Endovascular therapy of intracranial lesions: experience at Riyadh Armed Forces Hospital

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Abstract Background: Endovascular therapy ET is a technique of treatment which approaches the lesion by transvascular route, either transsatrial or transvenous.
Objectives: Describe the technique, the indications and the complications of endovascular therapy at Riyadh Armed Forces Hospital.
Methods: In the last two years, 59 patients with arteriovenous malformation (AVM), arteriovenous (AV) fistula cerebral aneurysm and intracranial vascular tumors were treated with embolization or detachable latex balloon and platinum mini-coils.
Results: Twenty-four patients had brain AVM. Total embolization was achieved in 21%, subtotal in 42%, while the remaining 37% were still on therapy. Other patients (25 with tumors, 7 with AV fistulas and 3 with giant cerebral aneurysms) had successful endovascular therapy. Complications were immediate bleeding and neurological deficit and in 8% of patients overall mortality of 1.6%.
Conclusion: ET is safe and effective in treating vascular anomalies alone or in conjunction with surgery or radiosurgery. A multidisciplinary approach is the key to success for this therapy.


KEYWORDS: Intracranial vascular tumors, endovascular therapy, embolization.

Endovascular therapy (ET) is a technique of treatment which approaches the lesion by transvascular route, either transarterial or transvenous. Initially, it was performed to devascularise tumours prior to surgical removal. The development of the microcatheters and new embolic agents has made it possible to treat arteriovenous malformations (AVMs), and arteriovenous (AV) fistulas. Detachable platinum micro-coils (Gugleimi coils) and detachable balloons are important in treating intracranial aneurysms and occluded or stenotic vessels by thromboembolism or arterial spasm.

Endovascular therapy has become an established and organized section of Neuroradiological and Neuroscience Services at Riyadh Armed Forces Hospital since 1990. We present our experience in this new therapeutic technique in our institution during the last two years and also discuss the indications of the procedure, the techniques, and the possible complications. Illustrative cases are presented.

Patients and methods Between February 1992 and December 1993, 59 patients with vascular malformations and vascular tumors were treated by means of ET. The variety of lesions treated and number of patients are summarized in Table 1.

Technical Procedure All cases were discussed by a special multidisciplinary team of neurosurgeons, neurology, neurophysiology and neuroradiology consultant who evaluated the patients and monitored their outcome. Embolization procedures were carried out via percutaneous transfemoral approach under local anesthesia. General anesthesia was used only in non-cooperative patients and children. Dexamethasone was given for a period of 5 days, starting the day prior to the procedure, to prevent
and reduce cerebral edema, which may occur after the procedure. The feeding vessels were superselectively catheterized with a micro-catheter allowing access to the lesions. Brain AVMs were embolized with liquid embolic material (N-butylcyanoacrylate) which was injected directly into the nidus. Hypervascular tumors were embolized preoperatively with a mixture of Ivalon (polyvinyl alcohol) particles or alcohol absolute. In a limited number of cases, histoacryl was also used. Patients with carotid cavernous (CC) fistulas and aneurysms were treated with detachable latex balloon and platinum mini-coils.

Table 1:

<table>
<thead>
<tr>
<th>Patients treated with endovascular therapy</th>
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<tbody>
<tr>
<td>Cerebral AV malformation</td>
<td>24 (42%)</td>
</tr>
<tr>
<td>Fistulas</td>
<td>7 (11%)</td>
</tr>
<tr>
<td>Spontaneous</td>
<td>2</td>
</tr>
<tr>
<td>Traumatic</td>
<td>5</td>
</tr>
<tr>
<td>Tumors</td>
<td>25 (15%)</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>3 (32%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>59 (100%)</td>
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</tbody>
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1. **AVMs** Superselective embolization of brain AVMs was undertaken in 24 patients (4 women and 20 men); mean age 37 (12-63) years. Embolization, as a definitive treatment, is performed to completely obliterate the abnormal vascular network. The technique is performed either as a sole treatment or as an adjunct to surgery or radiosurgery to reduce the size of the malformation, to occlude the fistula and to decrease the flow. We treated all patients in whom embolization was considered technically feasible, regardless of operability, size and location of malformation. Brainstem AVMs is the only malformation we did not treat due to the high risk of complications. Clinically, 14 (58%) patients presented with hemorrhage, 8 (33%) with seizures, and 2 (8%) with progressive neurological deficit. Total embolization was achieved in 5 (21%), subtotal in 10 (42%), 3 patients had surgical resection of the residual nidus and 7 were treated with radiosurgery (Linac). The remaining 9 (37%) are still continuing the treatment.

**a. Total embolization**

Case 1. A 12-year-old boy presented with intraventricular hemorrhage one month prior to treatment. Computerized tomography (CT) and magnetic resonance (MR) revealed a medium-sized AVM located in the right hippocampal gyrus. Angiographic study demonstrated the supplying arterial feeder to arise from branches of the posterior temporal artery of the right posterior cerebral artery and the presence of multiple cortical draining veins. Embolization was performed in one session and the malformation was totally obliterated. (Fig 1)

**Figure 1a:** Left vertebral artery angiogram, Towne projection. A medium-size AVM supplied by multiple feeders arises from the posterior temporal branch of the right PCA. Multiple cortical draining veins drain into the sigmoid sinus.

**Figure 1b:** 3 months post-embo, follow-up vertebral artery angiogram shows complete obliteration of the malformation.
b. Subtotal embolization

Case 2. A 26-year-old male presented with seizures and severe headaches for 2 years. MR revealed a large vascular malformation in the right occipital lobe associated with a venous aneurysm. Angiography demonstrated a large AVM supplied by multiple arterial feeders from the distal branches of the right middle cerebral artery (MCA) and the anterior cerebral artery (ACA). Embolization was performed in 4 sessions resulting in obliteration of more than 90% of the malformation, including the AV shunts and the venous aneurysm (Fig. 2).

Case 3. A 35-year-old man presented with seizures and intracerebral hemorrhage. CT and MR showed a medium-sized AVM located in the trigonum of the left lateral ventricle. Angiographic study revealed the AVM to be supplied by numerous cortical branches of the MCA and the hypertrophied anterior choroidal artery (AChA). The malformation drained via multiple cortical veins, including the vein of Labbé. Embolization was performed in 3 sessions resulting in occlusion of 80% of the total malformation. The residual nidus was supplied from the AChA. It was impossible to reach the residual nidus via this feeder due to the tortuosity of its origin. The patient had complementary radiosurgery (Fig. 3).

Figure 2a: Pre-embo MRI study, coronal T1 (TR 500/TE 11) demonstrates the large cortical AVM extending deep into the brain substance invading the wall of the lateral ventricle. Note the venous aneurysm (curved arrow).

Figure 2b: Post-embo MRI shows subtotal obliteration of the nidus including the venous aneurysm (asterix). Note the flow signal void in the peripheral residual nidus (arrows).

Figure 3a: Left internal carotid angiogram, lateral view, demonstrates a mid-size AVM located in the temporopolar lobe supplied by multiple cortical branches of the MCA and the tortuous and hypertrophic anterior choroidal artery (arrows).
2. AV Fistula
   
a. Traumatic CC fistula
   This is defined as a tear in the wall of the internal carotid artery (ICA) within the cavernous sinus caused by severe head injury where a high-flow fistula can develop.\textsuperscript{11-14} We treated 5 male patients, aged 10-36 years, presenting with pulsating exophthalmos associated with complete or partial ophthalmoplegia. All of them were successfully treated with complete closure of the fistula by latex balloon. The ICA was preserved in 2 cases and in the remaining 3 who had very wide fistulas, it was impossible to occlude only the fistula with detachable balloon, so both the fistula and the ICA were occluded by trapping. One developed hemiparesis, and the other had no deficit.
   
   Case 4. A 30-year-old man who developed a right-sided CC fistula 10 days after a head injury, presented with pulsating exophthalmos, conjunctival redness, swelling of the eyelids and bruit. The fistula was treated and occluded with 2 detachable balloons. The carotid artery was preserved. Angiographic cure was achieved and there was immediate relief of his eye symptoms (Fig. 4).

b. Spontaneous CC fistula.
This is defined as an acquired lesion that develops after rupture of an intracavernous ICA aneurysm. The fistula is of a high flow type. Dural AVM of the cavernous sinus is another cause of spontaneous CC fistula, but usually of slow flow type. Spontaneous CC fistula usually has clinical symptoms similar to those of traumatic fistula. We treated 2 patients with spontaneous CC fistula due to dural AVM. Both presented with mild proptosis, redness of the conjunctiva, swollen eyelids and bruit.

   Case 5. A 27-year-old male presented with chronic headache and progressive right-sided
exophthalmos associated with conjunctival injection and swollen eyelids. Angiographic study revealed a dural CC fistula involving the right cavernous sinus supplied by branches of the external carotid artery, including the middle meningeal artery, the artery of foramen rotundum and the infero-lateral trunk of the ICA. Endovascular treatment was performed in 3 sessions to occlude the malformation resulting in an angiographic and clinical cure (Fig. 5).

3. Cerebral Aneurysms We treated 3 patients one is illustrated below:

Case 6. A 42-year-old man presented with progressive gait disturbances, dizziness, dysarthria and dysphagia. CT and MR showed a large extra-axial mass at the left ponto-medullary junction compressing the brainstem. Arteriography confirmed the mass to be a giant serpiginous aneurysm of the left vertebral artery. The aneurysm was successfully trapped with two detachable

Figure 5a: Selective injection of the right internal maxillary artery showing the fistula, supplied by the artery of foramen rotundum (arrow head).

Figure 5b: Selective injection of the accessory middle meningeal artery supplying the fistula.

Figure 5c: Right internal carotid artery angiogram, lateral view, demonstrating the abnormal vascular network in the carvenous sinus and the hypertrophic inferolateral trunk (double arrows).

Figure 5d: Superselective injection of this feeder showing the nidus (open arrow), the cavernous sinus, and the dilated superior ophthalmic vein (arrow).
Two years’ follow-up showed marked neurological improvement (Fig. 6). MRI showed complete thrombosis in the

**Figure 6a:** Sagittal T1 (TR 500/TE 11) MRI showing a round extra-axial mass compressing the lower brain stem posteriorly. There is a small hypointense spot representing signal flow void (arrow). Anteriorly, there is a hyperintense rim representing thrombus (methemoglobin) in this giant aneurysm.

**Figure 6b:** Lateral right vertebral artery angiogram demonstrating posteriorly displaced vertebral and basilar artery due to an extra-axial mass (asterix).

**Figure 6c:** Left oblique view of the left vertebral artery angiogram showing luminal irregularities (curved arrows).

**Figure 6d:** Lateral skull X-ray demonstrating the occlusion balloon.

**Figure 6e:** Pre-embolization axial T1 (TR 500/TE 15) MRI demonstrating the giant aneurysm (asterix), the right vertebral artery (RV), and the lumen of the left vertebral artery (LV).

**Figure 6f:** 3-months post-embo, MRI shows obliteration of the left vertebral artery.
aneurysmal sac and shrinkage of the sac without compressive effect on the brainstem.

4. **Vascular Tumors** Preoperative embolization was performed in 25 patients with hypervascular tumors, including meningioma, angiofibroma, hemangioblastoma and glomus tumors.

**Case 7.** A 51-year-old female presented with slowly progressive left mono-ocular partial visual loss for 2 years. MRI showed a left para-sellar extracerebral mass, which was homogeneously enhanced after intravenous contrast. Angiography revealed a highly vascular tumor supplied mainly from the middle meningeal artery and the dural branches of the internal carotid artery. Parasellar inner ridge meningioma was diagnosed. Preoperative embolization was carried out to devascularize the tumor followed by surgical resection (Fig. 7).

*Figure 7a.* A right internal carotid angiogram, AP projection, demonstrating the tumor supply from the infero-lateral trunk of the carotid siphon and the ophthalmic artery.

*Figure 7b.* Typical tumor blush of a meningioma.

*Figure 7c.* Coronal T1 post-contrast MRI demonstrates a homogenous enhancing para-sellar meningioma.

*Figure 7d.* Post-embo MRI shows necrosis of the tumor.
Complications. Complications occurred in 5 (8%) patients, 3 had neurological deficit, 2 intracranial bleeding, and one died (mortality = 1.5%).

Neurological deficit. This occurred in 2 patients with AVM and 1 patient with traumatic CC fistula. The first patient was a 35-year-old man with right paraventricular AVM of the right lateral ventricle who developed left hemiplegia and upper quadrantanopia. This was due to occlusion of the posterior choroidal and the thalamoperforating artery. After 1 year, he had mild improvement. The second patient was a 33-year-old man with right thalamic AVM. He developed complete ophthalmoplegia due to occlusion of the posterior choroidal artery six hours after partial embolization. Follow-up of 1 year showed partial improvement. The third patient was a 36-year-old who had complex right-sided CC fistula treated by occlusion of ICA and trapping and fistula with 2 detachable balloons. An attempt to occlude the fistula only was not successful due to wide opening. An early deflation of the cranial detachable balloon led to recurrence of the fistula supplied retrogradely from and ICA (C4 portion). The fistula was approached via the basilar artery to the posterior communicating artery with a flow-guided microcatheter (Tracker catheter). As it was technically impossible to bring a detachable balloon from post-circulation to cavernous sinus to occlude the fistula, the only option was to inject histoacryl at the site of the fistula, which led to a reflux of embolization material to the right MCA territory. The fistula was completely occluded, but the patient developed left hemiparesis.

Bleeding. Two patients developed acute intracerebral bleeding. The first had intraventricular bleeding 8 hours after a nonsuccessful attempt to embolize the AVM, which was located in the root of the third ventricle. He developed severe neurological deficit. The second patient died 4 days after the second embolization of AVM. He developed thrombosis of the draining veins, had intracranial bleeding, and died.

Discussion. Therapeutic intra-arterial embolization of vascular lesions is not a new technique. At the beginning of the century, a mixture of paraffin and vaseline was injected into the branches of the external carotid artery to devascularize a facial sarcoma during surgery. Brooks in 1930 introduced transarterial embolization using muscle as embolic material to occlude a traumatic CC fistula. At the beginning of 1960, it was used extensively as an adjunct to surgery or as a definitive therapy, and many interventionalists recommended different embolic materials and techniques, but their procedures were limited to lesions located in the external carotid artery territory. In 1974, considerable advances were made in this field when Serbinenko introduced a balloon catheter to treat a CC fistula. His technique was later refined by Dobrin. The ingenious invention of a flow-guided microcatheter by Kerber opened a new era in endovascular therapy, enabling catheterization of the intracranial vessels and reaching lesions in the brain. This microcatheter device was changed and improved after the introduction of the non-flow-guided tracker microcatheters (target therapeutic) with a stellate guide wire that allows us to routinely catheterize intracerebral vessels. Magic (Balt) catheters allow us to approach intracerebral vessels more distally to reach the nidus.

The material used for embolization in our institution is cyanocrylate. This produces acute and chronic granulomatous inflammation of the vessel wall with long-lasting occlusion. Other material used is ethylene vinylacetate copolymer dissolved in polyvinyl alcohol (EVAL). This material is not adhesive and handles easily during embolization. When in contact with blood, it rapidly becomes a soft gel causing inflammatory reaction to the vessel wall and its surrounding tissues. It is less effective than cyanocrylates and recanalization has been reported in some cases. Avitene was also used for embolization but can result in more frequent recanalization.

Arteriovenous malformation (AVM), parenchymal or dural, is still the commonest to be treated by embolization followed by AV fistula, cerebral aneurysm and tumors. The rate of major recurrence of bleeding in patients with intracranial AVM is 4% per year, with a mortality rate of 1% per year, and a combined major morbidity and mortality rate of 2.7% per year with estimated mortality of 15-20% and morbidity of 20-30% over a 15-20-year period. This is worse than those treated surgically with operative mortality ranging from 7% in low grade AVMs (I,II,III) and 32% of high grade AVM (IV,V). Embolization alone is expected to be curative in 14% of patients (in our patients 21%) but also very important is preoperative preparation for resection or radiosurgery with an expected morbidity of 9-15%, but no embolization-related mortality. Combination of embolization with radiosurgery and surgical resection is expected to be curative in
74% of patients with further improvement in mortality.  

Endovascular therapy has made a great impact in treating AV fistula, especially in children with vein of Galen malformation where an immediate postembolization improvement is reported to be 82% with long-lasting improvement of 61%.  

The advantage of endovascular therapy for cerebral aneurysm, should a spasm be detected while carrying out arteriography, is to inject papaverine, so that clipping of the aneurysm can be carried out with less complications. If the aneurysm has a wide neck, partial occlusion should be carried out to prevent recurrence of bleeding with a plan for embolization after the patient is stable. However, the results of both endovascular treatment and surgery in cases of cerebral aneurysm with wide neck are relatively poor. Also, endovascular therapy is performed when standard neurosurgical techniques have failed, or are not applicable. These include patient's poor general condition, inaccessible location of the aneurysm and an aneurysm without a clippable neck or a giant type.  

Embolization is applicable mainly in large tumors or those inaccessible to surgical intervention, such as tumors invading the skull base or infiltrating the dural sinuses, the calvarium and the scalp. There is no indication for the treatment of small lesions which present no difficulty at surgery. The aim of embolization is to devascularize the tumor in order to facilitate easier surgical removal and to reduce morbidity. To achieve this goal, superselective catheterization of the feeding vessels is necessary, and the small particles or liquid embolic material have to pass deep into the capillary bed of the tumor to induce necrosis. Ocluding the feeding vessels only will not be sufficient, as it will result in a rapid development of collateral supply to the tumor. Contrary to popular belief, this embolization procedure requires a high degree of expertise. The neurointerventionalists have to master a superb catheterization technique, have intimate knowledge of vascular anatomy, be aware of the dangers of external-internal carotid artery anastomosis and the vascularization of the cranial nerves. Hemodynamic alterations during embolization in the external carotid artery territory may open an existing potential dangerous anastomosis that was not visualized on the diagnostic angiogram. Early detection of this anastomosis during the procedure with the aid of sophisticated fluoroscopic monitoring equipment may prevent catastrophic complications.  

Complications of ET due to the technique in centers with experience are less than 10% (in our institution 10%). Those reported are: immediate cerebral hemorrhage due to rupture of feeding vessels, subarachnoid hemorrhage due to penetration of subarachnoid space, retrograde thrombosis of feeding artery, especially after resection of embolized AVM, neurological deficit with hemiplegia, quadranopia and cerebellar ataxia, pyogenic infection of the nidus, pulmonary embolization and revascularization of the embolized vessel. Headache is reported in endovascular treatment of either AVM and aneurysms. Delayed venous thrombosis is uncommon but reported after embolization of AV fistula.  

Superselective amytal test and EEG monitoring are important in achieving safe procedures and avoiding complications during endovascular therapy. Serial acetazolamide challenge Xenon-CT following embolization and transcranial doppler are valuable non-invasive methods to monitor hemodynamic changes after embolization and allow more precise indications for further stages of embolization and timing of surgery after embolization.  

In conclusion, ET is safe and effective in treating vascular anomalies alone and in conjunction with surgical resection or radiosurgery. The key to successful therapy is an expert team of neurologists, neurosurgeons, neuroradiologists and neurophysiologists who concur the indications, carefully monitor the complications, and deal with them promptly and aggressively.  

References  


ملخص

الأهداف: وصف الأساليب الدوائية والاستعمال المضاعفات المتصلة بالعلاج عبر الأوعية في مستشفى القوات المسلحة بالرياض.

الطريقة: تم في الستين السابقتين علاج 59 مريضًا يعانون من تشوهات شريانية وريديّة، وناتورس شرياني وريدي وأنوريزما دماغي، وأورام وعائية داخل الجمجمة باستعمال بالون اللاتكس الساد، أو القابل للمفصل والملفات الصغيرة المصنوعة من البلاستيك.

النتائج: تم علاج أربعة وعشرين مريضًا من يعانون من تشوهات شريانية وريديّة في الدماغ. وقد تم تحقيق السد الكامل لدى 21% من الحالات والسدا الجزئي لدى 42% من الحالات، بينما النسبة الباقية من الحالات والبائدة 37% اما تزال قيد العلاج. أما المرضى الآخرين (وهم 25 مريضًا يعانون من الأورام، وسبعة مرضى يعانون من الناتورس الشرياني الوريدي، وثلاثة مرضى يعانون من أنوريزما دماغية عملاقة) فقد تم علاجهم بشكل ناجح عبر الأوعية. وقد حدثت مضاعفات التنيف العصبي والاعتصام العصبي وحوادث وفيات بنسبة 3.7% لدى 8% من المرضى.

الخلاصة: يُعدَّ العلاج عبر الأوعية من أسلوب العلاج الأمثل والفعالة في علاج التشوهات الوعائية سواء مفردة أم مقتربًا بالجراحة أو الجراحة الشعاعية. ويُعدَّ العلاج المتعدد التخصصات هو مفتاح النجاح في هذا الأساليب من العلاج.