

Early Experience with the AMPLATZER Vascular Plug IV for the Occlusion of Pulmonary Arteriovenous Malformations

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ABSTRACT

The recent generation of AMPLATZER Vascular Plug (AVP; ie, the AVP IV) was used for the occlusion of eight pulmonary arteriovenous malformations (PAVMs) in five patients. A treatment was considered successful when there was a reduction or disappearance of the aneurysmal sac. At a mean follow-up of 20.1 months, no recanalization of PAVMs was observed on multidetector computed tomographic angiography. This shows the AVP IV to be safe and effective as an embolic device to occlude PAVMs.

ABBREVIATIONS

AVP = AMPLATZER Vascular Plug, DSA = digital subtraction angiography, PAVM = pulmonary arteriovenous malformations

Transcatheter embolization has become the treatment of choice for the management of pulmonary arteriovenous malformations (PAVMs) (1,2). Although there are diverse embolizing devices, the most widely used are coils (3,4). Types I and II AMPLATZER Vascular Plugs (AVPs; St. Jude Medical, St. Paul, Minnesota) have been proven to be effective for the therapeutic embolization of PAVMs, although some technical difficulties associated with reaching distal PAVMs with the use of these devices have been observed (5–9). These early-generation AVPs required larger sheaths or guiding catheters for their introduction, which could make the procedure technically challenging and occasionally unsuccessful for the treatment of tortuous or small peripheral vessels (5–9). The fourth-generation AVP IV has a lower profile and

may be delivered through a 0.038-inch inner lumen angiographic catheter.

The AVP IV has been successfully used in nonpulmonary vascular regions (10,11). However, its use for the treatment of PAVMs has not been reported in the literature to our awareness. The present report aims to present the preliminary results of the treatment of PAVMs with the AVP IV.

MATERIALS AND METHODS

The charts of the study subjects were reviewed with the approval of our institutional review board. Informed consent was obtained from all patients at the time of the procedures. Technical success was defined by occlusion of the feeding artery of PAVMs no further than 1 cm from the aneurysm sac without evidence of flow through the AVP.

Study Group

Since the institutional hereditary hemorrhagic telangiectasia multidisciplinary unit was established in our hospital in February 2010, 25 patients have been considered candidates for PAVM embolization in view of the presence of an intrapulmonary shunt based on the results of transthoracic echocardiography with a bubble study.

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Within this group, five patients (four women and one man) with a mean age of 49.5 years (range, 33–73 y) were discovered to have simple PAVMs with a feeding artery smaller than 6 mm in size and were therefore considered candidates for embolization with the AVP IV.

Four patients were symptomatic and one was asymptomatic. The patients' symptoms included hypoxemia (n = 4), cyanosis (n = 4), clubbing (n = 1), hemoptysis (n = 1), and transient ischemic attack (n = 2). One patient had a history of paravertebral and epidural abscess, and another had a history of two strokes and a brain abscess. Three patients had one lesion, one patient had two lesions, and the remaining patient had three lesions, which resulted in a total of eight PAVMs. The number and locations of PAVMs and feeding arteries and aneurysmal sac diameters were determined from a multidetector computed tomography (CT) scan obtained during workup and are presented in the [Table](#).

Multidetector CT was performed with the use of a 64–detector-row CT system (Aquilion; Toshiba, Tokyo Japan) with the following technical parameters: 0.5-mm slices, 0.25-mm table feed, 80 mA, 120 kV, rotation time of 0.75, and pitch of 0.875. A 20-gauge intravenous catheter was inserted into the basilic vein. A total of 80 mL of nonionic iodinated contrast material (iobitridol; Xenetix 350; Guerbet, Roissy, France) at a dose of 0.8–1 mL/kg was infused by using an automatic injection pump at a rate of 4.0 mL/s; this injection was followed by an injection of 30 mL of saline solution. The scanning

delay after initiation of the contrast material injection was determined by using a bolus-tracking method. The region of interest was positioned at the pulmonary trunk, and the threshold for the multidetector CT angiography was set to 100 HU. Two trained radiologists with 5 and 7 years of experience in the field independently analyzed all multidetector CT images.

The patients were clinically evaluated periodically at the hereditary hemorrhagic telangiectasia multidisciplinary unit. Imaging follow-up was performed at 3, 12, and 36 months with multidetector CT of the chest ([Fig 1](#)). The diameters of the feeding artery and aneurysmal sac were measured on multidetector CT angiography. Radiologic follow-up was considered successful if the aneurysmal sac disappeared or was reduced in diameter by at least 30%.

Embolization Technique

The procedures were performed under local anesthesia via a femoral vein approach under systemic heparinization with 5,000 U of sodium heparin (Sobrius; Fada Pharma, Buenos Aires, Argentina). During the procedure, the patients received prophylactic antibiotic coverage with 1 g of intravenous cefazolin (Cefazolina Northia; Northia, Pilar, Argentina). A 6-F guiding catheter (Destination; Terumo, Tokyo, Japan) was used in all cases. The guiding catheter was advanced to the main pulmonary artery, and a digital subtraction angiogram (DSA) was obtained by using a 5-F pigtail catheter ([Fig 2a](#)).

Table. CT Details of PAVMs and Feeding Artery and Aneurysmal Sac Diameters

PAVM No.	Localization	Diameter						Follow-up (mo)
		Before Embolization			After Embolization			
		Afferent Artery (mm)	Sac (mm)	AVP (mm)	Afferent Artery (mm)	Sac (mm)	Aneurysm Reduction (%)	
1	Middle lobe medial segment	4	9	7	2	3.2	64.4	38
2	Left lower-lobe posterobasal segment	3.4	7.5	6	1.9	4	46.6	34
3	Right lower-lobe lateral segment	4.5	0	8	2.6	0	0	34
4	Right lower-lobe posterior segment	2.3	3.6	4	1.9	0	100	12
5	Left lower-lobe lateral segment	4.2	10.5	8	2.2	0	100	17
6	Right lower-lobe anterior segment	3	10	6	2	0	100	17
7	Middle lobe medial segment	3.8	8	7	1.8	0	100	6
8	Left lower-lobe lateral segment	5	25.5	8	2.8	15	41.17	3

All PAVMs were simple.

AVP = AMPLATZER Vascular Plug, PAVM = pulmonary arteriovenous malformation.

When the PAVM had been identified (**Fig 2b,c**), its feeding artery was selectively catheterized by using a 5-F hydrophilic vertebral catheter (Terumo) introduced coaxially (**Fig 2d**). Vascular plugs that were oversized by at least 20% in relation to the feeding artery that had

a diameter that was previously measured by multi-detector CT were chosen.

The device was advanced inside the diagnostic catheter by pushing its wire until it reached the catheter tip. The catheter was then retracted, and the plug was deployed

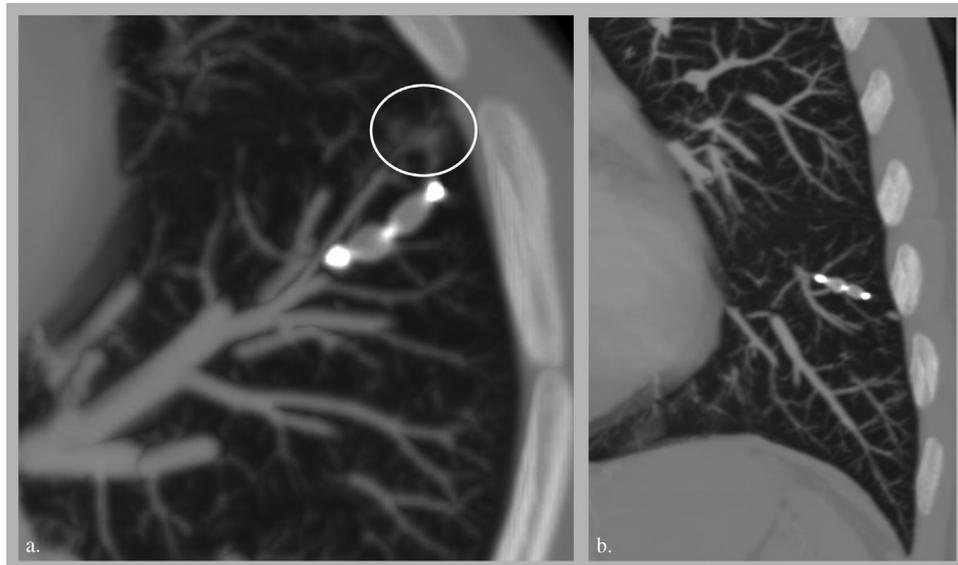


Figure 1. Multidetector CT angiography performed 17 months after embolization. **(a)** Axial image of a multiplanar reconstruction shows the AVP IV structure with a ground-glass density image distal to the device (circle) that is consistent with the fibrous scar tissue of the aneurysm and arterial segment. **(b)** Coronal multiplanar reconstruction image shows the AVP IV structure with the absence of aneurysm and PAVM draining vein.

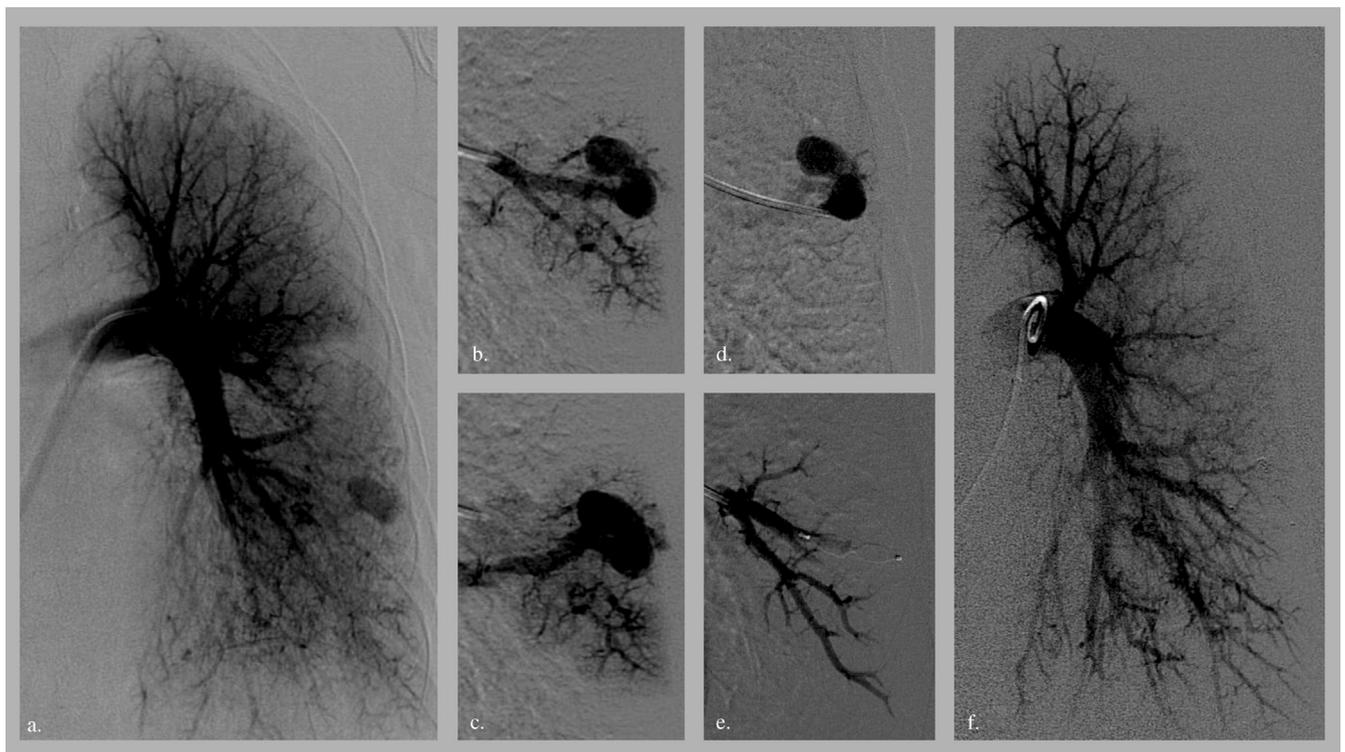


Figure 2. **(a)** Left pulmonary DSA image shows a PAVM with an aneurysmal dilation in the lower-lobe lateral basal segment. **(b)** Selective DSA of the branch of the lateral basal segment shows the feeding artery and PAVM aneurysmal dilation. **(c)** At a later phase, the same series shows the aneurysmal dilation and PAVM draining vein. **(d)** Correct position of the catheter is seen before AVP IV deployment. The catheter tip is located almost inside the aneurysmal sac. **(e)** Postembolization DSA reveals a complete artery occlusion. The aneurysm and draining vein are not visualized. **(f)** Final DSA of the left pulmonary artery shows the absence of PAVM.

and expanded (Fig 2e). Before detaching the plug, an angiogram was obtained by injecting contrast material through the guiding catheter to verify the plug position. If the plug was located at an undesired position, it was recaptured, repositioned, and deployed again. For recapture, the catheter was advanced over the plug, repositioned, and then detached.

In all cases, a control DSA study was performed after plug detachment to confirm vessel occlusion (Fig 2f). If complete occlusion of the vessel was not obtained, another control DSA study was performed minutes later to objectify the absence of flow passage through the AVP.

RESULTS

Technical success was achieved in all cases (100%). One AVP IV was used for each PAVM. All patients were discharged from the hospital 24 hours after the procedure. There were no complications that required patient readmission or any additional procedures. Only one patient presented with persistent pleuritic pain that eventually improved with oral analgesic therapy. The Table shows the imaging findings before and after the procedure and the size of the plug used in each case.

The mean follow-up was 20.1 months (range, 3–38 mo). No paradoxical embolic events were recorded. Radiologic follow-up with multidetector CT angiography showed therapeutic success in all cases. No recanalization of PAVMs was observed during the follow-up period.

DISCUSSION

Embolization is considered the treatment of choice for PAVMs (1,2). Coils have been reported as the most commonly used embolic agent for the treatment of PAVMs. However, the recanalization rate after the embolization of PAVMs with coils has been reported to range from 4% to 19% (3,12,13).

Vascular plugs (AVP I and II devices) have been used to treat PAVMs with good results and low recanalization rates (0%–8%) (5–7,12–14). Although the recanalization rate after embolization with the AVP I is lower than that obtained with coils, some researchers (12) recommend the supplementary use of coils in addition to the AVP I or II to achieve a rapid occlusion and to decrease the risk of recanalization.

The persistence of flow to the PAVM after embolization can occur via several mechanisms. A technical fault includes an embolization 1 cm away from the aneurysmal sac and the use of a single or oversized coil (3). Predisposing anatomic factors include the growth of a missed or previously small accessory artery, bronchial artery flow into the pulmonary artery beyond the level of the embolization (ie, left-to-left shunt), and pulmonary artery-to-pulmonary artery flow distal to the embolized

location (3,12). From a technical perspective, the recanalization of a previously embolized vessel and the reperfusion of the PAVM without recanalization of the embolized vessel should be differentiated.

Hayashi et al (15) reported no reperfusion in 15 PAVMs when direct venous sac embolization was performed, compared with standard feeding artery embolization. Milic et al (16) found that an increased feeding artery diameter, a low number of coils, the use of oversized coils, and proximal coil placement within the feeding artery are associated with reperfusion and that recanalization was the mechanism responsible for the reperfusion in 88% of cases. Therefore, it can be stated that recanalization is present only when the occluded vessel opens, and the reconstitution of flow distal to a blocked pulmonary artery through collateral vessels should not be considered to represent recanalization.

In the present patients, technical and therapeutic success was achieved in all PAVMs treated, and no evidence of recanalization was obtained during the mean 20.1-month follow-up. Hart et al (14) reported a series of 69 consecutive patients who underwent embolization of PAVMs with the AVP I. Embolization was not feasible in 8.7% of these patients because the vessels precluded the introduction of the sheath to a suitable distal position. In these cases, coils were used to achieve embolization.

Use of the AVP IV may solve most of these technical difficulties because the device passes through a 4-F diagnostic catheter. This is the great advantage compared with the AVP I and II devices, which require the use of large-diameter guiding catheters. Embolization proves to be unfeasible when the vessels are very thin and the PAVMs are too distally located.

Although coil embolization is a safe technique, migration rates ranging from 2% to 4% have been reported (5). The AVPs allow a more controlled embolization compared with that achieved with coils because this device can be deployed and may be recaptured and repositioned before its final detachment. To our awareness, there are no references in the literature regarding the migration of this device, regardless of type.

To achieve a rapid occlusion, the plug must be sized appropriately for the vessel, with a certain degree of oversizing. Because the largest available size of the AVP IV is 8 mm, it has been suggested that vessels larger than 6 mm in diameter may not undergo a rapid or total occlusion (7). In fact, some researchers have reported the need to add additional embolic agents for the treatment of larger vessels (10). Therefore, one of the disadvantages of this device is that it is useful only when the PAVMs are smaller than 6 mm.

The present study has some limitations, including a small number of cases and short follow-up. Despite these limitations, the present study provides reliable information on the use of the AVP IV device for the occlusion of small PAVMs that reflects a high level of technical success.

In conclusion, the AVP IV shows promising early results for the treatment of PAVMs. The device has interesting features, such as its safety, low recanalization rate, low profile, versatility, and ease of delivery. The AVP IV may become the device of choice for the embolization of PAVMs with feeding arteries smaller than 6 mm in diameter.

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