradiosurgical hemorrhagic events/patients (with hemorrhagic presentation) risk years from the dates of GKS to the dates that the AVM were judged to be obliterated on MRI or the dates of last follow up if the nidi remained patent.

\[
\text{Postradiosurgical Annual rebleeding rate} = \frac{\text{number of hemorrhages}}{\text{patient risk years}}
\]

Adverse Radiation Effects

In 23 patients (21.3%), symptomatic adverse radiation effects (AREs) (edema) developed after Gamma knife treatment. In 4 patients (3.7%), a persistent clinical deterioration developed (one of them suffered hemiparesis and 3 patients suffered a visual field defect but no total loss of vision). In the other 19 (17.5%) patients AREs were successfully managed with a short course of corticosteroids.

Factors associated with a higher rate of AREs included (Table 3)

- Old age (highly significant/p value= 0.006) with cut off value of ≥39 years
- High Pittsburgh Scale (highly significant/p value= 0.001) with cut off value of ≥1.13
- Large AVM volume (highly significant/p value= 0.001) with cut off value of ≥3.7 cc
- High Prescription Dose (highly significant/p value= 0.035) with cut off value of ≥23.5 Gy
- High Integral dose (highly significant/p value= 0.001) with cut off value of ≥125.7 mJ
- Parietal and frontal location (highly significant/p value= <0.001)

<table>
<thead>
<tr>
<th>Items</th>
<th>Edema Radiological occurrence</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Range Median</td>
<td>Range Median</td>
</tr>
<tr>
<td>Age</td>
<td>15 72 35 5 63 29</td>
<td>0.006**</td>
</tr>
<tr>
<td>Pittsburgh Scale</td>
<td>0.5 2.1 1.3 0.4 2.1 0.8</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td>AVM Volume</td>
<td>0.5 14 4.5 0.4 11.5 1.7</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td>Treatment Prescription Dose</td>
<td>16 35 25 16 25 25</td>
<td>0.035*</td>
</tr>
<tr>
<td>Treatment Isodose</td>
<td>40 60 50 44 65 50</td>
<td>0.632</td>
</tr>
<tr>
<td>Treatment Integral dose</td>
<td>17.8 289.7 143 13.4 225.2 57.4</td>
<td>&lt;0.001**</td>
</tr>
<tr>
<td>Treatment Cover</td>
<td>87 99 93 80 100 93</td>
<td>0.467</td>
</tr>
</tbody>
</table>
Seizures after gamma knife treatment

Follow up of patients who presented with seizures showed that 27 patients (67.5%) became seizure free (Engel grade 1), 9 patients (29.7%) had rare seizures (Engel grade 2) and only one patient (2.7%) showed no improvement (Engel grade 4). Follow up of patients presenting with seizures for more than one year (24 patients) showed that 17 patients (67.5%) became seizure free (Engel grade 1), 7 patients (29.7%) had rare seizures (Engel grade 2).

DISCUSSION

Management of cerebral AVMs remains a major challenge. Currently, there are different methods available including microsurgery, radiosurgery, embolization, and their combinations. Different problems related to each method make the selection of treatment strategy difficult. Radiosurgery has been found to be one of the most effective treatments for cerebral AVMs.

Hemorrhage rates

By studying the natural hemorrhage rate of AVM the pre-radiosurgical annual hemorrhage rate was calculated in our study to be 2.3%. Ondra et al published their landmark study that prospectively followed untreated patients with AVM for 24 years and reported an annual bleeding rate of 4%\(^30\). Additional studies from Yen et al.\(^50\), Crawford et al.\(^4\), Itoyama et al.\(^13\) the annual hemorrhage rate was 2% and from Yamane et al.\(^48\) it was 4.2% led to the generally accepted 2% to 4% natural hemorrhage rate of cerebral AVM so the cumulative risk of hemorrhage is considered significant because the disease usually manifests itself in adolescents.

It has been reported that patients would be at a higher risk of hemorrhage after a prior hemorrhage\(^4\). In our study the pre-radiosurgical annual rebleeding rate was calculated to be 12% while Yen et al.\(^50\) reported it to be 10.4%. Forester reported that patients who had bled once had a 25% chance of rebleeding in 4 years and those who had bled twice had a 25% chance of rebleeding within 1 year.\(^8\)

In our series the post-radiosurgical annual bleeding rate before cure was 1.5%. Yen et al reported it to be 2.5%\(^50\). This compared to the 2-4% annual bleeding rate reported for the natural course of patients with untreated AVMs in our study and others\(^30,4,13\). The majority of these hemorrhages occurred in patients who had previously hemorrhaged before treatment (80%). The post-radiosurgical annual rebleeding rate in our study was 1.9%. Yen et al reported it to be 2.5%\(^50\). This compared to 11.3% the Pre-radiosurgical Annual rebleeding rate in our study.

AVM obliteration

Complete angiographic obliteration efficacy documented in this study was 87%. The following table (Table 4) shows the rates of complete AVM obliteration in other series.

<table>
<thead>
<tr>
<th>Author</th>
<th>Modality of treatment</th>
<th>Year</th>
<th>No. of patients</th>
<th>Efficacy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Izawa (^14)</td>
<td>GK</td>
<td>2005</td>
<td>237</td>
<td>54.9</td>
</tr>
<tr>
<td>Maruyama (^26)</td>
<td>GK</td>
<td>2005</td>
<td>500</td>
<td>91</td>
</tr>
<tr>
<td>Reyns(^38)</td>
<td>LINAC</td>
<td>2007</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Kiran(^39)</td>
<td>GK</td>
<td>2007</td>
<td>103</td>
<td>87</td>
</tr>
<tr>
<td>Karlsson(^17)</td>
<td>GK</td>
<td>2007</td>
<td>133</td>
<td>62</td>
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<tr>
<td>Liščák(^32)</td>
<td>GK</td>
<td>2007</td>
<td>330</td>
<td>92</td>
</tr>
<tr>
<td>Javalkar(^15)</td>
<td>GK</td>
<td>2009</td>
<td>37</td>
<td>46.5</td>
</tr>
<tr>
<td>Kim(^19)</td>
<td>GK</td>
<td>2010</td>
<td>44</td>
<td>34.1</td>
</tr>
<tr>
<td>Yen(^40)</td>
<td>GK</td>
<td>2010</td>
<td>186</td>
<td>58.6</td>
</tr>
<tr>
<td>Sun(^45)</td>
<td>GK / LINAC</td>
<td>2011</td>
<td>127</td>
<td>64</td>
</tr>
<tr>
<td>Blamek(^2)</td>
<td>LINAC</td>
<td>2011</td>
<td>62</td>
<td>35.5</td>
</tr>
<tr>
<td>Our series</td>
<td>GK</td>
<td></td>
<td>108</td>
<td>87</td>
</tr>
</tbody>
</table>

In our series we found that the major factors associated with AVM obliteration were:

1. Small AVM volume (highly significant/p value=0.052), this finding is consistent with those in other reported series.\(^3,5,9,32,33\).
2. Low Pittsburg Scale (Pollock-Flickinger score) highly significant/p value= 0.019, this finding is consistent with those in other reported series.\(^46,37\).
3. Frontal, ventricular and cerebellar location (highly significant/p value= <0.001), this is explained by the fact that these locations are away from critical areas so AVMs in these locations were treated by the full prescription dose and high cover.
4. No previous embolization (highly significant/p value= <0.001).
Other treatment modalities

The rate of AVM complete obliteration in different series using embolization alone is shown in the following table (Table 5). The purpose of embolization of an AVM nidus prior to radiosurgery is reduction of AVM volume to facilitate the radiosurgery and minimize the risks. Mathis et al.\textsuperscript{27} reported that combined embolization and stereotactic radiosurgery was more efficacious than radiosurgery alone for large brain AVMs. Pollock et al.\textsuperscript{38} did not find an association between obliteration and prior embolization, while Kano et al.\textsuperscript{16} reported that prior embolization reduces the rate of total obliteration after radiosurgery and that the latency interval hemorrhage risks were not affected by prior embolization. This could be partially explained if we know that the rate of recanalization after embolization was reported in series to be from 7 to 20%\textsuperscript{5,12,38}.

In our series we found that prior embolization reduce the rate of total obliteration after radiosurgery which could be explained by the difference in radiation attenuation of the embolization materials such as Onyx compared to water which was determined by Sihra et al.\textsuperscript{42} to be 3% for beam energy of 6 MV, AVM recanalization after embolization which was also reported in different series\textsuperscript{7} and also embolization provides difficulty in target definition. Yet, there is still controversy about the efficacy of embolization prior to radiosurgery.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>No. of patients</th>
<th>Efficacy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katsaridis\textsuperscript{38}</td>
<td>2008</td>
<td>101</td>
<td>27.7</td>
</tr>
<tr>
<td>Panagiotopoulos\textsuperscript{31}</td>
<td>2009</td>
<td>82</td>
<td>24.4</td>
</tr>
<tr>
<td>Pierot\textsuperscript{30}</td>
<td>2009</td>
<td>5</td>
<td>8.3</td>
</tr>
<tr>
<td>Gao\textsuperscript{3}</td>
<td>2009</td>
<td>88</td>
<td>26.1</td>
</tr>
<tr>
<td>Maimon\textsuperscript{24}</td>
<td>2010</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>Lv\textsuperscript{23}</td>
<td>2011</td>
<td>147</td>
<td>19.7</td>
</tr>
<tr>
<td>Xu\textsuperscript{47}</td>
<td>2011</td>
<td>86</td>
<td>18.6</td>
</tr>
<tr>
<td>Saatci\textsuperscript{41}</td>
<td>2011</td>
<td>350</td>
<td>51.1</td>
</tr>
</tbody>
</table>

While the rate of AVM complete obliteration in different series using surgery alone is shown in the following table. (Table 6)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>No. of patients</th>
<th>Efficacy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malik\textsuperscript{25}</td>
<td>1996</td>
<td>156</td>
<td>95.8</td>
</tr>
<tr>
<td>Pikus\textsuperscript{39}</td>
<td>1998</td>
<td>72</td>
<td>98.6</td>
</tr>
<tr>
<td>Pik\textsuperscript{35}</td>
<td>2000</td>
<td>110</td>
<td>98.8</td>
</tr>
<tr>
<td>Solomon\textsuperscript{41}</td>
<td>2000</td>
<td>86</td>
<td>90.7</td>
</tr>
<tr>
<td>Stapf\textsuperscript{44}</td>
<td>2002</td>
<td>240</td>
<td>89</td>
</tr>
<tr>
<td>Morgan\textsuperscript{29}</td>
<td>2004</td>
<td>220</td>
<td>98.6</td>
</tr>
<tr>
<td>Lawton\textsuperscript{21}</td>
<td>2005</td>
<td>224</td>
<td>98</td>
</tr>
</tbody>
</table>

The high results of complete AVM resection in the previous series were usually associated with high morbidity and mortality as in Lawton et al. series 20.1 % of patients deteriorated while 6.7% of patients died. In other series with high cure rate and low morbidity and mortality as in Morgan et al., the overall surgical morbidity rate was 0.9%, and the mortality rate was 0.5%, which is considered less than other series and this can be explained by the fact that the series only involve patients with Spetzler-Martin Grade I or II AVM\textsuperscript{29}, also Pik et al. only operated on AVMs smaller than 3 cm in diameter\textsuperscript{35}.

Radiosurgery and seizures

In our series follow up of patients presented with seizures showed that 27 patients (67.5 %) become seizure free (Engel grade 1), 9 patients (29.7%) have rare seizures (Engel grade 2) and only one patient (2.7%) showed no improvement (Engel grade 4). While Follow up of patients presented with seizures for more than one year (24 patients) showed that 17 patients (67.5 %) become seizure free (Engel grade 1), 7 patients (29.7 %) have rare seizures (Engel grade 2).

Adverse Radiation Effects

The risk of a radiation injury resulting in a permanent neurological deficit is 2%–10% in most gamma knife reports. In a multicenter retrospective study, Flickinger et al.\textsuperscript{6} reported that the risk of permanent AREs in patients with cerebral AVMs was 6.3%, Izawa et al. reported 9.3%\textsuperscript{14}, Maruyama et al. reported 3%\textsuperscript{26}, Karlsson et al. reported 3%\textsuperscript{17}, Liščák et al. reported 2.7%, Yen et al. reported 3.2%\textsuperscript{49}.

In the present series, 4 patients (3.7%) developed permanent neurological deficits due to AREs. Four patients (6%) experienced temporary neurological symptoms or signs. Neurological deficits due to AREs included visual field defect but no total loss of vision (in 3 patients),
hemiparesis (in 1 patient). In the present series, factors associated with a higher rate of symptomatic AREs included higher Pittsburgh Scale (p value= 0.001), Larger AVM volume (p value= 0.001), high integral dose (p value= 0.001), old age (p value= 0.006), high prescription dose (p value= 0.035) and parietal and frontal location (highly significant/p value= <0.001).

CONCLUSION

Gamma knife radiosurgery for AVMs is an effective treatment modality. We were able to treat all patients with both ruptured and unruptured malformations and reached excellent or good clinical outcome in 96% of our patients, with a 87% angiographic obliteration. Larger or deeply located AVMs showed less favorable outcomes in terms of lower obliteration rates and more adverse radiation effects.

The present study provides further evidence that patients with AVM remain at risk for hemorrhage as long as the nidus is patent after radiosurgery. However, radiosurgery seems to reduce the hemorrhage rate during the latency period. This phenomenon is more prominent in patients who present with hemorrhage before GKS.

REFERENCES


43. Solomon R. A., E. S. Connolly, Jr., C. J. Prestigiacomo, A.G. Khandji, and J. Pile-Spellman. 'Management of


Comment

The authors report Gamma Knife Radiosurgery for treatment of 108 patients having AVMs of the brain. The obliteration rate was 87% and the complication rate was 8%; half of them were hemorrhages and the other half (AREs) with persistent neurological disorder.

The epilepsy control rate was 67.5%. These results are satisfactory and compare very well to most of the published data.4,2

The authors utilized the Pittsburgh Scale in evaluating the results and this is a common practice for stereotactic Radiosurgery of AVMs. The Gold Standard for grading AVMs from the surgical point of view is Spetzler-Martin grading system3. Patients in grade I and II can get very satisfactory results from surgical treatment. Also patients having high flow Fistula or associated aneurysm are better treated by surgery4.

The high grade AVMs (Spetzler-Martin) are a real problem to single modality treatment. Neither Gamma Knife Treatment alone nor surgery or endovascular treatment can treat these cases. The multimodality approach is the only way for proper management.1

Prof. Dr. Ahmed Issa
Professor of Neurosurgery
Cairo University

References