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Feasibility and outcomes of endovascular embolization of cerebral arteriovenous malformations at a low-volume centre

K Sobh[1] and **A Hegazy**[2]

[1] *Department of Neurology, Al-Azhar University, Cairo, Egypt*

[2] *Department of Neurosurgery, Cairo University, Cairo, Egypt*

Abstract

Background and purpose: Herein, we report our initial experience with the endovascular management of cerebral arteriovenous malformations (AVMs) using the liquid embolic agent Onyx and n-butyl cyanoacrylate for AVM embolization.

Methods: We reviewed data from 15 patients with brain AVMs, who were observed at our endovascular facility from January 2008 to July 2011. All cases were embolized with Onyx and/or n-butyl cyanoacrylate. There were 8 women and 7 men with a mean age of 27.2 years (range 17–43 years). The clinical presentations included intracerebral haemorrhage (n = 7), seizures (n = 4), headache (n = 2), and focal neurological deficits (n = 2); according to the Spetzler–Martin classification (Spetzler R and Martin N (1986)*J Neurosurg* **V65** 446–83), 8 AVMs were grades I–II, 5 were grade III, and 2 were grades IV–V.

Results: A total of 31 embolization procedures were performed in 15 patients, and 44 feeding pedicles were embolized, ranging from 1 to 5 per patient, with an average size reduction of 70% (median 75%, range 40–100%). Total obliteration was achieved for 3 AVMs (20%) (2 patients had single feeders and 1 patient had double feeders), and a partial embolization was achieved in 12 patients (80%). The procedure was related to a permanent disabling morbidity in one patient (6.6%), and no mortalities occurred.

Conclusions: The outcome of (AVM) embolization in our centre is comparable to the reported outcome in other larger-volume centres. The feasibility and safety of AVM embolization in our low-volume centre are similar to the outcomes reported at high-volume centre

Keywords

cerebral AVMs; Onyx; n-BCA; endovascular treatment; low-volume centres

Introduction

Treatment options for intracranial arteriovenous malformations (AVMs) include the following: radio surgery, conventional surgery, and endovascular embolization or a combination of one or more of such procedures. Endovascular techniques can be used for a curative embolization, nidus reduction before conventional surgery or radio surgery, and palliative embolization. The goal of curative embolization is the complete and permanent obliteration of the AVM nidus with the restoration of normal arterial blood flow and the preservation of venous drainage [2].

The most commonly used embolic agent is the rapidly polymerizing liquid adhesive n-butyl Cyanoacrylate (n-BCA). The use of n-BCA for brain AVMs requires experience and skill, because the intra-nidal flow and polymerization of n-BCA are both quick and largely unpredictable. After the introduction of the Onyx liquid embolic system (ev3, Irvine, CA), which is less adhesive, more slowly polymerizing and accordingly much more advantageous than n-BCA [2,4], n-BCA was largely replaced as an agent used for AVM embolization. In the current study, we report the endovascular management outcomes of AVMs in our growing low-volume centre in Egypt.

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* Correspondence to A Hegazy, Email: aahegazy71@gmail.com

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Table (1) :Patients characteristics at admission

Characteristics	No
Demographics	
Male	7
Female	8
Age (yr) (mean)	27.2 (17–43)
Presenting symptoms	
Intracerebral hemorrhage	7
Seizure	4
Neurologic deficit	2
Headache	2
SM scale	
I-II	8
III	5
IV-V	2

Table (2) :Location of brain AVMs

Location	No.
Frontal	1
Temporal	2
Parietal	2
Occipital	3
Frontoparietal	1
Temporoparietal	2
Parieto-occipital	3
Cerebellar	1

Methods

Patient demographics and clinical presentation

We reviewed data from 15 patients with cerebral AVM, who were observed at our endovascular facility at Al Hussein University Hospital between January 2008 and July 2011. The study included 8 women and 7 men with a mean age of 27.2 years (range 18–43 years). Their clinical presentations included symptoms due to intracerebral haemorrhage in 7 patients, seizure in 4 patients, headache in 2 patients, and a non-hemorrhagic neurological deficit in 2 patients. According to the Spetzler–Martin (SM) classification, 8 AVMs were grades I–II, 5 AVMs were grade III, and 2 AVMs were grades IV–V. One AVM was located in the cerebellum and 14 were located supratentorially (Tables 1 and 2).

Indications for treatment

(1) All of our patients were symptomatic with variable clinical presentations as mentioned above (Table 1).

(2) The AVM location and size, the number of arterial feeders, and the site of the draining veins were defined from MRI and angiography, and all AVMs were classified according to the Spetzler–Martin scale. Angiographic architecture was assessed to determine the nidal size (3 cm, 3–6 cm, >6 cm), nidus morphology (compact or diffuse), shunt type (plexiform fistulas or mixed), arterial feeders (numbers, direct, en passage, leptomeningeal), and venous drainage (deep, superficial number). The aim of embolization was size reduction in AVMs larger than 3 cm, enhancing surgical safety or rendering small AVMs suitable for radio surgery.

(3) AVM size reduction after embolization was estimated. Patient clinical status was assessed immediately following the embolization procedure and at follow-up visits.

Embolization procedure

We obtained informed consent from all patients before embolization. The procedures were performed by a single endovascular interventional neurologist who had more than 5-year experience. All procedures were performed under general anaesthesia (with the exception of one patient who was embolized using n-BCA only) on a unipolar angiographic unit (G.E.). Systolic blood pressure was maintained between 100 and 110 mmHg during the procedure to prevent embolic material migration to the venous side. All patients received 5,000 units of heparin intravenously followed by1,000 units per 1 l saline. The guiding catheter (Envoy, Cordis Corp.) was first positioned in the vessel that allowed AVM access (either the carotid or the dominant vertebral artery). In the case of n-BCA, the AVM nidus was accessed with a flow- directed 1.2F Balt magic micro-catheter (Target Therapeutics, Fremont, CA). Once the catheter was in the appropriate location for embolization, the dead space of the magic micro-catheter was flushed with 5% dextrose using a 3-ml syringe. A mixture of 1–3 histoacryl (B. Braun, Aesculap, Tuttlingen, Germany) in lipiodol (Guerbet, Aulney-Sous-Bois, France) was used to obliterate the nidus, depending on the flow dynamics of the AVMs.

Post-embolization angiography was performed to assess the degree of nidus obliteration. For Onyx (ev3), superselective catheterization with flow-directed micro-catheters (Marathon or Ultra Flow, ev3) and micro-guide wires (Mirage, ev3) was performed with the tip of the micro catheter placed as close as possible to the AVM nidus. The angiographic series, performed using a micro catheter with a 3-ml syringe, proved to be especially useful for ensuring a safe and optimal position. Micro-angiography (nidogram) was performed to evaluate the angio-architecture of the AVMs and illustrates the anatomy of the draining vein. The micro-catheter was flushed with normal saline and filled with DMSO.

Thereafter, 0.25 ml Onyx (ev3) was injected slowly (0.1 ml/min) into the micro-catheter. Injection beyond the catheter tip into the AVMs was monitored fluoroscopically by road mapping. In the event that a reflux >1 cm occurred around the catheter tip, we temporarily discontinued the injection of Onyx for 1–2 min to form an Onyx cast around the tip of the micro-catheter. Thereafter, we performed a second nidal penetration. The arte-

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rial compartment is typically occluded first to avoid potential bleeding that could complicate the early occlusion of venous drainage. This was accomplished by redirecting Onyx using short breaks in Onyx administration that lasted between 30 s and 1 min and thereafter injecting more of the solution. To avoid an increase in intranidal pressure, which may lead to AVM rupture, Onyx injection into the draining veins was allowed only to proceed to their origin and only after the occlusion of the arterial nidus compartment. Angiographic control was performed through the guiding catheter during the injection intervals to evaluate the residual flow to the AVMs or non-target embolization. The micro-catheter was removed by gentle increasing traction.

Follow-up observation

The patients were hospitalized in the neuro-critical care unit for 2 days after the procedure for clinical observation. Patients with complete AVM obliteration had an increased risk of retrograde thrombosis in the stump of the feeder artery. Low-molecular weight heparin was administered to these patients subcutaneously for 2 days. No anticoagulation therapy was given to patients with incomplete AVM obliteration. Patients were given a small dose of corticosteroids for a short period to prevent or reduce oedema.

Results

A total of 31 embolization procedures were performed in 15 patients, with a mean of 2.06 (range 1–5) procedures per patient. A mean of 2.92 (range 1–6) feeding pedicles were embolized per patient. An average of 4.5 ml Onyx was used per patient. Onyx 18 was used in 13 patients, and it was used in combination with n-BCA in 1 patient. Only one patient received n-BCA alone.

Angiographically, 8 AVMs were <3 cm, 5 AVMs were 3–6 cm, and 2 AVMs were >6 cm. Additionally, 13 AVMs had compact nidi and 2 AVMs had a diffuse nidus, while there were 12 plexiform AVMs, 2 mixed (plexiform-fistulous) shunt types, and 1 fistulous AVM. A total of 7 AVMs had 3 or fewer arterial feeders, whereas 8 AVMs had >3 feeders; en passage feeders were present in 5/15 AVMs. Furthermore, 13 AVMs had superficial venous drainage and 2 had deep drainage; 6 AVMs had a single draining vein and 9 AVMs had 2 draining veins. Initial complete obliteration was obtained at the end of the embolization procedure in 3/15 patients (20%), while incomplete obliteration was achieved in 12/15 patients (80%). An average volume reduction of 70% (range 40–100%) was achieved at the end of the endovascular procedure. An evaluation of AVMs volume was performed by using the method of Pasqualin *et al*[5]. A 3-month follow-up of the three initially completely embolized AVMs continued to show complete obliteration of the AVMs. At the time of follow-up, 9 patients were referred to surgery or radio surgery, 1 patient refused a follow-up angiography because of complications, and 2 patients immigrated to other countries and were lost to follow up. Additionally, 2 AVMs were completely occluded in 1 session and 1 AVM was completely occluded in 2 sessions. Complete embolization was achieved through a single pedicle in 2 AVMs and through 2 pedicles in 1 AVM. Immediate post-procedural complications were recorded in one patient who developed RT-sided hemiparesis and dysphasia; this complication most likely occurred due to Onyx reflux into an undesirable venous branch.

Case presentation

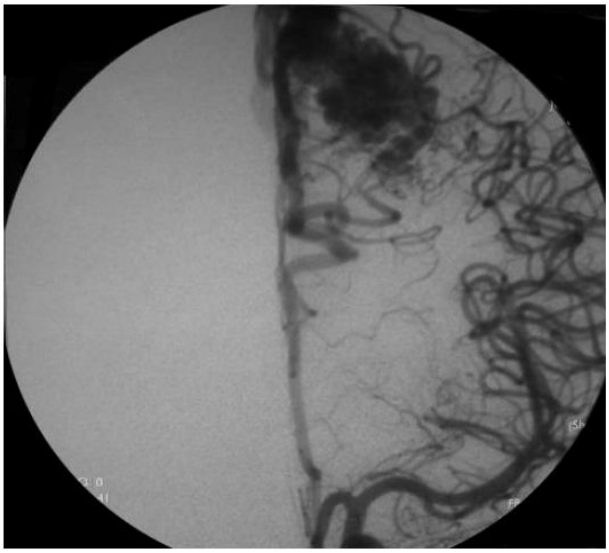
Case 1: A 35-year-old male patient presented with spastic right side weakness.

The AVM was supplied by branches from the Lt. anterior cerebral artery and drained into the posterior portion of the superior sagittal sinus. (a) Town's view, (b) Lateral view, (c) and (d) Town's view and lateral view three months after embolization, respectively.

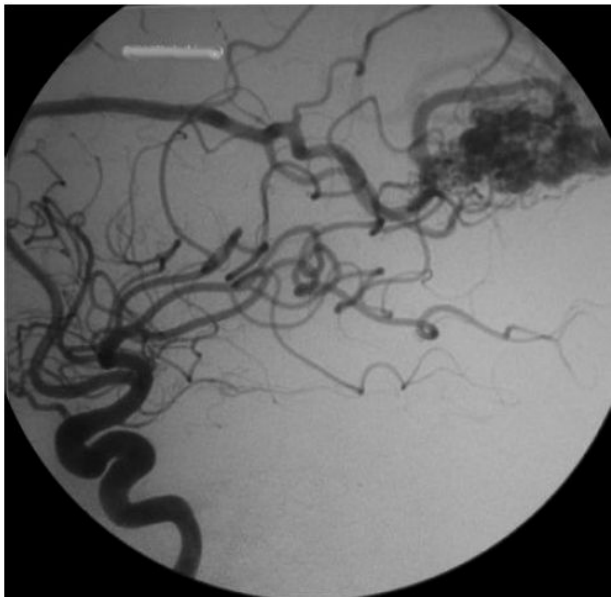
Discussion

Cerebral AVMs represent a relatively uncommon intracranial vascular disorder when compared to other intracranial vascular disorders, such as aneurysms. Accordingly, a number of authors have stated that such lesions should only be treated in highly specialized, well-equipped, high-volume referral centres. Vascular and interventional specialists question whether such demanding lesions can be treated in less-equipped, low-volume centres, and few trials have attempted to answer this question. Our study was designed to challenge this idea. Our initial results are encouraging: 20% complete obliteration and 70% volume reduction in 80% of cases, only one patient with a permanent deficit and no mortalities. These results are indicators of the feasibility and safety of management of cerebral AVMs in our low-volume, less-equipped centres, and they coincide with other results published from larger-volume centres.

In sum, 53.3% of our embolized AVMs were grade I, 33.3%were grades II–III, and 13.3% were grades IV–V according to the Spetzler–Martin's classification of AVMs. The percentage of patients in this study with grades II–III and IV–V is larger than that reported in other series [6,7]. This can be explained by the small



A.



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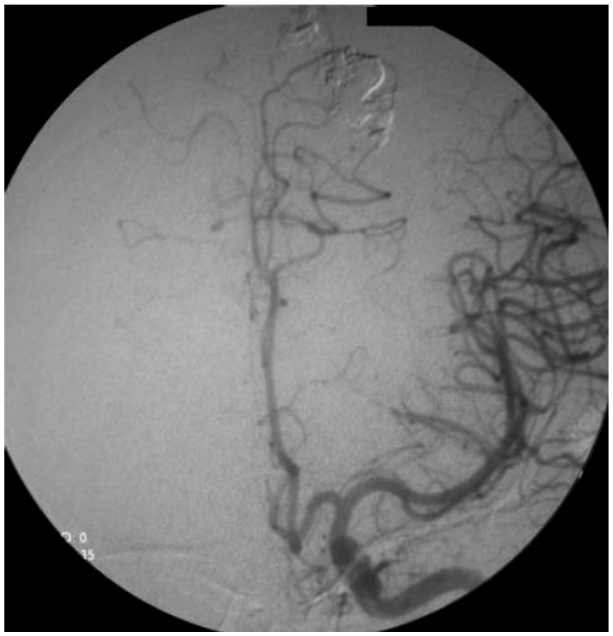

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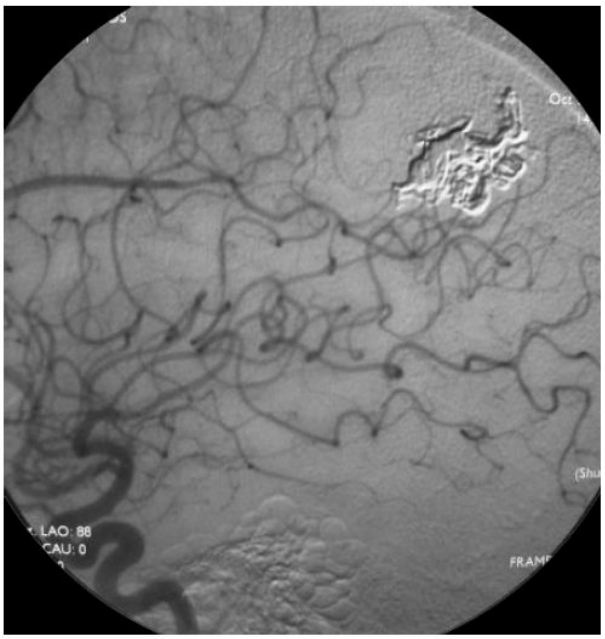

D.

number of patients in our study, but it indicates that the presence of a larger percentage of relatively more complex cases was not a hindering factor in our low-volume, less-equipped centre. It also did not have an effect on the final outcome when compared to other series.

Onyx was used as the sole embolic agent in 86.66% of our cases, and it was used in addition to n-BCA in 6.66% of cases; n-BCA alone was used in 6.66% of cases. Although Onyx is much more favoured than n-BCA by most authors [6,8], expenses can be reduced using n-BCA under very limited circumstances due to a shortage of financial resources. In our cases, there were no complications related to n- BCA use. This coincides

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with the work of others who have also used this agent [7,9].

The complete obliteration rates for AVMs reported in recent clinical series that used Onyx as an embolic agent are variable. In one series [10], 10 totally occluded AVMs (22.2%) were reported among 45 cases. Van Rooij *et al* [7] achieved complete occlusion for 7 cases of 44 (15.9%) for grades I and II AVMs, whereas Weber et al [4] reported 19 patients (20%) with completely obliterated AVMs among 93 treated patients. In a series of 70 patients [11], 13 AVMs (18.6%) were completely embolized with Onyx. In another series of 94 patients, Mounayer *et al* [12] reported an angiographic cure in 26 patients. In that series, the treatment was completed for 53 patients using a combination of Onyx and n-BCA.

In the current study, complete AVM embolization was achieved in 3 patients (20%), 2 patients had a single feeder and 1 patient had 2 feeders. Additionally, the average nidal size reduction was 70%. In most patients, the embolization sessions were sufficient to obtain a size reduction suitable for subsequent surgery or radio surgery.

No mortalities occurred in the present series. One patient had an AVM supplied by the left middle cerebral artery that received two pedicle vessels from its M3 and M4 divisions with a very high flow, an intranidal aneurysm, one en-passage vessel and two draining veins into the superior sagittal sinus; this patient developed a right-sided weakness and aphasia. The patient was neurologically intact before the intervention. During the procedure, while injecting one of the pedicle vessels, an Onyx reflux occurred in one of the cortical M4 branches. At the time of the clinical follow-up, the weakness had improved and the patient could walk with support. However, his dysphasia only partially improved (he could utter words but not sentences).

No further improvement was observed during subsequent follow-up visits. The patient refused to have another angiogram and was discharged. The patient was observed repeatedly for 1 year after discharge but unfortunately showed a persistent deficit with no signs of improvement. The incidence of permanent deficits in our study coincides with that published in other series [13].

The small number of cases in our initial experience limits our ability to draw solid statistical conclusions regarding the applicability of our experience to other low-volume, less-equipped centres. However, this is an ongoing process and we believe that with the accumulation of more cases and with an increase in our own experience, more solid statistical conclusions could be drawn to provide an answer to this question.

Conclusion and recommendations

The feasibility and safety outcomes in our low-volume centre with this small case series are similar to large-volume centres with more expertise. Accordingly, we intend to pursue this study to increase our case numbers with the intention of providing more solid statistical conclusions that would finally indicate that this study should be repeated by similar centres elsewhere.

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