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Clinical Article

Clinical features and management of brain arteriovenous malformations in elderly patients

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Summary

Background. Brain arteriovenous malformations (AVMs) of the elderly have not received sufficient attention, given the increase in age of individuals in recent years. We therefore designed a retrospective study to clarify features of brain AVMs in this age group in comparison with their counterparts in the general population.

Methods. A retrospective study was performed, based on data for AVMs treated in Nara Medical University Hospital and affiliated hospitals over the past 13 years. The series included all cases of brain AVMs, except for pure dural AVMs, diagnosed from June 1989 to June 2003. A total of 175 patients were diagnosed as having an AVM during this period, including 32 patients more than 60 years old. Clinical features and effective treatment of brain AVMs in those over and under 60 were explored and outcome at 3 to 6 months after surgery was evaluated according to a modified neurological scale.

Findings. The most common mode of presentation was intracranial hemorrhage in both groups, and this was remarkable in the elderly. Epilepsy at presentation was less frequent in the elderly ($P < 0.05$). In the elderly group infratentorial lesions were encountered more frequently ($P < 0.05$). Good or excellent outcomes of surgery were accomplished in 82.6% of the non-elderly group, and in 69.6% of the elderly group. When restricted to the grades I or II of Spetzler and Martin (S & M) grading, postoperative neurological scores of both groups were significantly better than preoperative values ($P < 0.01$). In the grade III cases, the non-elderly demonstrated significant improvement after surgery ($P < 0.01$), but the elderly did not.

Interpretation. Elderly patients with a brain AVM had clinical features of less frequent epileptic presentation and more frequent infratentorial lesions. It was suggested that surgery was acceptable in elderly patients with pallial AVMs of grade I and II. Surgery for grade III AVMs of the elderly remains to be clarified.

Keywords: Arteriovenous malformation; brain; elderly patient; surgery.

Introduction

Arteriovenous malformations (AVMs) of the brain are congenital vascular lesions with characteristic clinical and radiological features. The lesions sometimes manifest remarkable growth in children and but occasionally become reduced in size, even disappearing later in life [8, 18, 34, 35]. Although occasionally seen in the elderly they mostly become symptomatic by the fourth decade [20, 26]. Autopsy data suggest that as few as 12 percent of AVMs are symptomatic during life [21]. Although malformation-related hemorrhage accounts for only 1–2 percent of all strokes [11, 23, 26], when hemorrhage occurs, the combined risk of permanent neurological deficit and death is approximately 50% [2, 3, 10, 12, 13, 25, 26].

Treatment for brain AVMs includes such options as microsurgery, radiosurgery, embolization, or combinations of these. The final decision about the most appropriate treatment for any patient with AVM will obviously take into account many factors, such as age, neurological status, associated clinical risk factors, and angio-architectural features of the lesion. Advanced age has long been considered a limiting factor for surgical excision [17, 20, 36]. However, the predominance of hemorrhagic presentation in the elderly suggests that the natural history of this disease in the aged is not as benign as previously thought [6, 13–16, 19]. Elderly populations in developed countries are growing at an extraordinary rate [4, 32] and advances in imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) are increasing the number of AVMs detected, including asymptomatic or subclinical lesions. Since brain AVMs in this generation have not been studied in detail, we therefore conducted

the present retrospective analysis focusing on AVMs in the elderly to clarify clinical features and effective treatments.

Methods and patients

All patients diagnosed as suffering from a brain AVM at Nara University Hospital or affiliated hospitals from June 1989 to June 2003 were registered in the current study: pure dural AVMs and AV fistulas, cavenous angioma, and venous angioma were excluded. The diagnosis of brain AVM in each case was confirmed by cerebral angiography, MR imaging, or surgical findings and histology.

One hundred and seventy five patients were found to harbor brain AVMs during this period. The elderly group, arbitrarily defined as those more than 60 years old, accounted for 32 cases and the non-elderly group 143 cases. Both groups were comparatively evaluated with regard to the location of the lesion, mode of clinical presentation, treatment modality, and surgical outcome. The AVMs were allocated into subgroups according to the Spetzler and Martin (S & M) grading system [28].

Surgical outcomes were analyzed according to the following neurological scale. The neurological score system simplified by Morgan *et al.* [22] was used to evaluate pre- and postoperative neurological states of patients: pre- and postoperative scores in each case were determined at the time of diagnosis and at 3 to 6 months after surgery, respectively. The neurological score system was divided into 4 categories: Grade 1 was normal examination for age; Grade 2 was the presence of a neurological deficit but independence with regard to mobility; Grade 3 was the loss of independent mobility; Grade 4 was death.

Statistical analysis

Categorical variables were compared by Fisher's exact two-tailed test or the chi-square test. Ordinal variables were calculated using the Mann-Whitney U-test or Wilcoxon signed rank test.

Results

Characteristics of the elderly patients

A total of 32 patients with ages ranging from 60 to 82 years at presentation were identified. Thirty-one had no history of presentation related to AVMs and the other had 5 previous episodes of hemorrhage. Liver cirrhosis, mild liver dysfunction, coexistent cerebral hemorrhage, and acute subdural hemorrhage were noted as accompanying illnesses in 4 patients. Twenty-nine of the 32 had some symptoms and signs related to AVMs at diagnosis. These patients underwent CT and/or MRI. Cerebral angiography was performed and provided a definite diagnosis of AVM in 29 of the 32. The other three were identified as having angiographically occult AVMs during surgery, subsequently proven by histological examination.

Twenty-one of the 32 patients had ruptured AVMs; 17 presented with cerebral or cerebellar hemorrhage, 3 with subarachnoid hemorrhage (SAH), and 1 with intraventricular hemorrhage. Two patients with unruptured AVMs complained of intractable pulsatile headaches. The other four presented with transient ischemic attacks. Eleven presented with symptoms unrelated to hemorrhage; 4 with transient ischemic attack, 2 with intractable pulsatile headaches, 1 with disorientation, 1 with convulsions, and 3 incidentally.

Microsurgical removal of AVMs was performed for 23 patients. None of these underwent preoperative embolization procedures since the AVMs were less than 3.5 cm in size and straightforward. Complete excision of the lesions was confirmed by intra-operative and/or postoperative angiography in 20 of the 23 cases. The other three were identified as angiographically occult AVMs during surgery and were confirmed by histological examination. After surgery, 16 of the 23 (69.6%) patients demonstrated an excellent or good outcome (full work capability or independent daily life with only minor deficits) with a superior status 3 months postsurgery than on admission. Four patients suffered significant postoperative complications; one died due to a pulmonary embolus 2 weeks postsurgery with no change in the neurological state, and the other three remained moderately disabled due to a delayed vasospasm and postoperative hemorrhage. Epilepsy occurred postsurgery in one case although controllable with anticonvulsant medication. Four patients underwent radiosurgery, preceding embolization having been performed in one of these, but two of the AVMs thus treated were not yet obliterated at follow up angiography 3 years later (Table 1).

Comparison of the elderly with the non-elderly

According to the S & M grading there were 29 grade I (20.3%), 54 grade II (37.3%), 42 grade III (29.4%), 11 grade IV (7.7%), and 7 grade V (4.9%) cases in the non-elderly, and 5 grade of I (15.7%), 17 of grade II (53.1%), 9 of grade III (28.1%), and 1 of grade IV (3.1%) in the elderly. Supratentorial lesions accounted for 128 (89.5%) in the non-elderly group, and infratentorial lesions for 15 (10.5%). The elderly group included 24 (75%) supratentorial and 8 (25%) infratentorial lesions. The elderly group thus had a higher rate of infratentorial lesions with statistical significance ($P < 0.05$). Patients presented with intracranial hemorrhage, convulsions, neurological deficits or arbitrary symptoms including pulsatile headaches, and in some detection was incidental. In the non-elderly group there were 87 cases (60.8%) of intracranial hemorrhage, 25 (17.5%) of convulsions, 25 (17.5%) of neurological deficits, and 6 (4.2%) of incidental detection; there were 21 (65.6%) of intracranial hemorrhage, 1 (3.1%) of convulsions, 7 (21.9%) of neurological deficits

Table 1a. *Summary of elderly patients aged more than 60 with brain arteriovenous malformation**

Patient no	Age/sex	Presentation	Location	Size (cm)	S & M grading [28]	Management	Neurological score preop./postop. [22]	Complication	Others
1	75 M	ICH	Rt. frontal	2.5	1	surgery	3/1		thrombosed AVM
2	65 M	convulsion	Lt. frontal	2	1	surgery	2/1		cerebral aneurysm
3	72 M	ICH	Lt. parietal	1.5	2	surgery	3/2	convulsion	
4	65 M	ICH	corpus callosum	2.5	3	surgery	3/4	pulmonary embolism	
5	64 M	ICH	Rt. parietal	3	2	surgery	3/1		
6	60 M	ICH	Rt. frontal	2.5	2	surgery	3/3		
7	61 M	ICH, SAH	cerebellum	2.5	2	surgery	3/2		cerebral aneurysm
8	65 F	SAH	Lt. temporal	2	2	surgery	2/1		
9	65 M	SAH	Rt. CP angle	1	3	surgery	3/3	vasospasm	cerebral aneurysm
10	62 F	ICH	cerebellum	2	2	radiosurgery			
11	62 M	TIA	tectal plate	1.5	3	radiosurgery			
12	60 M	Pulsatile headache	Lt. CP angle	3	3	radiosurgery embolization			

* *ICH* Intracerebral hemorrhage; *SAH* subarachnoid hemorrhage; *TIA* transient ischemic attack; *Rt.* Right; *Lt.* Left; *CP* angle cerebello-pontine angle; *S & M* grading Spetzler-Martin grading; *Preop.* preoperative; *Postop.* postoperative; *AVM* arteriovenous malformation.

Table 1b. *Summary of elderly patients aged more than 60 with brain arteriovenous malformation**

Patient no	Age/sex	Presentation	Location	Size (cm)	S & M grading [28]	Management	Neurological score preop./postop. [22]	Complication	Others
13	68 F	incidental	Lt. frontal	1.5	1	surgery	1/1		
14	70 F	TIA	Lt. frontal	2	1	surgery	1/1		
15	74 M	ICH	Rt. frontal	2.5	2	surgery	2/2	postoperative hemorrhage	thrombosed AVM
16	81 M	TIA	Lt. frontal	2.5	2	radiosurgery			
17	61 F	pulsatile headache	Lt. frontal	3.5	3	surgery	2/1		cerebral aneurysm
18	70 F	ICH	Rt. parietal	2	2	surgery	2/2		thrombosed AVM
19	60 M	ICH	Rt. temporal	2	2	surgery	2/1		
20	75 M	IVH	Lt. temporal	4	4	observation			
21	68 F	ICH	Lt. insula	2.5	2	surgery	3/3		
22	79 M	SAH	Rt. CP angle	2	3	observation			expired
23	82 M	incidental	Rt. trigone	3	3	observation			
24	67 M	ICH	Rt. trigone	2.5	3	surgery	3/2		
25	67 M	ICH	Rt. insula	3	2	surgery	3/2		

* *TIA* Transient ischemic attack; *ICH* intracerebral hemorrhage; *IVH* intraventricular hemorrhage; *SAH* subarachnoid hemorrhage; *Rt.* Right; *Lt.* Left; *CP* angle cerebello-pontine angle; *S & M* grading Spetzler-Martin grading; *Preop.* preoperative; *Postop.* Postoperative; *AVM* arteriovenous malformation.

and 3 (9.4%) of incidental detection in the elderly. The most common mode of presentation was intracranial hemorrhage in both groups, and it was more remarkable in the latter. Convulsions as the presenting symptom were less often encountered in the elderly ($P < 0.05$) (Table 2).

143 patients of the non-elderly group, 92 (64.3%) underwent microsurgery, with preoperative embolization in 23. Twenty-seven (18.9%), 6 with embolization, underwent radiosurgery. Twenty-four (16.8%) were conservatively observed. In the 32 patients of the elderly group, 23 (71.9%) underwent microsurgery. Four (12.5%), 1 of whom was given embolization, underwent radiosurgery. Five (15.6%) were conservatively observed, one of whom died (Table 3).

Table 1c. *Summary of elderly patients aged more than 60 with brain arteriovenous malformation*[*]

Patient no	Age/sex	Presentation	Location	Size (cm)	S & M grading [28]	Management	Neurological score preop./postop. [22]	Complication	Others
26	75 M	TIA	Rt. frontal	2	2	surgery	2/2		
27	66 M	disorientation	Lt. frontal	2.5	2	surgery	2/2		
28	82 M	incidental	cerebellum	2	2	observation			
29	66 M	ICH	cerebellum	2.5	2	observation			cerebral aneurysm
30	66 M	ICH	Lt. frontal	3	3	surgery	2/3	postoperative hemorrhage	
31	74 M	ICH	Lt. temporal	2	2	surgery	3/2		
32	78 M	ICH	Rt. frontal	1.5	1	surgery	3/2		

[*] *ICH* Intracerebral hemorrhage; *SAH* subarachnoid hemorrhage; *TIA* transient ischemic attack; *Rt.* Right; *Lt.* Left; *CP* angle cerebello-pontine angle; *S & M* grading Spetzler-Martin grading; *Preop.* preoperative; *Postop.* postoperative; *AVM* arteriovenous malformation.

Table 2. *Baseline characteristics in patients with brain AVMs*

Characteristic	No. of patients (%)	
	Non-elderly group	Elderly group
Number of patients	143 (81.7)	32 (18.3)
Mean age in years ⟨range⟩	32.2 ⟨7–59⟩	68.9 ⟨60–82⟩
Spetzler & Martin grading [28]		
I	29 (20.3)	5 (15.7)
II	54 (37.7)	17 (53.1)
III	42 (29.4)	9 (28.1)
IV	11 (7.7)	1 (3.1)
V	7 (4.9)	0 (0)
Clinical presentation		
Intracranial hemorrhage	87 (60.8)	21 (65.6)
Convulsion	25 (17.5)	1 (3.1)[§]
Neurological deficits	25 (17.5)	7 (21.9)
Incidental	6 (4.2)	3 (9.4)
Supratentorial/Infratentorial location	128 (89.5)/ 15 (10.5)	24 (75)/8 (25)[§]

AVM Arteriovenous malformation, [§] $p < 0.05$.

Table 3. *Management and surgical outcome in patients with brain arteriovenous malformations*

Characteristic	No. of patients (%)	
	Non-elderly group	Elderly group
Management of patients		
Microsurgery	92 (64.3)	23 (71.9)
Radiosurgery	27 (18.9)	4 (12.5)
Observation	24 (16.8)	5 (15.6)
Surgical outcome		
Good or excellent outcome	76/92 (82.6)	16/23 (69.6)

Surgical outcome

Overall, good or excellent outcomes, defined as full work capability or independent daily life with only minor deficits, were accomplished with surgery in 82.6% of the non-elderly group, and in 69.6% of the elderly group (Table 3).

According to the above noted neurological scale, pre- and postoperative neurological scores at various levels were assessed to compare surgical outcomes of both groups. In all surgical cases in the non-elderly the preoperative neurological score with a mean of 2.21 was higher than the postoperative 1.70 ($P < 0.001$). This was also found for all surgical cases of the elderly, with mean scores of 2.43 and 1.91, respectively. Surgical outcomes of grade I or II of S & M grading were comparatively studied. In the non-elderly group, the postoperative neurological score with a mean of 1.52 improved from the preoperative score with a mean of 2.03 ($P < 0.001$). In

Table 4. *Pre- and postoperative neurological scores [22] in patients with a brain AVM who underwent surgery*

Characteristic	Preoperative score (mean)	Postoperative score (mean)	P value
All surgical cases of the non-elderly	(2.21)	(1.70)	<0.001[*]
All surgical cases of the elderly	(2.43)	(1.91)	0.005[**]
Surgical cases of the non-elderly of grade I or II	(2.03)	(1.52)	<0.001[*]
Surgical cases of the elderly of grade I or II	(2.32)	(1.68)	0.002[**]
Surgical cases of the non-elderly of grade III	(2.43)	(1.93)	0.001[**]
Surgical cases of the elderly of grade III	(2.6)	(2.6)	>0.999

Ordinal variables were calculated using Wilcoxon signed rank test.
AVM Arteriovenous malformation, [*] $p < 0.001$, [**] $p < 0.01$.

Table 5. *Postoperative neurological score in patients with a brain AVM who underwent surgery*

Variable	Non-elderly	Elderly	P value
Postoperative score in cases of grade I or II (mean)	(1.52)	(1.68)	0.248
Postoperative score in cases of grade III (mean)	(1.93)	(2.6)	0.160

Ordinal variables were calculated using the Mann-Whitney U test. *AVM* Arteriovenous malformation.

the elderly group, postoperative neurological score with a mean of 1.68 improved from preoperative neurological score with that of 2.32 ($P<0.01$). With grade 3, the postoperative score with a mean of 1.93 improved from the preoperative score with that of 2.43 in the non-elderly ($P<0.001$), but the neurological score of the elderly did not improve after surgery (Tables 4, 5).

Discussion

Incidence of AVMs

AVMs of the brain may behave variably according to the age of patients and consequently, it is difficult to precisely evaluate their natural history. Pathological evidence indicates the occurrence of multiple subclinical hemorrhages which do not reach clinical significance [20]. This suggests that a considerable number of AVMs, small AVMs in particular, are asymptomatic or subclinical without being correctly diagnosed. The number of detected AVMs, including asymptomatic lesions, is growing as neuro-imaging techniques evolve, and management decisions need to be made.

In Yasagil's series of AVMs, only 13 patients (2.6%) out of 500 were older than 60 years of age [37]. In another surgical series, 13% of the surgically treated patients with parenchymal AVMs were 60 years of age or older [19]. In the current study, cases in individuals aged over 60 accounted for no less than 32 (18.3%) in a total of 175. With hospitalization, 31 of the 32 could be correctly diagnosed without any previous history of lesions. Since all cases with intracranial hemorrhage were very carefully investigated for the cause, particularly by angiography, this might have contributed to the finding of lesions in the elderly. There are several reasons why AVMs of the elderly might previously have been presumed unusual. Before the era of MRI, ICH of the elderly does not seem to have received much attention. Small AVMs are difficult to diagnose correctly without angiography even though MRI has facilitated their identification. Elderly patient's sustaining ICH might not necessarily be appropriately referred to a neurosurgical clinic because of advanced age. With the aging of the general population, and the widespread availability of noninvasive diagnostic tools and therapeutic modalities, more elderly patients with intracranial AVMs would attract neurosurgical attention. Elderly patients clearly constitute a significant proportion of those with intracranial AVMs.

Clinical features of the elderly to the non-elderly

In the present study very few elderly patients were high grade in the S & M grading. In the elderly most of the lesions were small to medium size, in line with the expectation that a large AVM would be diagnosed at a young age. The proportion of infratentorial lesions in the elderly was no less than 25% compared to 10.5% in the non-elderly, and the difference was statistically significant. Whether this reflects physiological changes remains to be clarified. Supratentorial lesions may be prone to be detected until patients are advanced in years so that those have more epileptic presentations than infratentorial lesions.

In our study the most frequent presentation was intracranial hemorrhage in both groups, especially in the elderly. Twenty-one of the 32 elderly patients presented with hemorrhage associated with AVMs. It has been suggested that after 40 years of age the likelihood of bleeding rapidly declines, irrespective of any prior history [20]. However, the authors did not describe how many elderly patients were included and how long they were followed up. The conclusion that the risk of bleeding declines in the elderly might simply be based on the infrequency of the diagnosis in elderly patients with AVMs. Crawford *et al.* [6] reported that the older the individual at diagnosis, the greater the risk of hemorrhage during follow-up. Of their 24 patients over the age of 60, eight had a hemorrhage during follow-up. The risk was 89% after 9 years as compared with 15% in the same period if aged 20 to 29. Brown *et al.* [3] also noted 20% of hemorrhages related to intracranial vascular malformations to occur in patients over 60 years of age. Thus the available evidence suggests that patient's age at diagnosis is of importance as a risk factor for hemorrhage. Therefore, it is possible that a considerable number of elderly patients presenting with parenchymal hemorrhage who are conservatively treated without any exploration might in fact harbor AVMs. There clearly need to be more pertinent studies to resolve clinical aspects of AVMs in the elderly.

Epilepsy as a presentation was prominent in the non-elderly with only one patient affected in the elderly group, in line with the earlier finding that the younger the patient at diagnosis, the more likely they are to develop epilepsy during follow-up [6]. Although patients seldom suffered first seizures after the age of 50, a number of patients suffer their first hemorrhage in advanced years [14–16, 19]. Although pulsatile headache was arbitrarily grouped into neurological deficits without hemorrhage in the current series, the proportions did not significantly differ between the two groups. An excess of small AVMs in patients presenting with hemorrhage has been reported, with an excess of large lesions amongst patients with epilepsy [6]. Whereas AVMs more often tend to enlarge at a young age [8, 18, 20, 33], they seem to reach a stable size and occasionally decrease after middle age [20]. The sizes were less than 4 cm in all the elderly cases of our series but this is complicated by the fact that patients harboring a large AVM are unlikely to be symptom-free until the age of 60 years.

Management of AVMs

Elderly patients have been managed conservatively based on the assumption that brain AVMs would have a more benign course in this group [17, 20]. Neurological state and age of AVM patients certainly would be factors of importance in deciding whether surgery should be performed [17]. Benign neglect, endovascular treatment, and stereotactic radiation therapy have been suggested as methods of management that may be safer than surgical excision for AVMs in the elderly [7, 29, 30]. However, this may be based on a bias rather than objective evidence. Therefore, we conducted the present retrospective study in order to determine whether surgery can provide any benefit in the management of brain AVMs of the elderly.

In the current study pallial supratentorial AVMs of grade I, II and III were generally treated by surgery, or embolization and surgery. Radiosurgery was performed in most of deep supratentorial, brain stem and cerebellopotine angle AVMs. Grade IV and V AVMs were observed if those neither developed frequent episodes of hemorrhage nor progressive neurological deterioration. Elderly patients with a poor neurological status or severe accompany illness were observed. Two of 3 patients aged more than 80 years old also were observed since they had less years of life at risk; the other one insisted on undergoing radiosurgery. Our series included some cases in whom a treatment-decision depended on patient's preference. Thus, there was a selection bias in deciding who would be observed or treated by surgery or radiosurgery.

There have been a number of arguments in favor of treatment for small AVMs. Luessenhop and Rosa [20] insisted that mortality and morbidity rates were lower than the reasonably projected natural risk, so that most cases were candidates for surgery. Whether small AVMs of the brain should be treated by microsurgery or radiosurgery has lately given rise to much controversy [31]. The risks of radiosurgery include intracranial hemorrhage during the latency period, delayed neurological deficits, and failure to obliterate the AVM [1, 5, 9, 27]. There is a 5 to 7% risk of treatment-related complications [24]. With regard to radiosurgery for elderly patients with AVMs, data are limited. There are some AVMs for which microsurgery is clearly not an option, primarily on the basis of location in difficult-to-access areas. In elderly patients considered high-risk surgical candidates due to associated medical conditions or to the location of the AVMs, stereotactic radiosurgery may represent an excellent alternative to surgical excision although this needs confirmation.

In making decisions it is very important to assess whether the probable deficit from surgery exceeds the natural deterioration that would occur during the patient's remaining lifetime. In our study good or excellent outcomes of surgery were achieved in 82.6% of the non-elderly group, and in 69.6% of the elderly group. Surgical outcomes of both groups were comparable and satisfactory, when restricted to grade I or II of S & M grading. All grade I AVMs of the elderly managed surgically had excellent outcomes. Only 1 patient (7.7%) of 13 with grade II AVMs of the elderly operated on suffered a surgical complication. Life expectancies of Japanese men and women are presently 76.6 and 83.82 years, respectively [4]. If the annual rate of hemorrhage in AVMs of the elderly is assumed to be 3%, those patients have a hemorrhage-risk of 30% in a follow-up of 10 years. Surgery for AVMs of the elderly has to surpass a natural course estimated for these conditions. Thus, these results suggest that surgery for grade I and II pallial AVMs of the elderly should be acceptable.

Five elderly patients with grade III AVMs underwent surgery with the results being inferior to the counterpart. The mean preoperative score for elderly patients was 2.6 compared to 2.43 for non-elderly patients in this class; elderly patients presented with a poor neurological status than non-elderly patients. That may account for their

diminished potential for recovery. This small number of patients did not provide any conclusive answer. It seemed that management for elderly patients with grade III AVMs should be individualized.

Conclusions

Elderly patients with a brain AVM have clinical features of less frequent epileptic presentation and more frequent infratentorial location. It is suggested that surgery is acceptable in elderly patients with pallial AVMs of grade I and II. Surgery for grade III AVMs of the elderly remains to be clarified.

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Comment

Hashimoto *et al.* describe their experience with intracranial arteriovenous malformations (AVMs) and make interesting comparisons between non-elderly and elderly populations. They conclude that in the elderly population, surgery for grade III AVMs is unwarranted based on their morbidity and mortality profile. Their conclusions imply that surgical treatment of grade I and II AVMs may be of only marginal benefit compared to the natural history because the life expectancy of this older population is limited.

The mean preoperative neurological score for non-elderly patients was 2.21 compared to 2.43 for elderly patients. Based on Table 2, elderly patients were more likely to present with haemorrhage (65.6 v. 60.8%), extremely less likely to present with seizures (3.1 v. 17.5%), and more likely to present with neurological deficits preoperatively (21.9 v. 17.5%) than non-elderly patients. Therefore, these data indicate that the elderly population is more severely affected *at presentation* that the non-elderly population. Their postoperative status will therefore play a significant role in their potential for recovery since the more neurologically impaired patients are from their AVM before surgery, the less likely their neurological status will improve significantly. It is just as reasonable to conclude from these data that elderly patients with AVMs present with a poorer neurological status than non-elderly patients. This statement may account for their diminished potential for recovery compared with the non-elderly. It is difficult to determine whether patients with worse outcome would have fared any ''better without treatment. That is, *were* neurological deficits due to the direct act of surgery or were they residual sequelae of a devastating haemorrhage? If the latter is true, it is unfair to attribute their poor outcomes to surgery.

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