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Transcatheter Embolization for Arteriovenous Malformations and Fistulae

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動静脈奇形及び動静脈瘻に対する transcatheter embolization

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過去2年間に16例の動静脈奇形(AVM)及び動静脈瘻(AVF)に対して transcatheter embolization を施行したのでその技術と塞栓効果について述べる。

症例は頭頸部領域のAVM及びAVF9例、腎AVM5例、傍気管支AVM1例、回腸AVM1例である。塞栓物質として初期にGelfoam、脂肪及び肉片を、後にSpongostan, Ivalon, steel coil, Debrun's detachable balloonを使用した。術後再開通したと思われるものは4例で、そのうち1例は以後自然治癒した。他の12例は1~24カ

月に亘る良好な塞栓効果を得た。AVMはできるだけ末梢部を塞栓すべきで、そのためには多くの場合、IvalonとSpongostanの細片を併用することが効果的であると考える。動静脈ジャントの大きいAVMやAVFではdetachable balloonやsteel coilが適応となるが、AVMでは二度目の塞栓が不可能になるのでその使用は限定される。一度にすべての栄養動脈を長時間かけて塞栓することは合併症の発生にもつながるので避けるべきである。また硬膜性AVMでは、外頸動脈以外に内頸または椎骨動脈からも栄養血管があっても、外頸動脈のみの塞栓でかなりの効果が期待できることを強調したい。

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Numerous reports have been published concerning transcatheter embolization techniques. Various embolizing agents and their indications have likewise been investigated and reported¹⁾⁻²²⁾.

During the past two years, we have used transcatheter embolization for 16 arteriovenous malformations (AVMs) and fistulae, employing several embolizing agents. This report describes our experiences using this technique and the results obtained.

Materials and Methods

a) Patients

The sixteen patients in our series included 9 with lesions in the head and neck regions; 5, in the kidney; and one each in the lung and terminal ileum (Table 1). There were 5 dural AVMs of the skull base or occipital region, one carotid-cavernous fistula, 2 auricular AVMs and one AVM of the scalp.

The main symptoms and signs of the AVMs of the head and neck included one with hypoglossal nerve palsy, 6 with tinnitus, and 3 with exophthalmos.

All patients with renal AVMs had gross hematuria. Each of the patients with an AVM of the lung or terminal ileum developed frequent episodes of hemoptysis and melena.

b) Embolic Materials

During our early experience, Gelfoams and/or fat or muscle fragments were used for 2 dural AVMs and one pulmonary AVM. Spongostans (Danish gelatine sponge) were later used with or without Ivalons (polyvinyl alcohol foam) for the remaining AVMs. They were cut to the adequate sizes and shapes so as to conform to the AVMs and feeding arteries.

Ivalon was compressed using a heavy press, and small Ivalon particles were cut using hole punches of various sizes. A rapid delivery system was devised for Ivalon embolization.

A steel coil was used to embolize the large bronchial artery of case 15. Debrun's detachable balloons were used for the carotid-cavernous fistula patient and for the patient with the scalp AVM which had a fistulous arteriovenous communication.

Results

a) AVM in the head and neck regions

The external carotid arteries comprised the main arterial supply for 5 dural AVMs and one scalp AVM. The internal carotid and/or vertebral arteries provided the feeding arteries in cases 1 and 2. Only the external carotid arteries were embolized in these patients. Case 1 was nearly free of symptoms for one year after the embolization, followed by a sudden recurrence of symptoms. Fortunately, the symptoms spontaneously resolved one week after they occurred.

Bilateral external carotid embolization was successful in alleviating the hypoglossal nerve palsy of case 2 for the past 2 years (Fig. 1)

For case 3 with a dural AVM, bilateral external carotid embolization was performed on 2 occasions within one month. The hyperemia of the conjunctiva bulbi and the tinnitus decreased in severity during the subsequent year and a half. Subsequently, his symptoms spontaneously resolved completely, and he has been doing well for 2 years.

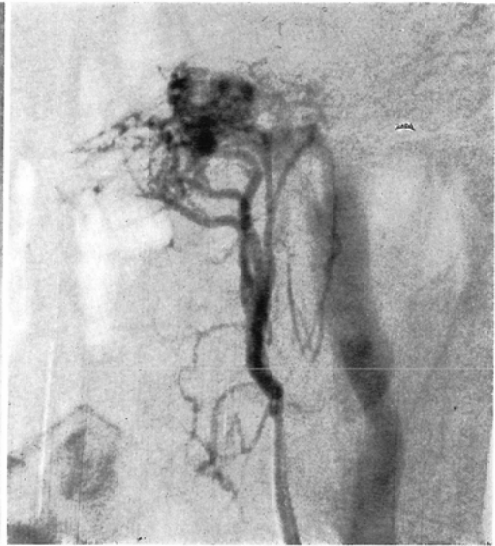
In case 4 with an occipital AVM, the patient has only minimal tinnitus at 20 months. Symptoms recurred early in one patient for whom Gelfoams and fat were used for embolization (case 5). He refused repeat embolization. For the patient with an auricular AVM, embolization was performed for two occasions within one month. Her enlarged ear decreased markedly in size and had only minimal tinnitus 8 months later. The enlarged ear of another patient decreased slightly in size during one month, and repeat embolization was

Table 1. Transcatheter embolization for arteriovenous malformations and fistulae

Case	Age Sex	Site	Clinical manifestations	Feeding and embolized (*) arteries	Embolizing agents	Results
1	56 F	Carotid- Cavernous, (dural)	Exophthalmos, Hyperemia of rt. eye, Double vision	external carotid bil. (rt.*) Internal carotid, bil.	Spongostan	Symptoms nearly disappeared for one year, then recurred. Spontaneous disappearance of symptoms in one week after recurrence.
2	47 M	Skull base (dural)	Hypoglossal nerve paralysis	External carotid, bil.* Internal carotid, lt. Vertebral, lt.	Spongostan	Complete healing at 2 years.
3	70 F	Carotid- Cavernous, (dural)	Tinnitus, Exophthalmos	External carotid, Bil.*	Gelfoam, Fat, Muscle	Symptoms decreased one year later by repeated emboliza- tions. Spontaneous healing in 22 months. No symptoms after 2 years.
4	35 M	Occipital, (dural)	Tinnitus,	Occipital, rt.*	Spongostan, Ivalon	Only minimal tinnitus at 20 months.
5	39 M	Occipital, (dural)	Tinnitus,	External carotid, lt.*	Gelfoam, Fat	Tinnitus recurred at 10 days. Reembolization was refused.
6	17 M	Carotid- Cavernous (fistula)	Tinnitus, Exophthalmos	Fistula*	Detachable balloon	No tinnitus, and only minimal exophthalmos at 3 months.
7	29 F	Auricle, rt.	Tinnitus, Giant auricle	External carotid, rt.*	Ivalon, Spongostan	Occasional tinnitus 8 months after 2 repeated emboliza- tions.
8	15 F	Auricle, rt.	Giant auricle	External carotid, rt.*	Ivalon, Spongostan	Auricle slightly decreased in size one month later. Repeat embolization for residual AVM.
9	30 M	Scalp	Tinnitus	Superficial temporal, rt.*	Detachable balloon	No tinnitus for one month.
10	36 F	Kidney, rt.	Hematuria Dysuria	Interlobar*	Ivalon, Spongostan	No AVM at follow up study one month later. No hematuria for 10 months.
11	25 M	Kidney, rt.	Hematuria, Dysuria	Interlobar*	Ivalon, Spongostan	Very minimal residual AVMs at follow up study 6 months later. No hematuria for 9 months.
12	58 F	Kidney, rt.	Hematuria	Interlobar*, Accessory*	Ivalon, Spongostan	No AVM at follow up study in 6 months. No hematuria for 9 months.
13	53 F	Kidney, lt.	Hematuria, Dysuria	Interlobar	Ivalon, Spongostan	No hematuria for 3 months.
14	75 F	Kidney, rt.	Hematuria	Interlobar	Ivalon	No hematuria for 3 months.
15	4 F	Lung	Hemoptysis	Bronchial*, Thyrocervical trunks, Bilateral (lt*)	Gelfoam, Steel coil	Minimal hemoptysis at 18 months after embolization.
16	47 M	Terminal ileum	Melena	Ileal	Spongostan Ivalon	Melena at one week, surgical resection.



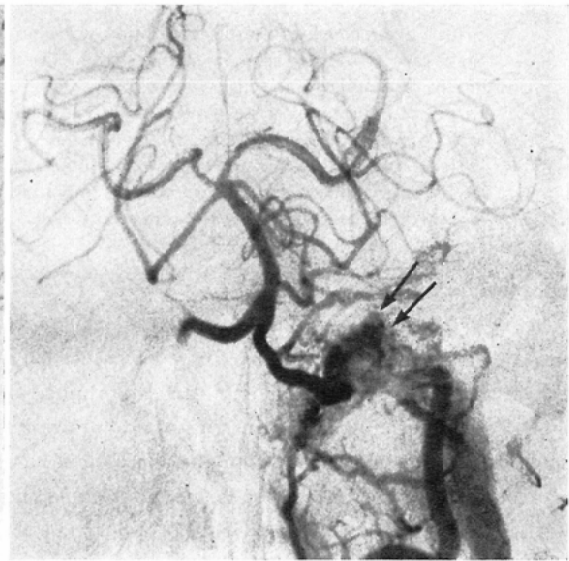
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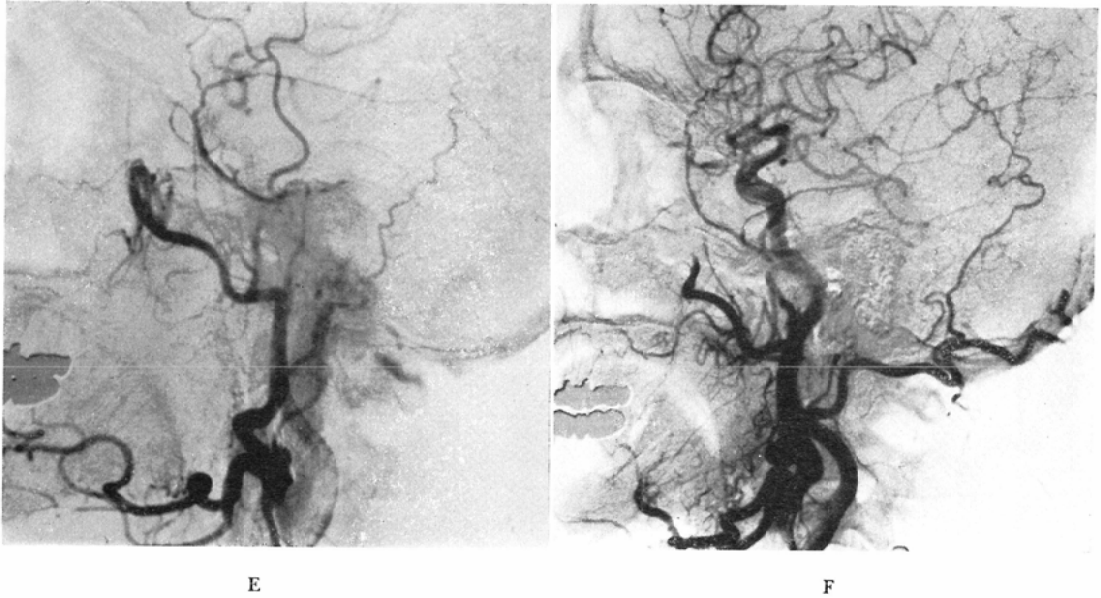


Fig. 1 (Case 4). A 47 year old male with a dural AVM causing hypoglossal nerve palsy.

- A. External carotid arteriography, anteroposterior (AP) projection. The ascending pharyngeal artery on the right supply the AVM in the area the clivus (short arrows) with early appearance of the internal jugular vein on the left (long arrow).
- B. Selective injection of the ascending pharyngeal artery on the left, AP projection. The AVM in the area of the clivus is again noted with early visualization of the internal jugular vein.
- C. Right carotid arteriography, lateral projection. The meningo-hypophyseal artery is enlarged supplying the AVM in the dorsal aspect of the clivus (arrows).
- D. Left vertebral arteriography, Towne projection. The AVM is seen in the area of the hypoglossal canal (arrows) with early visualization of the internal jugular vein.
- E.F. External carotid arteriography following embolization. Left (E) and right (F) lateral projections. Only the lateral projections were obtained following embolization. Bilateral ascending pharyngeal arteries and the jugular vein are no longer seen. Reflux of the contrast also demonstrates the left internal carotid circulation.

performed for the residual AVM.

One patient with a large left carotid-cavernous fistula was treated with one detachable balloon but complete occlusion of the fistula was impossible. The left internal carotid artery was then occluded at the orifice of the fistula using another balloon, after confirming that there was good blood flow in the left anterior and middle cerebral arteries via the anterior communicating artery (Fig. 2). The exophthalmos and tinnitus nearly disappeared following embolization and the patient has been doing well for 2 months. The patient who was treated using a detachable balloon for a scalp AVM has been free of tinnitus for one month (Fig. 2).

b) Renal AVMs

In the 5 renal AVMs, the interlobar and/or accessory renal arteries were embolized using Ivalon with and without Spongostan particles (Fig. 4). No AVMs were observed in 2 patients who had follow-up angiographies at one and 6 months. Very minimal residual AVMs were observed in one patient during angiography 6 months later.

All patients were free of hematuria for periods ranging from 3 to 10 months after embolization. No complications such as hypertension were noted in any of the patients.

c) Other AVMs

For the patient suffering from massive hemoptysis due to peribronchial AVMs, a steel coil was used for an

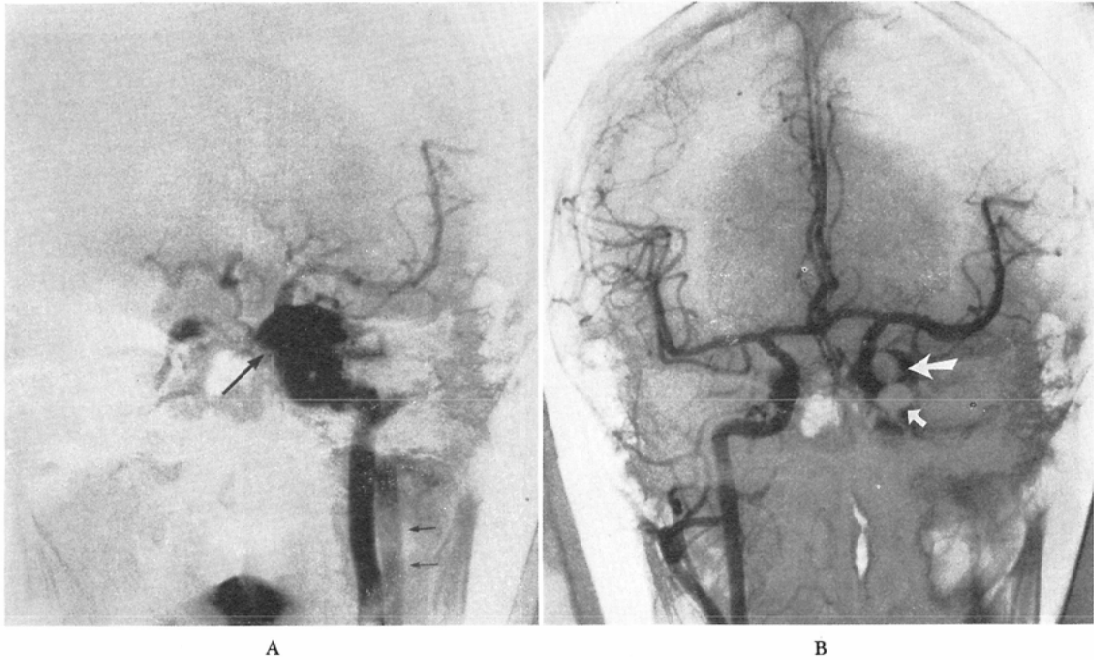


Fig. 2 (Case 6). A 17 year old boy with a direct carotid-cavernous fistula.
 A. Left internal carotid injection, AP projection. The cavernous sinus (long arrow) and internal jugular vein (short arrow) are seen in the early arterial phase. The intracranial circulation is only faintly visualized.
 B. Two detached balloons are seen, one in the cavernous sinus (long arrow) and the other in the internal carotid artery (short arrow). The cavernous sinus is still seen around the balloon but the internal jugular vein is no longer visualized.

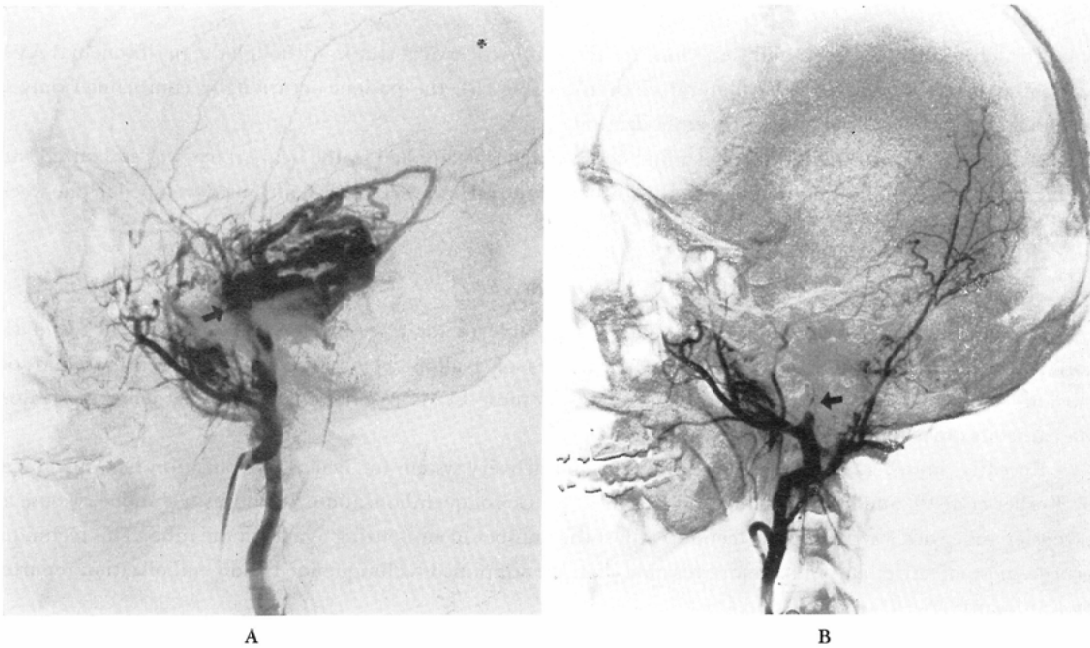


Fig. 3 (Case 9). A 30 year old male with a scalp AVM.
 A.B. Right external carotid arteriography, lateral projections, before (A) and after (B) embolization. The superficial temporal artery is markedly dilated, supplying the AVM in the retroauricular area. A large arteriovenous shunt was seen in an earlier phase at the point indicated by an arrow. The superficial temporal artery was embolized with a single detachable balloon at its proximal segment (arrow). The posterior auricular branch of the external carotid artery, not seen before embolization, is now visible. This branch does not appear to be feeding the AVM.

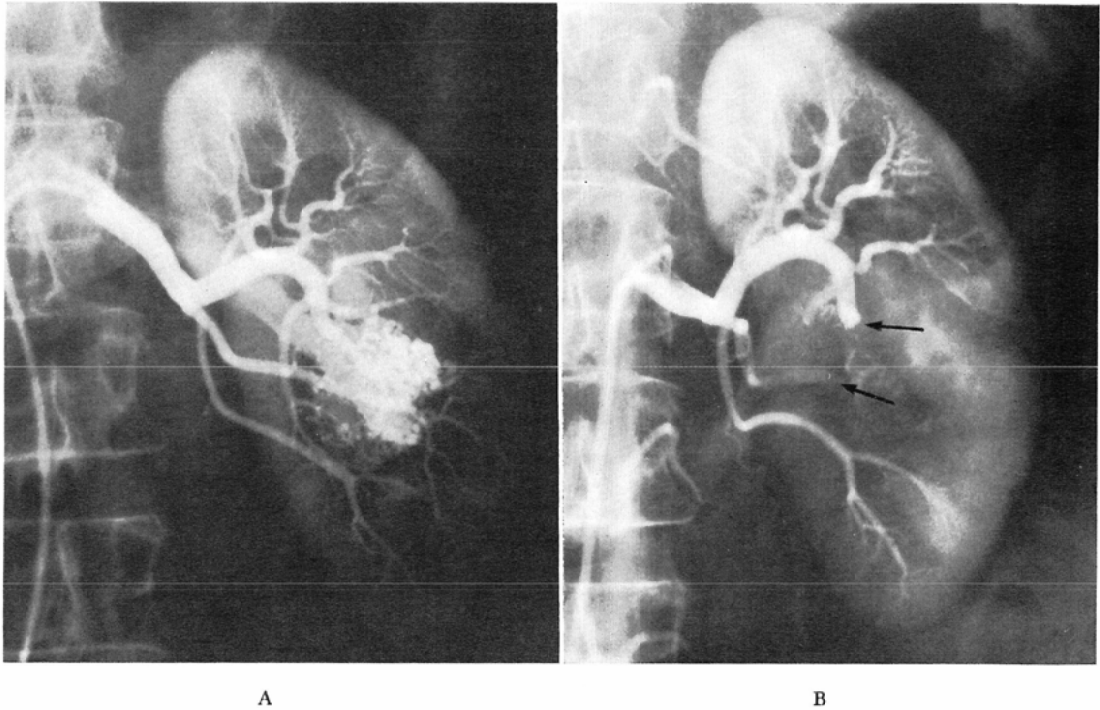


Fig. 4 (Case 13). A 53 year old female with a renal AVM.

A.B. Left renal arteriography. Before (A) and after (B) embolization. The AVM in the renal hilar portion fed by two interlobar arteries (arrows) was nearly embolized with Ivalon and Spongostan particles.

enlarged left bronchial artery, and Gelfoams, for the left thyrocervical trunk. Although the peribronchial AVM was subsequently supplied by a collateral circulation (Fig. 5), the patient occasionally complained only of minimal hemoptysis at 18 months after embolization.

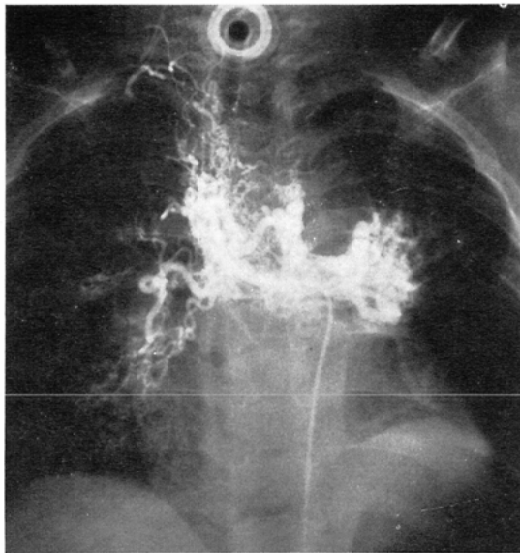
One patient with an AVM in the terminal ileum which was supplied by the ileal artery, was embolized with Spongostans and Ivalons, but mainly with the former (Fig. 6). However, massive melena developed in one week, and the lesion was surgically resected.

Discussion

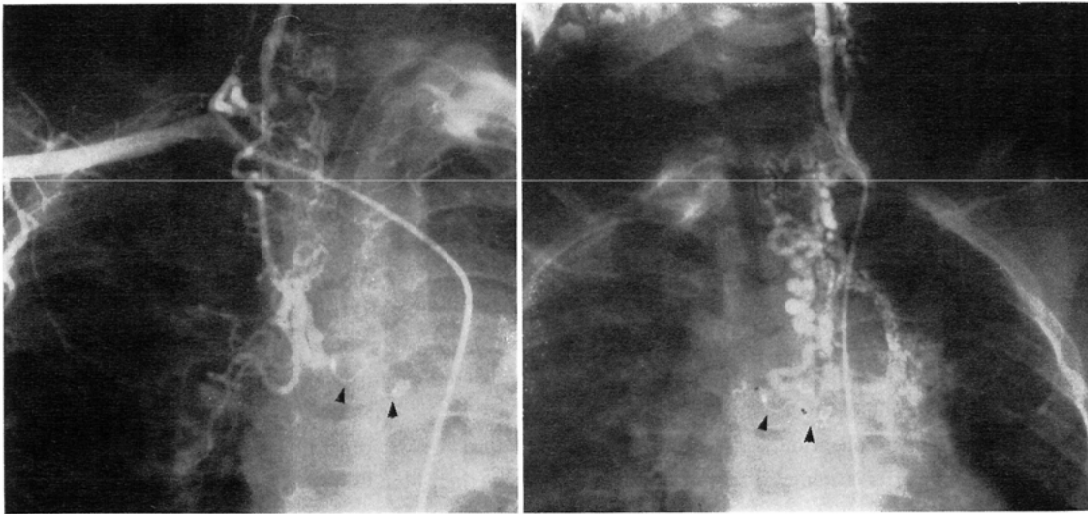
AVMs should be embolized as peripheral as possible to their feeding arteries in order to avoid the collaterals supplied by neighboring arteries. Particles of Ivalons which provide permanent vascular occlusion⁹⁾¹²⁾¹⁶⁾ seem to us to be ideal embolizing agents for most AVMs. We had some difficulty delivering Ivalons via catheters during our early experience.

Recently, however, we have been using the rapid delivery system for Ivalon embolization first introduced by Kerber et al.¹²⁾ and later by Bank and Kerber¹⁷⁾ for Gelfoam embolization. With this technique, we use an extension tube with a syringe at each end to adjust the number of embolizing agents in the tube. This technique proved most effective, and much more feasible than the simplified technique for Ivalon embolization reported by Kaufman¹⁴⁾.

Spongostan¹¹⁾²³⁾ or Gelfoam particles are susceptible to potential resorption in vessels 7-21 days⁶⁾²⁰⁾²²⁾. We use them when larger emboli are needed to occlude the feeding arteries of AVMs because they are relatively easy to deliver. They are also used in treating malignant abdominal tumors, or meningiomas just before



A



B

C

Fig. 5 (Case 15). A 4 year old boy with a peribronchial AVM causing massive hemoptysis.

- A. Bronchial arteriography. An extensive AVM is seen in the peribronchial region bilaterally fed mainly by the enlarged bronchial artery.
- B.C. Right subclavian (B) and left vertebral (C) arteriography one and one-half years following embolization. The bronchial artery has been embolized with a steel coil (arrow heads). However, the major portion of the AVMs are again supplied by collateral circulation.

surgery.

Liquid polymers such as Cyanoacrylate have been used to embolize AVMs¹⁵⁾, but we are reluctant to use this agent simply because it is difficult to deliver without resulting complications.

Steel coils also provide permanent embolization⁴⁾ and we successfully used one to occlude a bronchial

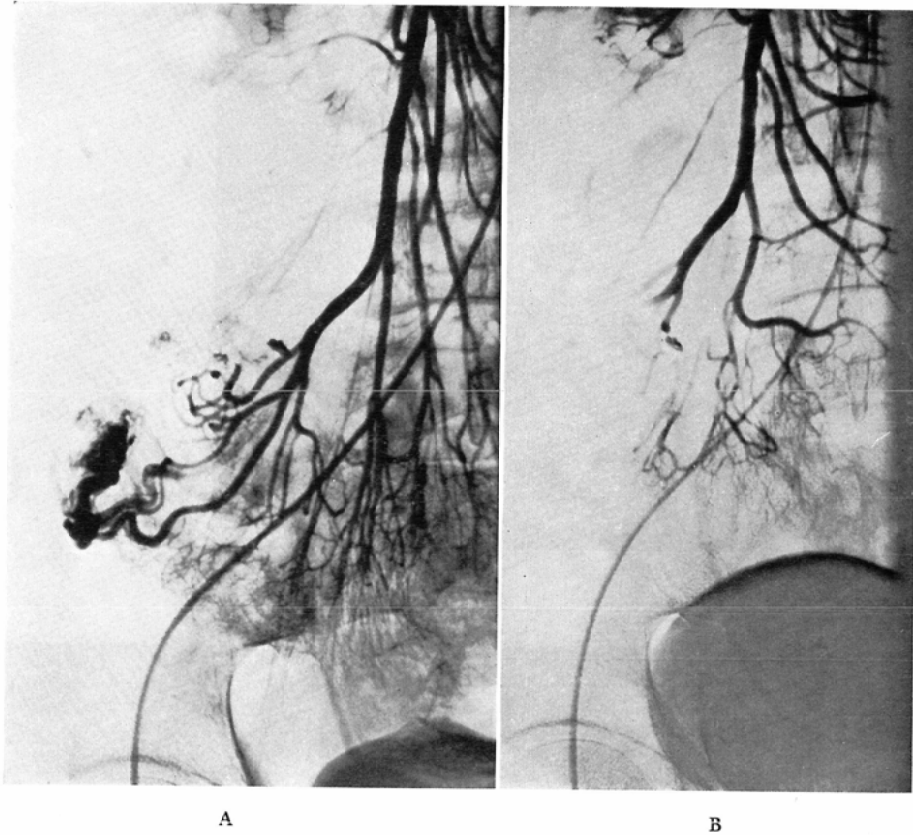


Fig. 6 (Case 16). A 47 year old male with an AVM in the terminal ileum.

A.B. Superior mesenteric arteriography, before (A) and after (B) embolization. The AVM in the terminal ileum was embolized mainly using Spongostan. Melena developed again one week later, and the lesions were surgically resected.

artery. However, we feel that this should be used only in restricted cases, since a second embolization will be impossible when the collateral circulations again feed the AVMs.

Transcatheter embolization is the choice in treating dural AVMs, providing safe catheterization of the external carotid arteries is achieved. Dural AVMs often receive their blood supplies from the internal carotid or vertebral arteries in addition to the external carotid, as occurred in our patients. In these instances, embolization of the internal carotid or vertebral arteries is difficult or practically impossible, but embolization of only the external carotids may yield good results as in cases 1 and 2.

Dural AVMs are known to regress spontaneously²⁴⁾, and this occurred in 2 of our patients. From this standpoint, aggressive embolization in an attempt to occlude all the feeders of AVMs may not be justified. Careful fluoroscopic control is important to avoid reflux of emboli into the internal carotid or vertebral artery through a potential anastomosis with the occipital artery.

Detachable balloons have been used to treat arteriovenous fistulae⁸⁾²¹⁾. In the case of a carotid-cavernous fistula, only the fistula should ideally be embolized, preserving the carotid arterial flow, but this was practically difficult to achieve in our patients.

Good results have been obtained with renal AVMs using embolization, without complications⁷⁾. All of our

patients were treated successfully; 3 of them had no recanalization, as confirmed by follow-up studies. Our good results may be due to our use of Ivalon particles. If the feeding arteries are enormous or the arteriovenous shunts are large in renal AVMs or fistulae, detachable balloons or steel coils may be the choice, as in case 9 and 15.

Rémy et al.⁵⁾ described treatment of hemoptysis by embolization of the bronchial arteries of 104 patients having various pulmonary diseases. This technique has become very popular recently.

Our patient's hemoptysis was probably due to diffuse pulmonary hemangiomas²⁵⁾ or capillary hemangioma of the lung²⁶⁾. There have been no reports of the angiographic findings of the latter, or their treatment by embolization. Although complete embolization of all arterial feeders may not be accomplished in such patients, occlusion of the vessels available to embolization will reduce the frequency and volume of hemoptysis. Collateral circulation again supplied the AVM following embolization with a steel coil in our patient. However, occlusion of the large bronchial artery may have reduced the arterial pressure alleviating his symptoms.

Embolization for AVMs of the intestine always has the potential hazards of ischemic sequelae and perforation⁹⁾¹⁰⁾. Careful clinical evaluation during and after embolization is therefore recommended.

In summary, most AVMs except those which are intracerebral, can be embolized using a transcatheter technique and Ivalon particles with or without Spongostan. Detachable balloons or steel coils may be the choice for large arterial feeders or fistulae. However, they should be used in restricted AVM cases because second embolization becomes impossible. Aggressive embolization with attempts to occlude all feeders during a first attempt should be avoided.

Acknowledgement

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