

Surgical Excision of Intracranial Arteriovenous Malformations after Preoperative Embolisation with N-Butylcyanoacrylate

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Abstract

The aim of this study was to determine the usefulness of preoperative embolisation of intracranial arteriovenous malformations (AVMs) with N-Butylcyanoacrylate (NBCA) since the introduction of this interventional neuroradiology technique in March 1994 at Tan Tock Seng Hospital, Singapore.

Twenty-one patients who underwent complete surgical excision of their AVMs (proven on postoperative angiograms) were studied. Eight patients had preoperative embolisation with NBCA prior to surgical excision of their AVMs. Thirteen patients had excision of their AVMs without preoperative embolisation and these were used as the control group.

The parameters studied were the patient's AVM characteristics, the amount of blood loss and the length of operative time. Statistically significant reduction in blood loss occurred in Spetzler and Martin Grade 3 and 4 AVMs but not in Grade 1 and 2 AVMs undergoing preoperative embolisation with NBCA. Operative time was reduced in Grade 3 and 4 AVMs but not in Grade 1 and 2 AVMs, although this was not statistically significant.

Preoperative embolisation of AVMs is hence a useful and important adjunct in the management of patients with Grade 3 and 4 AVMs of the brain undergoing conventional open microneurosurgery.

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Key words: Blood loss, Interventional neuroradiology, Operative time

Introduction

Intracranial arteriovenous malformations (AVMs) are congenital malformations which become symptomatic usually by the age of 40.¹ These are direct but primitive communications between otherwise normal arteries and veins.¹ They are about one-seventh as frequent as intracranial aneurysms.² Courville³ quoted an incidence of 1:1000 for AVMs in autopsies. They usually present with either haemorrhage or epilepsy.⁴ The annual bleeding rate is 2% to 3% and the annual mortality rate is 1%.⁴ Bleeding is the main cause of mortality and 23% of these patients die as a direct result of bleeding.⁵ The treatment of this disease has improved with advances in neurosurgery, neuroradiology, neuroanaesthesia and radiosurgery. Linac-based stereotactic radiosurgery or Gamma-knife radiosurgery has also been shown to be useful in

the treatment of AVMs, but this is usually reserved for AVMs located in deep cortical locations and with a diameter of less than 3 cm.⁶ Open surgery is still the gold standard and the treatment of choice for the majority of AVMs as complete excision eliminates the future risk of rebleeding.⁷

Neuroradiology has greatly improved the diagnosis of neurosurgical disease in general, but in intracranial AVMs, interventional neuroradiology has also greatly aided the treatment of this condition. The first endovascular approach to treating AVMs was described by Luessenhop and Spence in 1960.⁸ Since then improvement in catheters and embolic agents have made endovascular therapy a useful preoperative adjunct. It was observed that with preoperative embolisation, surgical excision of AVMs could be done more effectively

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with shorter anaesthesia time, clearer resection margin and decreased blood loss with decreased need for blood transfusion.⁹

The aim of this study was to confirm these observations in our own local setting and to obtain some quantitative evaluation of the benefit of preoperative embolisation, studying the parameters of intraoperative blood loss and length of operative time.

Materials and Methods

This is a retrospective study done by the Department of Neurosurgery, Tan Tock Seng Hospital, in collaboration with the section of Neuroradiology, Department of Radiology, Tan Tock Seng Hospital. The period of study was from January 1992 to December 1996.

The cases studied were all intracranial, intraparenchymal brain AVMs that had surgical excisions done for the first time. It did not include operations for residual AVMs from previous operations. Dural AVMs were also excluded as they are of a separate aetiology and morphology from classical brain AVMs.

Each of the cases was reviewed and the details entered into our study protocol. Blood loss and operative time were easily retrieved from the anaesthetic chart. The AVMs were graded by a single experienced interventional neuroradiologist (FH) to ensure consistency. This grading was based on the Spetzler and Martin grading system for AVMs which considers 3 factors: the size of the AVM, its venous drainage and the eloquence of the surrounding brain⁷ (Table I). The total score ranges from Grade 1 to Grade 5 in ascending order of complexity and difficulty. Postoperative angiograms were also reviewed and those with postoperative residual AVMs were excluded from our study.

The data on age, sex, presentation and location of AVM were collected. A total of 21 patients were studied.

TABLE I: SPETZLER AND MARTIN CLASSIFICATION OF AVM GRADE*

Grade feature	Points assigned
Size of AVM	
Small (<3 cm)	1
Medium (3 cm to 6 cm)	2
Large (>6 cm)	3
Eloquence of adjacent brain	
Non-eloquent	0
Eloquent	1
Pattern of venous drainage	
Superficial only	0
Deep	1

* Grade = [Size] + [Eloquence] + [Venous Drainage].
i.e. (1, 2 or 3) + (0 or 1) + (0 or 1)

AVM: arteriovenous malformation

The comparative part of our study involves comparing the effect of preoperative embolisation on blood loss and operative time between the group receiving preoperative embolisation and an equivalent control group not receiving preoperative embolisation.

The comparison between the non embolised and the preoperatively embolised groups would only be valid if there is a common end result for comparing completeness of the AVM excision. The gold standard for this is a postoperative angiogram confirming complete excision of the AVM.¹⁰ All the preoperatively embolised patients had postoperative angiograms done, but only those with complete excision were included in this study for comparison. Three patients with residual AVMs shown on the postoperative angiograms were excluded. Analysis of our data showed that there were cases in the non embolised group who did not have postoperative angiograms confirming completeness of AVM excision and the completeness of excision was in fact based on the surgeon's personal observation at the time of surgery itself.

We hence excluded patients without postoperative angiograms in both the preoperatively embolised and non embolised groups. Patients who had more than one operation were also excluded as the comparison would not be valid compared with those who were operated on only once.

Grade 1 and 2 patients were classified as Group A and Grade 3 and 4 patients were classified as Group B for statistical analysis as the number of patients in each grade was too small to analyse separately.

Fisher's exact test was used for statistical analysis.

Results

Between January 1992 and December 1996, there were 52 patients who underwent surgical excision of their brain AVMs in Tan Tock Seng Hospital, Singapore. Out of these, 21 cases of completely excised AVMs were found to satisfy the above criteria for inclusion in this study. Eight had preoperative embolisation and thirteen did not. Table II shows their distribution and grade according to the Spetzler and Martin Classification.

The male to female ratio was 11: 10, with a mean age of 34 years (range 17 to 56 years). The locations of the

TABLE II: NUMBER OF PATIENTS ACCORDING TO GRADES

Grade*	Embolised	Non embolised
G1	1	10
G2	2	1
G3	4	1
G4	1	1
Total	8	13

* Spetzler and Martin grading

AVMs were as shown in Table III, most being located in the parietal, temporal and frontal lobes. The most frequent mode of presentation was bleeding, followed by epilepsy, as shown in Table IV. These data are comparable to that found in other studies.⁷

Table V shows the blood loss occurring during operations for AVMs according to the grade of the AVMs. The blood loss was measured in millilitres for each grade. In Group A (Grade 1 and 2), the mean blood loss was 480 ml for both the embolised and the non embolised categories. In Group B (Grade 3 and 4), the mean blood loss was

560, and 1800 ml for the embolised and the non embolised categories respectively, and this difference was statistically significant ($P = 0.047$, Fisher's exact test).

Table VI shows the operating time for AVMs. The operating time was measured in hours for each grade. In Group A, the mean operating time was 5 hours for both the embolised and the non embolised categories. In Group B, the mean operating times were 7.2 and 12.2 hours for the embolised and the non embolised categories respectively, and this difference was not statistically significant ($P = 0.28$, Fisher's exact test).

TABLE III: LOCATION OF ARTERIOVENOUS MALFORMATIONS

Location	Number of cases
Frontal lobe	4
Parietal lobe	7
Temporal	7
Occipital	3
Total	21

TABLE IV: MODE OF PRESENTATION

Presentation	Number of cases
Bleeding	9
Epilepsy	5
Headache	4
Others	3
Total	21

TABLE V: BLOOD LOSS

Group	Grade*	Blood loss (ml)	
		Non embolised (n = 13)	Embolised (n = 8)
A	1	200	250
	1	250	
	1	250	
	1	300	
	1	300	
	1	500	
	1	500	
	1	700	
	1	1200	
	1	1600	
	2	200	250
B	2		750
	3	2100	100
	3		500
	3		600
	3		1000
	4	1500	600

*Spetzler and Martin grading

TABLE VI: OPERATIVE TIME

Group	Grade*	Operative time (hours)	
		Non embolised (n = 13)	Embolised (n = 8)
A	1	3.3	3.7
	1	3.4	
	1	3.8	
	1	4.3	
	1	4.3	
	1	5.8	
	1	6.2	
	1	6.2	
	1	7	
	1	8	
B	2	3.8	5.3
	2		5.4
	3	12	5
	3		5.5
	3		5.6
	3		7.3
	4	12.4	12

*Spetzler and Martin grading

TABLE VII: GLASGOW COMA SCALE

	Score
Eye opening	
Spontaneous	4
To speech	3
To pain only	2
No eye opening	1
Best motor response	
Obeys command appropriately	6
Localises to stimulation	5
Withdraws from stimulation	4
Abnormal flexion response	3
Abnormal extension response	2
No response	1
Best verbal response	
Orientated and appropriate	5
Confused conversation	4
Inappropriate words	3
Incomprehensible sounds	2
No verbal response	1

Total score = sum of eye opening + best motor response
+ best verbal response

With respect to outcome, the admitting Glasgow Coma Scale (Table VII) and the discharge Glasgow Outcome Scale (Table VIII)¹¹ were used. They are as tabulated in Table IX. All the patients who underwent preoperative embolisation had a full outcome score i.e. 5 on the Glasgow Outcome Scale. Similarly all the non embolised patients had a full outcome score except for one with a score of 3. This result indicates that the saving in blood loss and operative time was not done at the expense of patient care with preoperative embolisation. There was no postoperative death in this study.

Discussion

Open surgery is still the gold standard and treatment of choice for most AVMs. A complete excision eliminates the future risk of rebleeding. Embolisation is seldom the sole treatment, and even if embolisation shows complete angiographic obliteration, there is no assurance that haemorrhage cannot occur in the future.^{4*}

In contrast, radiosurgical treatment of AVMs is restricted to those less than 3 cm in diameter, and it still leaves the patient at risk of bleeding or rebleeding from the AVM until a period of about 2 to 3 years have elapsed after treatment, where there is an approximately 80% chance of the AVM obliterating.⁶

TABLE VIII: GLASGOW OUTCOME SCALE

Scale	Outcome
5	Good recovery
4	Moderate disability (disabled but independent)
3	Severe disability (conscious but disabled)
2	Persistent vegetative state
1	Death

TABLE IX: PREOPERATIVE GLASGOW COMA SCALE AND GLASGOW OUTCOME SCALE AT DISCHARGE

Embolised (n = 8)			Non-embolised (n = 13)		
Grade	GCS	GOS	Grade	GCS	GOS
1	15	5	1	15	5
2	9	5	1	15	5
2	15	5	1	15	5
3	15	5	1	15	5
3	15	5	1	14	5
3	15	5	1	15	5
3	14	5	1	14	5
4	15	5	1	12	3
			1	11	5
			1	9	5
			1	9	5
			3	13	5
			4	15	5

GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale

The advantage of preoperative embolisation of AVMs is still uncertain. Peerless¹³ wrote that “even major obliteration of the malformation with butylacrylate does not reduce the technical difficulty of sealing the small AVM vessels, nor does it reduce the risk of troublesome intraoperative and postoperative bleeding.” Samson et al¹⁴ reported that after butylacrylate embolisation, the malformation was brittle and multitentacled, making it more difficult to dissect from the brain.

Vinuela et al¹⁵ however wrote that in Grade 1 and 2 AVMs, preoperative embolisation is unlikely to make the subsequent treatment any safer. Others have written that it helps to reduce operative time and intraoperative bleeding.¹⁶ This was also found to be the case by Cromwell and Basil.¹⁷ However, these embolisations were performed intraoperatively and not preoperatively.

One of the main causes of operative morbidity in operation for AVM is blood loss and the difficulty of visualisation caused by the bleeding. Any reduction in blood loss will be helpful as it helps to reduce the requirement for blood transfusion and the time under anaesthesia. Our study showed that blood loss was significantly reduced with preoperative embolisation in Group B patients, namely those with Grade 3 and 4 AVMs. There was no statistically significant reduction in blood loss in Group A patients, namely those with Grade 1 and 2 AVMs.

Operating time was reduced from a mean of 12 to 7 hours with preoperative embolisation in Group B patients. However, this was not statistically significant and it could be due to the small number of patients that we were dealing with.

This study was done to include the transition period from when we did not have embolisation skill and facility to when it was available. This was done so that we could include in the study high grade AVMs which were operated on in the era when preoperative embolisation was not available. Even then, we only managed to recruit two patients who satisfied our strict criteria for inclusion in this study. Some were excluded because they were operated on more than once, and some were not operated on at all. It is probably now not acceptable to operate on Grade 3 and 4 AVMs without preoperative embolisation in our hospital as the embolisation service is now readily available. This also indicates the value of this retrospective study, as a prospective study of this kind is probably not feasible anymore in our hospital due to the above considerations.

The following case illustrates the usefulness of preoperative embolisation with N-Butylcyanoacrylate (NBCA). Figure 1 shows the magnetic resonance imaging scan of a patient with a left parietal AVM who presented with a seizure.

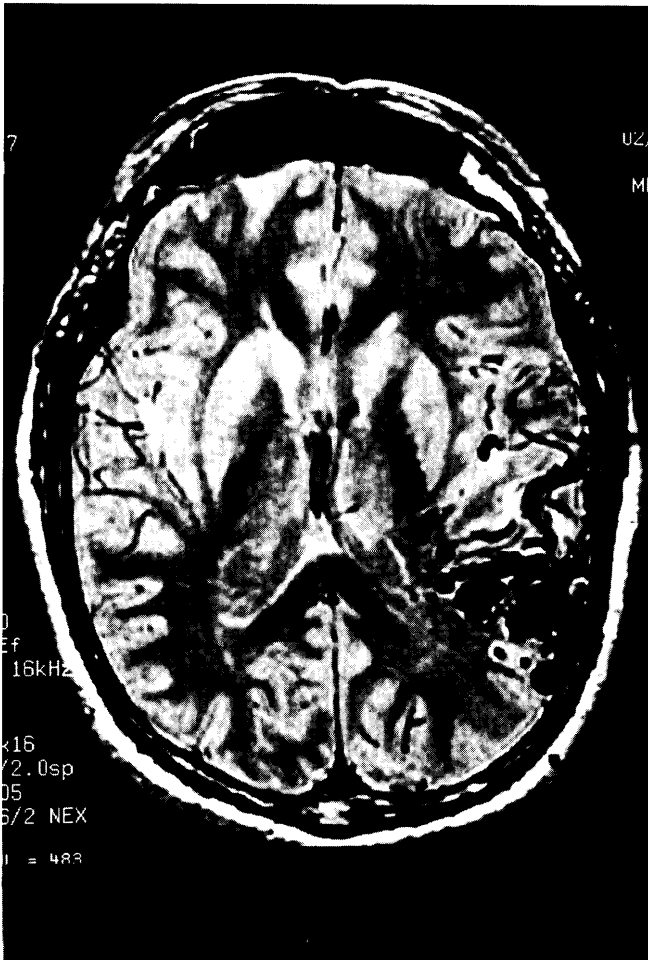


Fig. 1. The left parietal AVM on MRI scan.

Figure 2 is an angiogram showing the Spetzler and Martin Grade 3 left parietal AVM before embolisation. Radiologically, the reduction in AVM volume can be quite significant after preoperative embolisation. Figure 3 shows a reduction in size by about 80% after embolisation with NBCA. Figure 4 is a postoperative angiogram showing complete radiological disappearance of the AVM after surgical excision. This patient did very well and was neurologically intact at discharge. Intraoperative blood loss was 100 ml and operative time was 6 hours.

Conclusion

Preoperative embolisation of brain AVMs helps to decrease intraoperative blood loss in Grade 3 and 4 AVMs significantly. The mean operating time was decreased by about 50% in Grade 3 and 4 AVMs which had undergone preoperative embolisation. However, this was not statistically significant, probably due to the small number of patients.

Preoperative embolisation did not seem to help in reducing blood loss and operative time in Grade 1 and 2 AVMs. Preoperative embolisation should therefore be

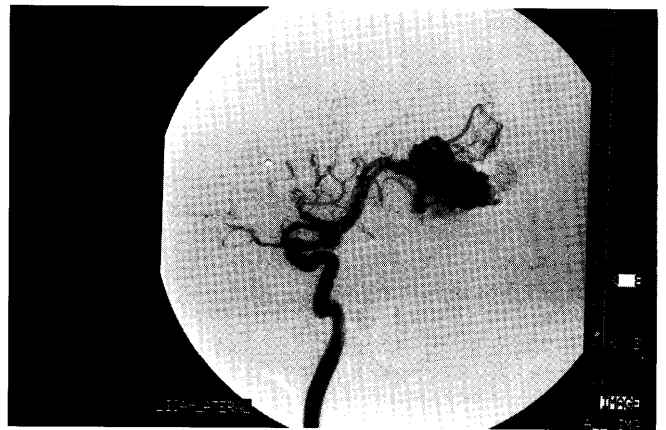


Fig. 2. Angiogram showing the arterial phase of the AVM before embolisation with NBCA.

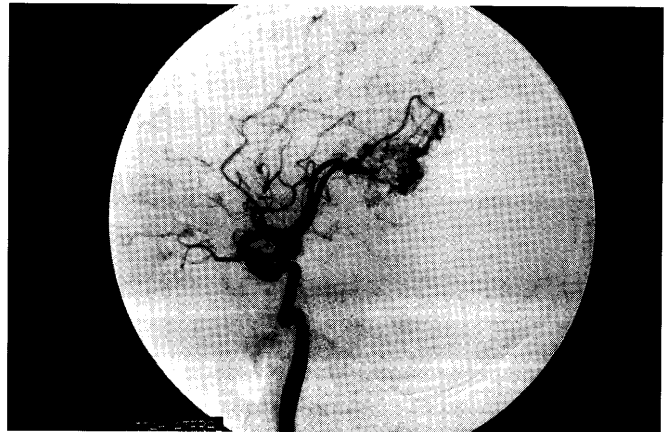


Fig. 3. Angiogram showing the arterial phase of the AVM after embolisation with NBCA.

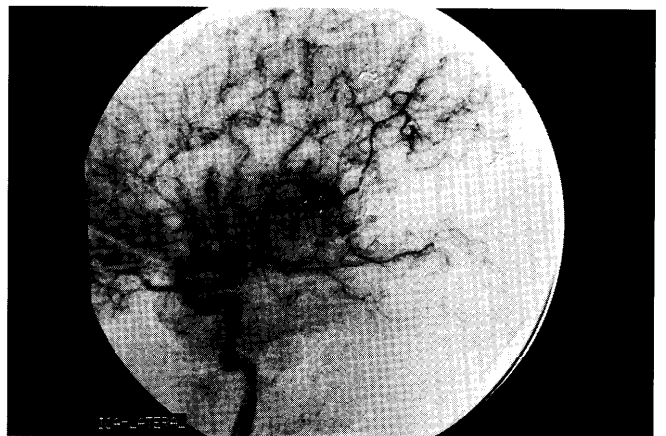


Fig. 4. Angiogram showing complete obliteration of the AVM after surgical excision.

used especially for the high grade AVMs that are usually difficult to operate on.

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