Conservatively treated patients with cerebral arteriovenous malformation: mental and physical outcome

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SUMMARY Twenty five patients with conservatively treated cerebral arteriovenous malformation were followed up for a mean of 10.6 years after diagnosis. The follow up included neuropsychological examination. Bleeding did not occur after the time of diagnosis. Three patients had moderate to severe neurological deficits, five had moderate to severe intellectual impairment. Nineteen had an unaffected occupational status. It is concluded that the outcome in conservatively treated patients may be no worse than in surgically treated patients.

Surgical versus conservative treatment of cerebral arteriovenous malformation (AVM) is still a matter of dispute. According to Svien and McRae¹ conservative treatment is appropriate for 80% of the patients. Yet in many centres the proportion of the surgically treated is substantially larger, from about 35% to 90%²⁻⁹ (table 1). In the Cooperative study¹⁰ the rate of surgically treated patients was about 45% of 415 AVMs. With refinement of the surgical technique this proportion may increase.

Results of follow-ups, some of which are shown in table 1, are difficult to interpret, partly because of different selection criteria and differences in analysis.

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Table 1 Results of previous studies

Author		Op./unop. No of cases	Follow up years	Outcome (%)			
				Operated		Unoperated	
				Severe disability	Dead	Severe disability	Dead
Troupp ²	1965	40/60	5.2 mean	—	—	13	14
Moody ³	1970	97/8	>3	22	14	0	20
Morello ⁴	1973	88/44	1-22	7	9	18	18
Trumpy ⁵	1977	42/47	9.1 mean	21	12	21	19
Pelletieri ⁶	1980	119/47	10.5 mean	15	13	36	17
Guidetti ⁷	1980	95/50	2-25	80*	6	57*	20
Abad ⁸	1983	70/42	4.8 mean	3	12	41	20
Fults ⁹	1984	48/83	8.2 mean	6	19	3	23

Op. = operated. Disability in percentage of operated and unoperated groups. *All degrees of disability included.

turbances have been reported, as by Svien and McRae¹ and Lange-Cosack.¹⁴ Systematic neuropsychological examination has been carried out in only a few studies. Thus Waltimo and Putkonen¹⁵ reported psychological test results of 40 patients with intracerebral or meningeal AVM. Presumably the test was performed shortly after the onset of symptoms, except in patients with initial haemorrhage when the test was postponed 4 years. It is not clear whether some of the patients underwent operation before the testing. Constans and Assal¹⁶ examined six patients with surgically treated AVM, three of these before surgical intervention. Finally Carter *et al*¹⁷ reported psychological examination of an AVM patient with intellectual impairment prior to and improvement following excision of AVM. The purpose of the present study is to evaluate the physical, mental and social status of a mainly nonselected group of conservatively treated patients with AVM, the mental condition being assessed by neuropsychological testing.

Material and methods

Patients

From the record files in the Copenhagen county hospitals, Gentofte and Glostrup, we identified all patients fulfilling the following criteria.

- (1) Intracerebral arteriovenous malformation proved by arteriography (or by necropsy if death from subarachnoid haemorrhage occurred before arteriography was performed) and without coexisting arterial aneurysms.
- (2) Time of diagnosis from 1 January 1960 to 31 December 1979.
- (3) Permanent address in the Copenhagen county at the time of diagnosis (600,000 inhabitants).

A total of 47 patients fulfilled the criteria. Excision of the AVM was performed or attempted in nine patients. Eight of these underwent surgery because of concomitant intracerebral haematoma (actually excision was performed on four patients and ligation of feeding vessels on two). Only one patient underwent elective excision in a hospital outside the county. Three died shortly after the onset of symptoms, all from the initial subarachnoid haemorrhage (SAH). Five of the remaining 35 patients died more than one year after diagnosis, but before the follow-up. One died from SAH, and one in status epilepticus. The cause of death in one patient was unrelated to AVM, and in two was unknown. One patient could not be traced.

Thus 29 unoperated patients were alive at follow-up. Four of these patients refused participation, but we were informed that two were well without physical or mental handicaps, one received disablement pension, and one was intellectually impaired but otherwise healthy. The remaining 25 unoperated patients participated in the follow-up. This re-examination group consisted of 14 males and 11 females. Mean age at the onset of symptoms was 29 years (range 4–63 years). Mean duration from the onset of symptoms to diagnosis was 4 years (range 0–46 years). Mean duration from the onset of symptoms to follow-up was 15 years (range 4–60 years). Mean age at the follow-up was 44 years (range 19–71 years).

Neurological evaluation

At the re-examination an accurate neurological history was taken and physical and neurological examination carried out. CT and intravenous radionuclide angioscintigraphy were performed. Scintigrams and CT scans have been presented in a previous report.¹⁸

Neuropsychological evaluation

The neuropsychologists undertook the neuropsychological investigation without knowledge of the results of the neurological/physiological studies. The two psychologists tested 10 and 15 patients respectively.

The psychological investigation consisted of a clinical interview and a thorough neuropsychological testing. The purpose of the interview was to obtain information on the patients' background (educational and occupational career) and current condition (neuropsychological symptoms and occupational status). As a part of the interview the patients answered a questionnaire about neuropsychological symptoms.

Three kinds of psychological tests were used. (1) Tests to evaluate intelligence (including subtests of the verbal part of the WAIS). (2) Tests to evaluate possible general impairment in intellectual functioning (including the complete standard neuropsychological battery from the Copenhagen University Hospital, Rigshospitalet).¹⁹ (3) Tests to evaluate possible dysfunctioning in specific cognitive areas (including memory tests, tests for aphasia, and visuo-spatial tests).

The patients were very heterogeneous with respect to background variables like education, age and disease story, and therefore the neuropsychological evaluation was based on both clinical judgment and a comparison with the results of a study of normal Danish subjects.²⁰ The two psychologists discussed and agreed upon a final evaluation of all patients. This evaluation included an estimation of intelligence, general intellectual impairment and symptoms of specific dysfunctioning in visuo-spatial and verbal tests.

Results

The localisation and size of AVMs were assessed by arteriography (small: diameter <2 cm; medium: diameter 2–4 cm; large: diameter >4 cm). The results are summarised in table 2 and correlated to the three types of symptom onsets, namely intracranial haemorrhage (SAH/intracerebral haematoma), epilepsy and neurological deficits (usually hemiplegia or aphasia).

At the time of onset of symptoms, three patients had slightly affected consciousness (11–12 on the Glasgow coma rating scale) and two patients had more pronounced affection (4 respectively 6 on the Glasgow coma rating scale). Within 6 days the level of consciousness was normal in all patients.

The AVM was diagnosed at the onset of symptoms in 12 of 13 patients with initial SAH. One was diagnosed after a rehaemorrhage 7 years later. Four patients with initial SAH later developed epilepsy. Epileptic seizures were the first symptom in eight patients. Two of these later suffered from SAH and one developed a hemiparesis. Neurological deficits

Table 2 Data of 25 conservatively treated patients with AVM

Case No	Sex	Age at symptom onset (yr)	Age at follow up (yr)	Onset symptom	Angiographic findings			Neuropsychological findings	
					Size	Side	Local.	Intellectual impairment	Cognitive dysfunction
1	M	4	20	SAH	large	R	P	slight	visuo-spatial
2	F	9	68	neurolog.deficit	medium	L	P	moderate	verbal
3	F	11	19	SAH	medium	L	C	moderate	visuo-spatial
4	M	11	20	SAH	medium	L	CE	none	none
5	M	12	22	SAH	medium	R	F	none	verbal
6	F	16	19	SAH	large	R	C	slight	visuo-spatial
7	F	18	30	SAH	small	R	P	none	none
8	M	19	26	SAH	large	L	P	none	verbal
9	F	20	54	epilepsy	small	R	T	slight	visuo-spatial
10	F	24	30	SAH	medium	R	O	slight	visuo-spatial
11	F	25	55	neurolog.deficit	medium	L	P	slight	none
12	M	26	32	neurolog.deficit	medium	R	P	severe	none
13	M	26	49	epilepsy	large	R	P	slight	visuo-spatial
14	F	27	54	epilepsy	large	R	F	none	none
15	F	31	42	epilepsy	large	R	T	slight	visuo-spatial
16	F	35	43	epilepsy	large	L	P	none	none
17	M	35	51	epilepsy	large	L	T	none	none
18	M	38	50	epilepsy	large	R	T	severe	none
19	F	38	55	epilepsy	small	R	P	none	visuo-spatial
20	F	39	49	SAH	large	L	F	none	none
21	M	39	50	SAH	large	R	CE	none	visuo-spatial
22	F	47	64	SAH	small	L	P	severe	verbal
23	F	59	66	neurolog.deficit	medium	L	T	slight	visuo-spatial
24	M	61	71	SAH	large	R	T	slight	none
25	M	63	68	SAH	small	R	T	slight	visuo-spatial

SAH = subarachnoid haemorrhage. R = right. L = left. F = frontal. T = temporal. P = parietal. O = occipital. C = central (deep structures). CE = cerebellar.

were the mode of presentation in four patients. Two of these later developed SAH and one developed epilepsy. During the period from diagnosis to the follow-up (264 patient-years) no episodes of SAH occurred.

Neurological status

Neurological symptoms at follow-up are described in table 3 (patients with previous epilepsy but without seizures during the last 5 years are not included in the group suffering from epilepsy). The epilepsy was adequately treated in all patients and the frequency of seizures was less than one every 6 months. Three patients showed moderate to severe neurological deficits. Eleven patients had neither epilepsy nor neurological deficits. CT and angioscintigraphy were not able to detect the small AVMs (lesions with a

diameter less than 2 cm on the original arteriograms). CT showed cerebral infarct in 7, localised atrophy in 5, diffuse atrophy in 5 and hydrocephalus in 1 patient. As mentioned above, these results have been elaborated and discussed in detail in a previous article.¹⁸

Neuropsychological status

The intelligence level of eight patients was estimated to be above average, the level of 14 patients was average, and the level of the remaining three patients was estimated to be below average.

Evaluated on this background five patients showed signs of severe general intellectual impairment. Of the remaining patients 10 had symptoms of slight impairment while 10 showed no signs of intellectual impairment.

In table 4 intellectual impairment is related to factors that may be important for the development of this condition. Onset symptoms, level of consciousness at onset/time of diagnosis, size and localisation of AVM, onset age, and duration from onset to follow-up. No obvious correlation between these variables was found. In all the five patients with severe general intellectual impairment CT showed positive findings. Three patients had diffuse cerebral atrophy, one patient had hydrocephalus, and one patient had sequelae from cerebral infarction. In two of the remaining 20 patients CT showed diffuse cerebral atrophy, but these patients showed no signs of general intellectual impairment. Using the evaluation of

Table 3 Symptoms at follow up in relation to symptom onset

Onset symptom	Follow up symptom			
	Epilepsy	Neurological deficits		
		Slight	Moderate	Severe
Haemorrhage (13)	3	3	1	1
Epilepsy (8)	5	3	0	0
Neurological deficits (4)	0	3	0	1
Total	8	9	1	2

The total number of patients with each onset symptom in brackets.

Table 4 Intellectual impairment in relation to different disease parameters

	General intellectual impairment				
	None	Slight	Moderate	Severe	Total
Onset symptom					
Haemorrhage	6	5	1	1	13
Epilepsy	4	3	0	1	8
Neurological deficits	0	2	1	1	4
Consciousness (at onset/diagnosis)					
Normal	8	8	2	2	20
Slightly affected	2	1	0	0	3
Severely affected	0	1	0	1	2
Size of AVM					
Small	2	2	2	1	7
Medium	2	3	0	1	6
Large	6	5	0	1	12
Localisation					
Right	5	8	0	2	15
Left	5	2	2	1	10
Age (yr) at onset					
≤20	4	3	2	0	9
21-40	6	4	0	2	12
>40	0	3	0	1	4
Years from onset to follow up					
3-9	2	4	1	1	8
10-19	7	3	0	2	12
≥20	1	3	1	0	5
Total	10	10	2	3	25

visuo-spatial and verbal functions, the patients were classified into three groups. One group with visuo-spatial dysfunctions, one with verbal dysfunctions, and finally patients with no signs of specific dysfunctions. In 15 patients the AVM was in the right side of the brain and in 10 in the left side. Of the patients with right-sided AVM nine had visuo-spatial dysfunctions and of the patients with left-sided AVMs three had verbal dysfunctions. Perhaps it is more remarkable that of the 15 patients who actually had specific dysfunctions, only three patients showed dysfunctions that were not in agreement with traditional assumptions about hemispheric functions.

Occupational status

Table 5 shows that occupation was unaffected by AVM in 19 patients. Of these patients 11 were full-time employed, one was part-time employed, one was a housewife, two were unemployed, three were students, and one was receiving old age pension. Six patients received disablement pension because of AVM. Two of these patients received the pension because of purely physical handicaps while four of the patients received the pension because of both physical and mental dysfunctioning.

Of the patients with severe intellectual impairment two received disablement pension, one had no employment, one was a student (secondary school level), and one was an unskilled worker. The last mentioned patient and one who received pension had

Table 5 Occupational status before and at follow-up

	Before diagnosis	At follow-up
Full time	12	11
Part time	2	1
Housewife	3	1
Unemployed	0	2
Disablement pension	1	6
Old age pension	0	1
Education	7	3

a history of drug and alcohol abuse, and this may of course be a partial or full explanation of the bad results in the neuropsychological testing.

Discussion

Cerebral arteriovenous malformation is a relatively rare abnormality. In the present material the incidence was 47 of 600,000 inhabitants in the county of Copenhagen during 20 years (0.4/100,000/year). Only nine of the patients were operated on (eight because of intracerebral haematoma). Compared with other studies our group of conservatively treated patients must be considered relatively unselected, since elective extirpation of AVM was performed in only one patient (in a hospital outside the county).

The incidence, sex, size and localisation of AVM and type of initial symptom do not differ from the results of other studies. Because of the relatively small number of patients, a statistical analysis of the correlations between the anatomical characteristics and the physical symptoms has not been performed.

The essential purpose of the present study was to evaluate the longterm risk of developing intellectual impairment and to evaluate the influence of physical and mental dysfunction on occupational status. To our knowledge, a thorough assessment of these parameters has not been carried out previously.

Only three patients had more severe neurological deficits. The epilepsy was acceptably treated in all eight patients as the seizure frequency was less than one seizure every 6 months and thus in no way disabling.

The following factors might be of importance in the development of intellectual impairment in patients with cerebral AVM.

- (1) Sequelae from haemorrhage (for example cerebral infarction, hydrocephalus).
- (2) Steal-phenomena caused by increased blood-flow in the AVM resulting in insufficient blood-flow in other parts of the brain.
- (3) Frequent and severe epileptic seizures.
- (4) Type of initial symptom and initial level of consciousness.
- (5) Duration of symptoms.
- (6) Age at the time of onset of symptoms.

Ten patients had signs of slight intellectual

impairment and only five had more severe impairment (in two of these patients the severe intellectual dysfunctioning may be related to drug and alcohol abuse). Thus, our results show that severe intellectual deficits are rare in AVM patients, and this conclusion is supported by both the results of Waltimo and Putkonen¹⁵ and Constans and Assal.¹⁶ However, differences in patient populations and neuropsychological methods make detailed comparisons with our results unreasonable.

In four of the five patients with more severe intellectual impairment CT findings may partially or fully explain the intellectual deficits (one patient with hydrocephalus and three patients with diffuse cerebral atrophy). Apart from this, no relation was found between general intellectual impairment and the above mentioned factors.

Fifteen patients showed signs of specific cognitive dysfunctions. Twelve of these showed the expected relation between the type of dysfunction and anatomical site of the lesion. Lack of relation between cognitive dysfunctions and the site of the lesion may be caused by steal-phenomena.

The occupational status of 19 patients seemed unaffected by deficits in their physical and intellectual functioning while six patients received disablement pension because of sequelae of AVM. It should be noted that three patients with severe intellectual impairment did not receive disablement pension.

We have performed a thorough physical, psychological and social evaluation of 25 relatively unselected patients with unoperated AVM. From our results we must conclude that only about 25% of these patients will be socially disabled in the long run, 10% because of physical dysfunction and 15% because of both physical and psychological dysfunctions. These fairly good results should be considered when evaluating the indication for operation in patients with AVM.

A systematic neuropsychological comparison of surgically and conservatively treated patients would indeed increase our knowledge of the factors of importance in dealing with the difficult question, when should there be surgical or conservative treatment of patients with cerebral arteriovenous malformation.

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