22 Vessel Embolization: Transcatheter Embolization of Pulmonary Arteriovenous Malformations and Aortopulmonary Collateral Arteries

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22.1 Transcatheter Embolization of Pulmonary Arteriovenous Malformations

Pulmonary arteriovenous malformations (PAVMs) are direct communications between the pulmonary arteries and veins, bypassing the normal pulmonary capillary bed and resulting in an intrapulmonary right-to-left shunt. Large or diffuse PAVMs can cause systemic hypoxemia and cerebrovascular complications secondary to paradoxical embolism as well as pulmonary hemorrhage due to sac rupture. Transcatheter embolization has emerged as the preferred treatment for PAVMs with favorable long-term follow-up results.

22.1.1 Indications and Patient Selection

All symptomatic patients

– Evidence of significant systemic hypoxemia

Asymptomatic patients

– Risk for paradoxical embolism or pulmonary hemorrhage
– Having a documented history of a paradoxical embolic event
– Discrete lesions with feeding arteries greater than 3 mm in diameter

Partial or staged closure may also be indicated in some patients with diffuse PAVMs in order to alleviate symptoms.

Although traditionally coils have been used to occlude PAVM, the size of the feeding vessels involved is usually more effectively occluded using the Amplatzer vascular plug (AVP) series (AGA Medical Corp., MN, USA) (Fig. 22.1). Transcatheter occlusion of a large PAVM in a 11-year-old female patient using the AVP I is shown in Figs. 22.2–22.6 and videos 1–3.

22.2 Transcatheter Embolization of Aortopulmonary Collateral Arteries

Aortopulmonary collateral arteries (APCs) can be detected frequently in patients with complex cyanotic CHDs such as tetralogy of Fallot, pulmonary atresia, and single ventricle with pulmonary stenosis, resulting in varying degrees of left-to-right shunting.

Large or multiple APCs can result in pulmonary overperfusion and symptomatic cardiac volume overload manifested as exertional dyspnea, recurrent pleural effusion, protein-losing enteropathy, frequent lower airway infection, and hemoptysis.

22.2.1 Indications and Patient Selection

22.2.1.1 Indications

Transcatheter occlusion of APCs is indicated for the treatment of aortopulmonary collateral vessels with documented large left-to-right shunting that results in congestive heart failure, pulmonary overcirculation, and respiratory compromise or development of pleural effusion or protein-losing enteropathy.

Relative Indications

1. Asymptomatic single ventricle patients with moderate-sized collaterals undergoing routine pre-Glenn or pre-Fontan cardiac catheterization
2. Patients with pulmonary atresia and APCs that have adequate dual supply from native pulmonary arteries

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-319-72443-0_22) contains supplementary material, which is available to authorized users.

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G. Butera et al. (eds.), *Atlas of Cardiac Catheterization for Congenital Heart Disease*,
https://doi.org/10.1007/978-3-319-72443-0_22

Contraindications

1. Transcatheter occlusion is not recommended for the presence of APCs of any size in patients who have significant cyanosis due to decreased pulmonary flow.
2. Transcatheter occlusion is not recommended for patients in whom the responsible collateral arteries directly supply a large area of pulmonary parenchyma, when embolization could result in infarction of the lung parenchyma.

Transcatheter occlusion of multiple APCs in three patients using coils or the combination of coils with AVP are shown in Figs. 22.7–22.24.

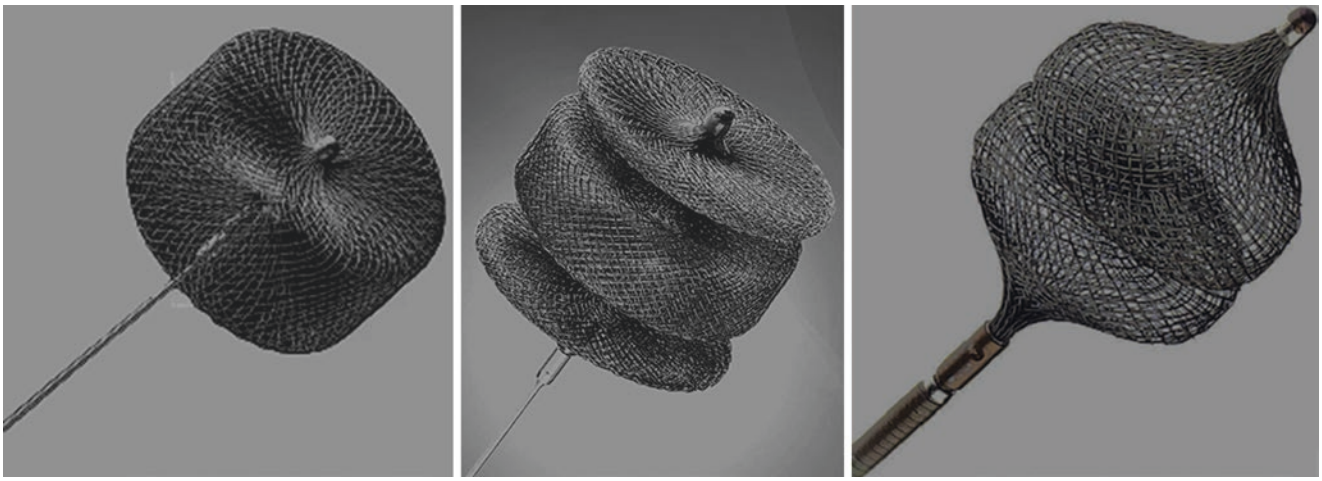

Fig. 22.1 Amplatzer plug I, Amplatzer plug II, and Amplatzer plug IV. The AVPs are particularly suitable for embolization of large high-flow feeding vessels. They are a woven nitinol wire cylinder that can be delivered via small catheters such as standard 5–8-Fr coronary guiding catheters. The size of the AVP selected for embolization was approximately 1.5–2 times the caliber of the feeding vessel

Fig. 22.2 Patient 1. A 11-year-old female patient with a diagnosis of hereditary hemorrhagic telangiectasia was referred for transcatheter treatment of multiple PAVMs. Pulmonary angiogram revealed diffuse PAVMs of the left lung, with major PAVFs identified in the upper lobes

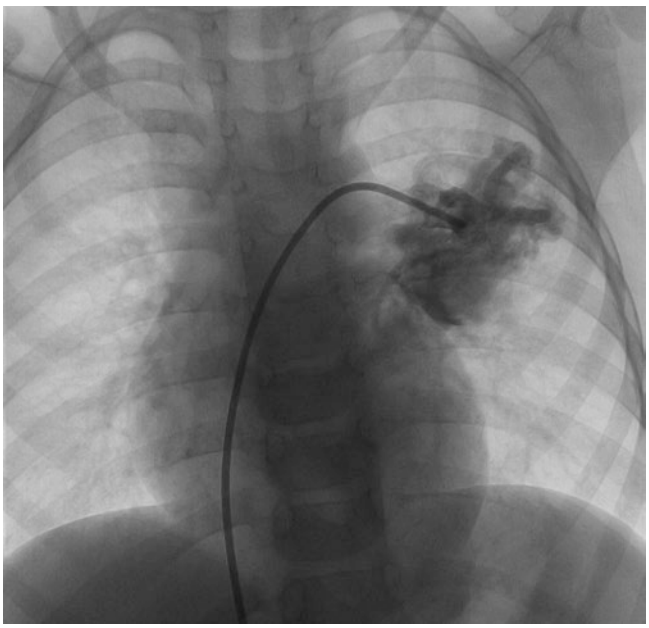

Fig. 22.3 Patient 1. The feeding vessel of the major PAVM located in the left upper was selectively engaged with the 5F VER135° angiographic catheter(Cordis, USA) and the feeding vessel measuring approximately 8 mm in diameter

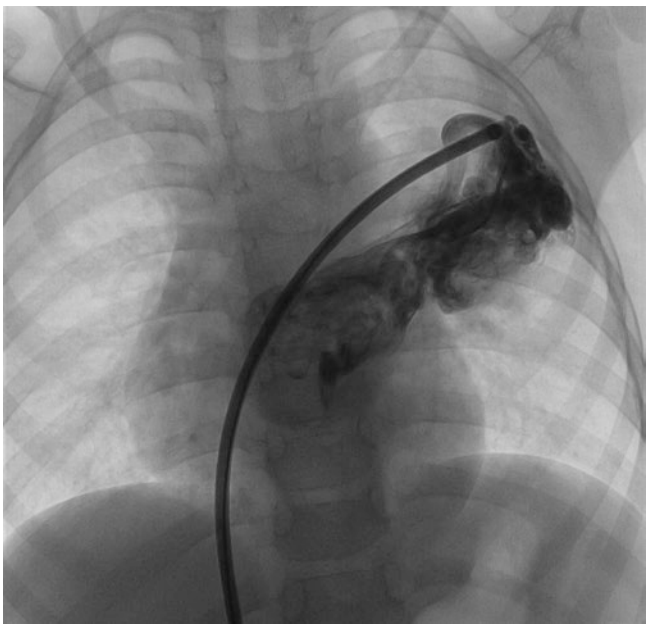

Fig. 22.4 Patient 1. The VER135° angiographic catheter was then exchanged for an 8 Fr, 80-cm long delivery sheath through which a 100 cm, 7 Fr Judkins Right 3.5 guide catheter was introduced. The guide catheter was then advanced as distally as possible within the feeding vessel beyond any branches to normal lung

Video 1 Patient 1. The VER135° angiographic catheter was then exchanged for an 8 Fr, 80-cm long delivery sheath through which a 100 cm, 7 Fr Judkins Right 3.5 guide catheter was introduced. The guide catheter was then advanced as distally as possible within the feeding vessel beyond any branches to the normal lung (AVI 15365 kb)

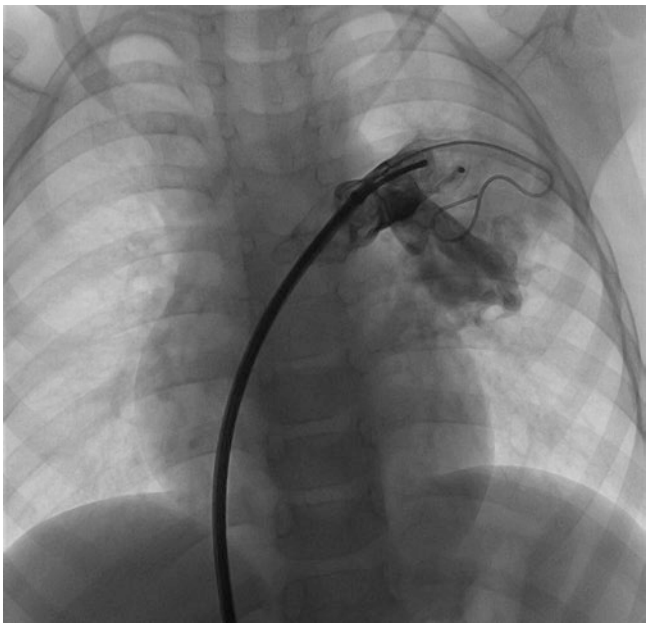

Fig. 22.5 Patient 1. A 12 mm AVP I (AGA Medical Corporation, Minnesota) was selected so as to be 50% larger than the target vessel and was delivered through the guide catheter to the feeding vessel. Selective arteriogram after deployment of the AVP in the feeding vessel showed near-complete occlusion of the left upper PAVM

Video 2 Patient 1. A 12 mm AVP I (AGA Medical Corporation, Minnesota) was selected so as to be 50% larger than the target vessel and was delivered through the guide catheter to the feeding vessel. Selective arteriogram after deployment of the AVP in the feeding vessel showed near-complete occlusion of the left upper PAVM (AVI 23814 kb)

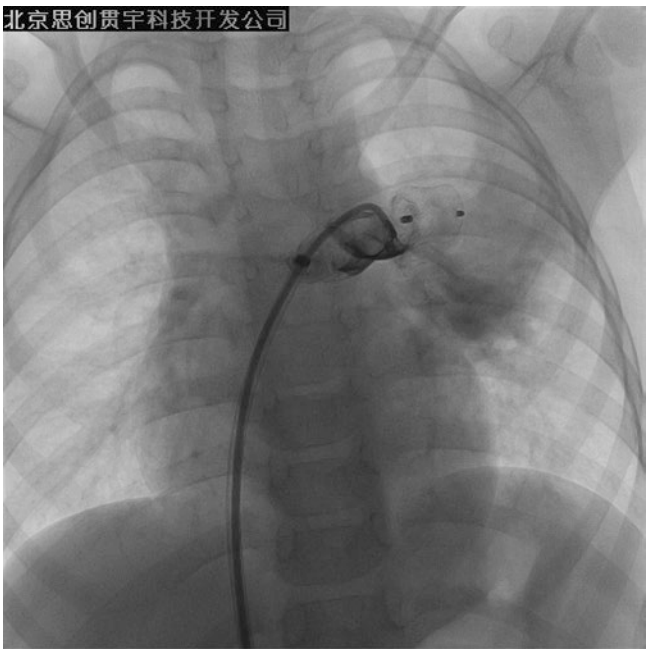

Fig. 22.6 Patient 1. Repeated selective arteriogram a 5 min later after the device release documented the AVP I in good position with no residual flow into the left upper PAVM. Upon deployment of the AVP, her peripheral arterial oxygen saturation improved from 86 to 93% at rest. Due to the length of the procedure and the amount of contrast given, no further embolization attempts to another PAVM were performed

Video 3 Patient 1. Repeated selective arteriogram a 5 min later after the device release documented the AVP I in good position with no residual flow into the left upper PAVM. Upon deployment of the AVP, her peripheral arterial oxygen saturation improved from 86 to 93% at rest. Due to the length of the procedure and the amount of contrast given, no further embolization attempts to another PAVM were performed (AVI 24070 kb)

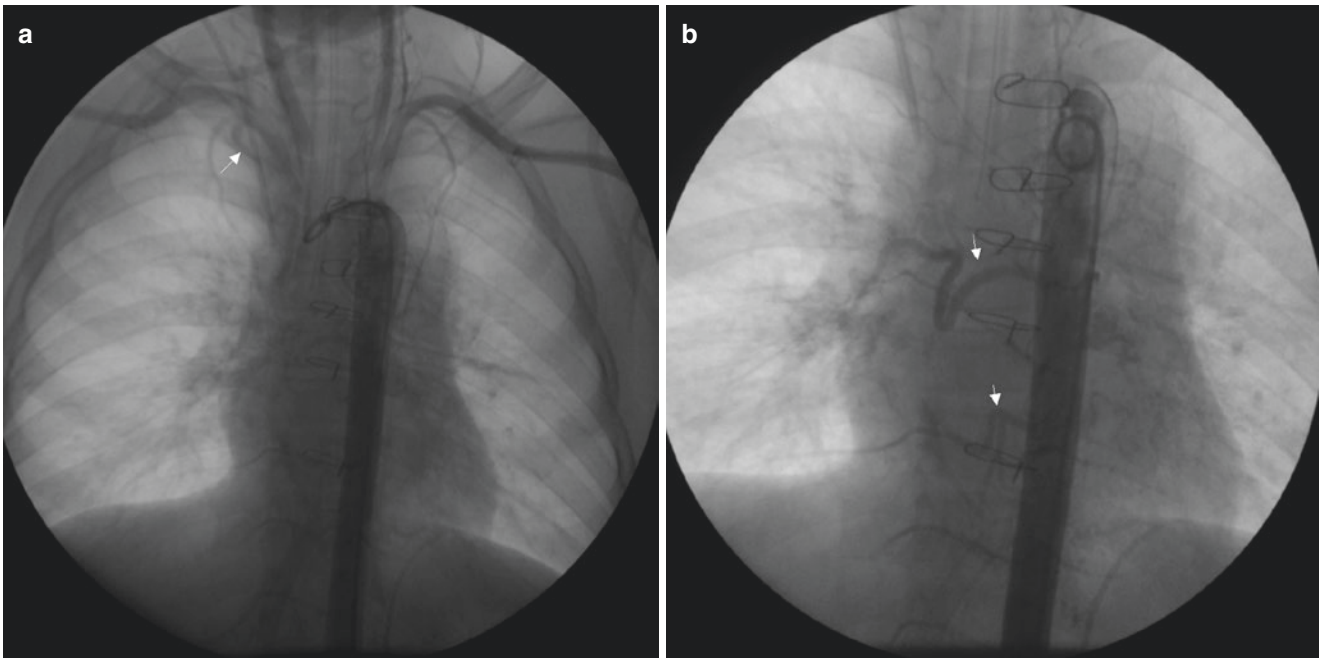

Fig. 22.7 (**a**, **b**) Patient 1.An 11-year-old boy (24 kg) who had undergone surgical correction for TOF was referred for transcatheter occlusion of multiple APCs due to failure to wean from ventilation. Ascending and descending aortogram showing multiple APCs arising from the right subclavian artery and descending aorta (arrows)

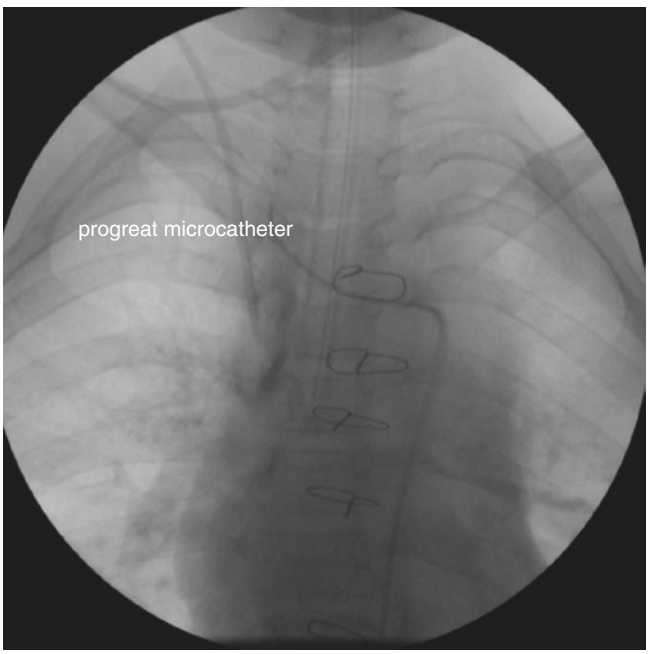

Fig. 22.8 Patient 1. The aortopulmonary collateral artery arising from right subclavian artery was selectively engaged by a 100 cm, 5-Fr Cobra catheter (Terumo, Japan) through which a 0.014 in. guidewire was advanced into the target vessel distally. Over the guidewire, a Progreat microcatheter (Terumo, Japan) was introduced into the target vessel as deep as possible

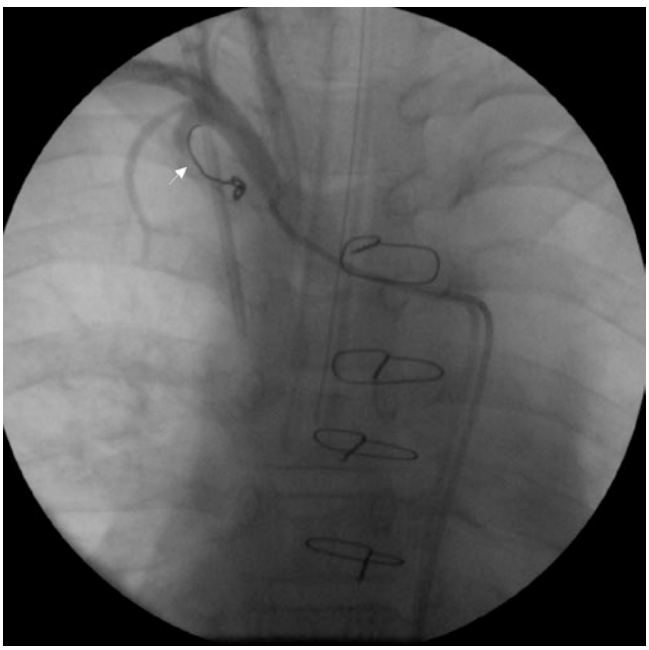

Fig. 22.9 Patient 1. Then, two MWCE-18S-3/2 coils (COOK, USA) were delivered to the target vessel through the Progreat microcatheter (arrow). After the coils were positioned, an angiogram performed through the Cobra catheter confirming complete occlusion of the collateral artery

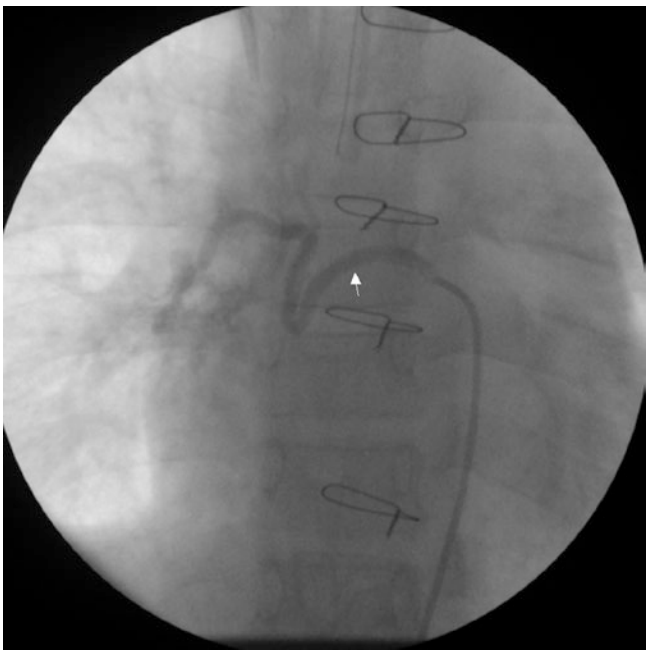

Fig. 22.10 Patient 1. The aortopulmonary collateral artery arising from the descending aorta was cannulated selectively with the Cobra catheter. Selective angiogram of the target vessel performed via the Cobra catheter showing its tortuous course to the right middle pulmonary artery branch (arrow)

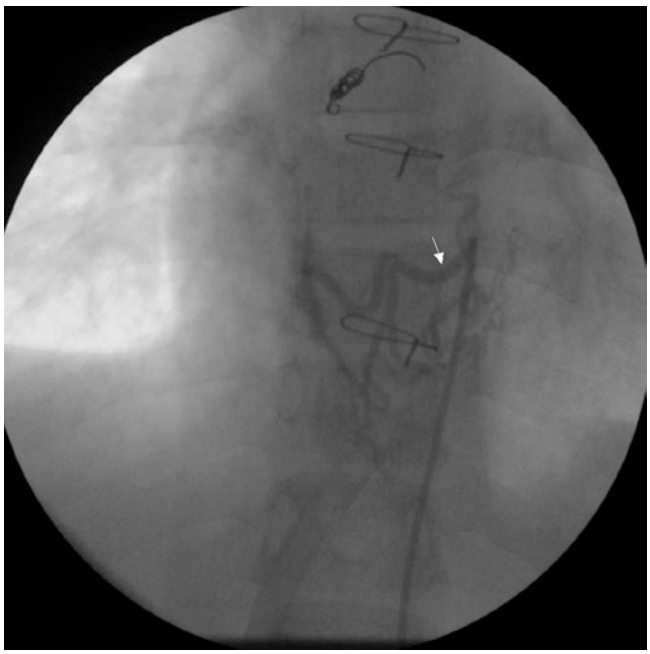

Fig. 22.12 Patient 1. Next, the Cobra catheter was placed into another aortopulmonary artery that arises from the descending aorta and a selective angiogram showing the tortuous features of the target vessel (arrow)

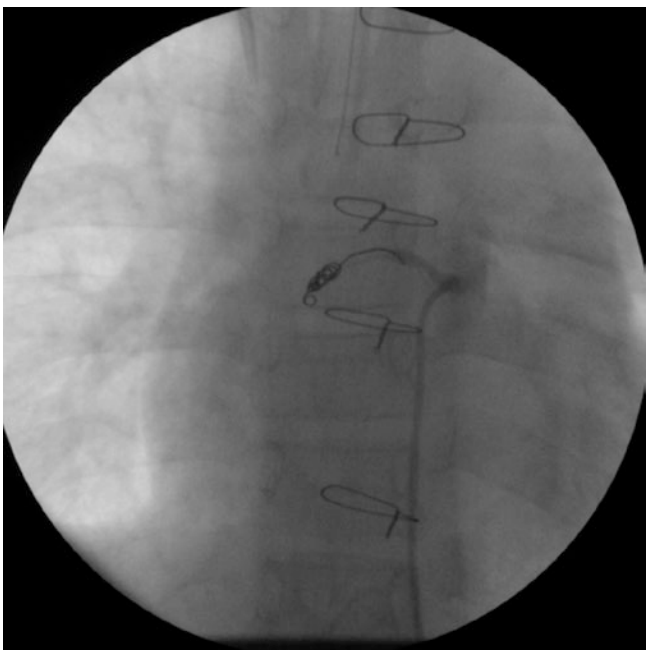

Fig. 22.11 Patient 1. A MWCE-18S-4/2 coil (COOK, USA) was deployed at the narrowest segment of the collateral artery. Repeated descending aortogram confirming complete occlusion of the collateral artery

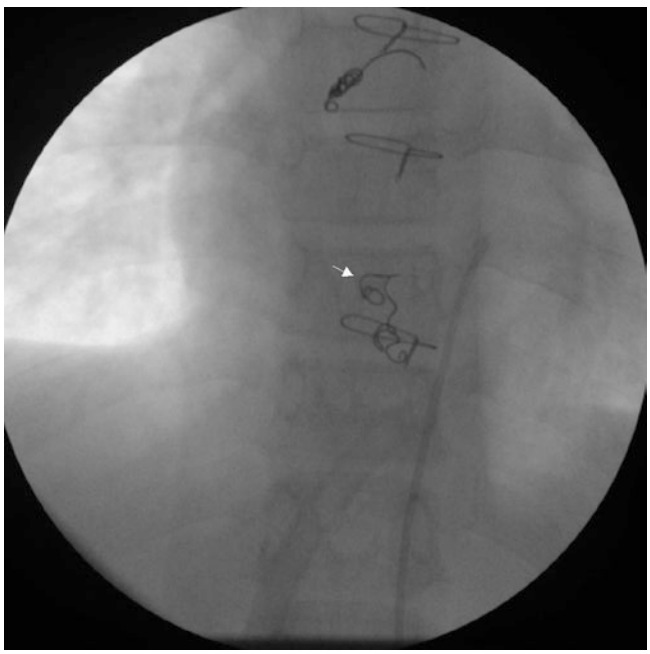

Fig. 22.13 Patient 1. Three Coils (MWCE-18S-5/2, 4/2, 3/2 coils, COOK, USA) were positioned at the appropriate position of the collateral artery in a similar fashion as previously described (arrow)

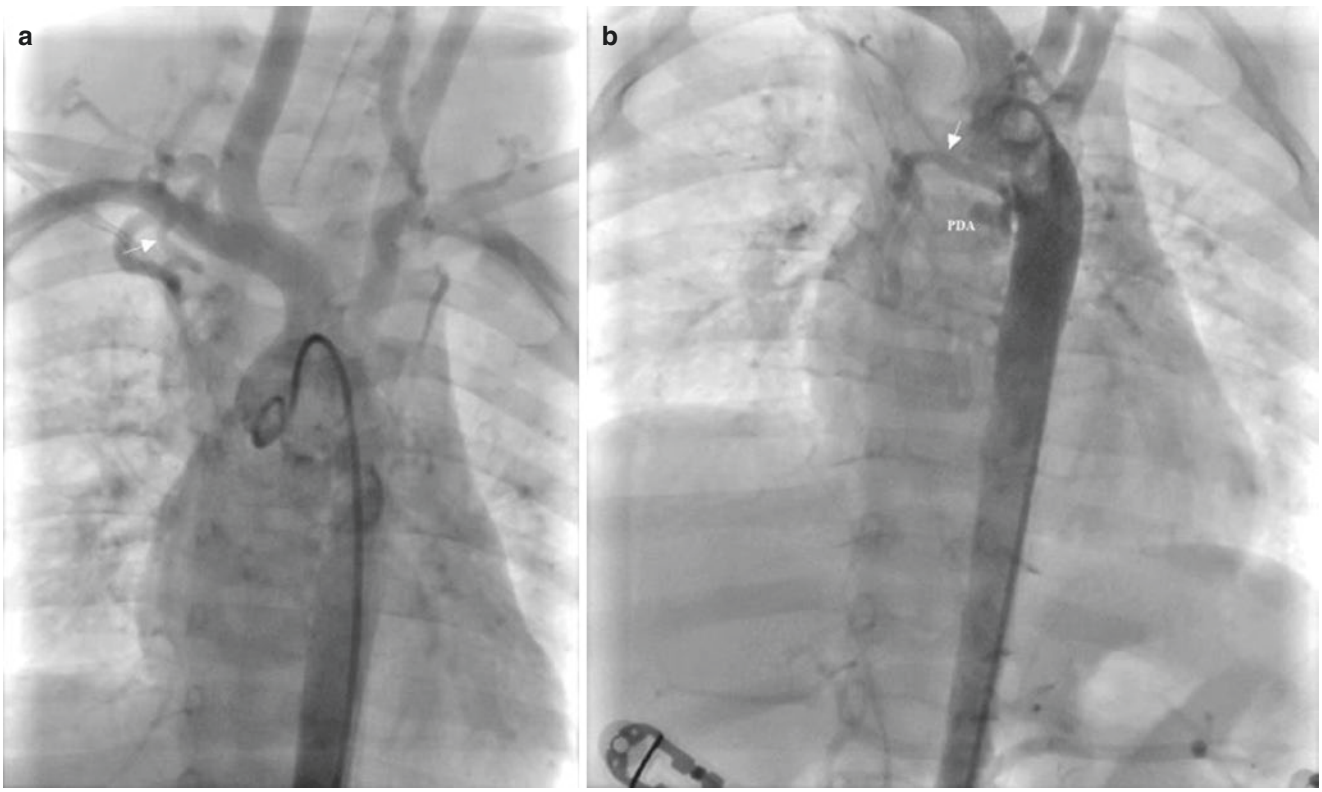

Fig. 22.14 (**a, b**) Patient 2. A three-year-old boy (15 kg) was diagnosed to have transposition of great arteries (TGA) with ventricular septal defects (VSD) and pulmonary valve stenosis (PS) was referred for transcatheter occlusion of APCs due to recurrent symptomatic heart failure and frequent lower airway infection. Angiogram in the ascending and descending thoracic aorta demonstrating multiple APCs arising from the right subclavian artery and descending aorta (arrows) with a PDA measuring approximately 4 mm in diameter at its narrowest (white arrow)

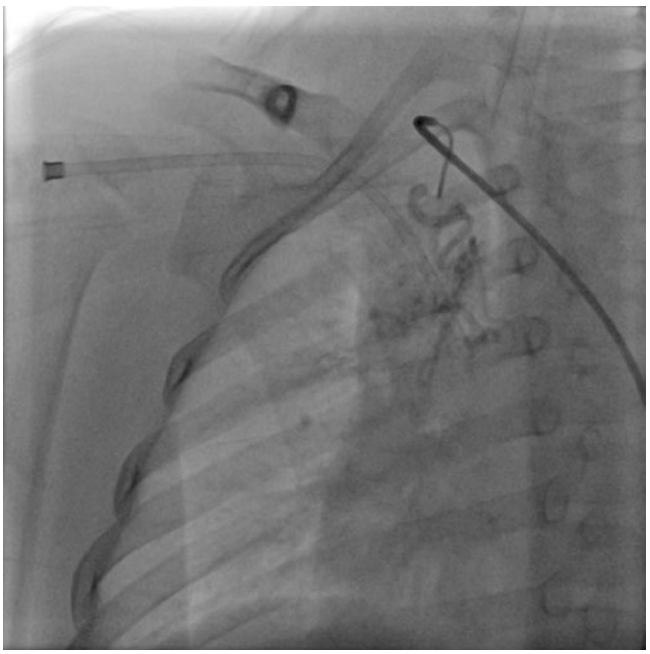

Fig. 22.15 Patient 2. The target collateral artery arising from right subclavian artery was selectively engaged using a coaxial guide system with an outer 5-Fr Cobra catheter (Terumo, Japan) and inner Progreat microcatheter (Terumo, Japan)

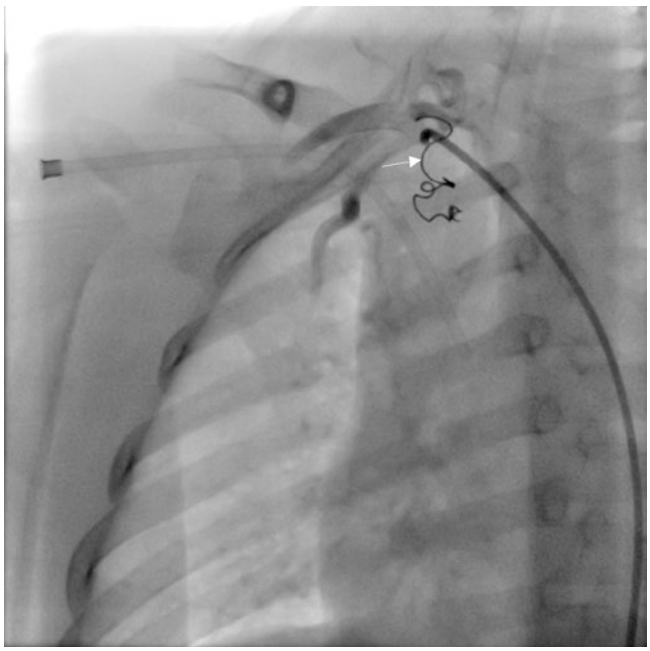

Fig. 22.16 Patient 2. Then, three appropriate sized coils (arrow) were delivered to the target vessel through the Progreat microcatheter as distal as possible. After the coils were deployed, an angiogram was performed through the Cobra catheter confirming complete occlusion of the collateral artery

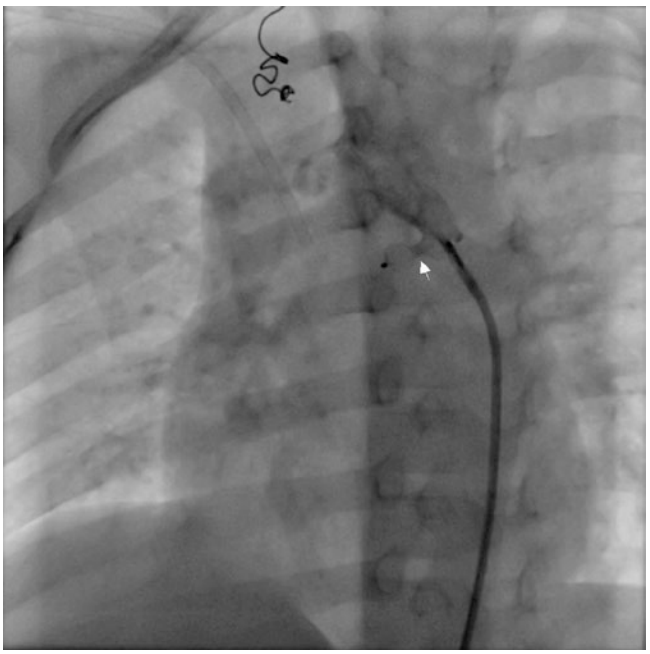

Fig. 22.17 Patient 2. A 5-Fr Judkins right guide catheter was advanced over a hydrophilic-coated guidewire into the PDA as deeply as possible. Then an 8 mm AVP was advanced via the guide catheter into the PDA and deployed at the suitable position (arrow)

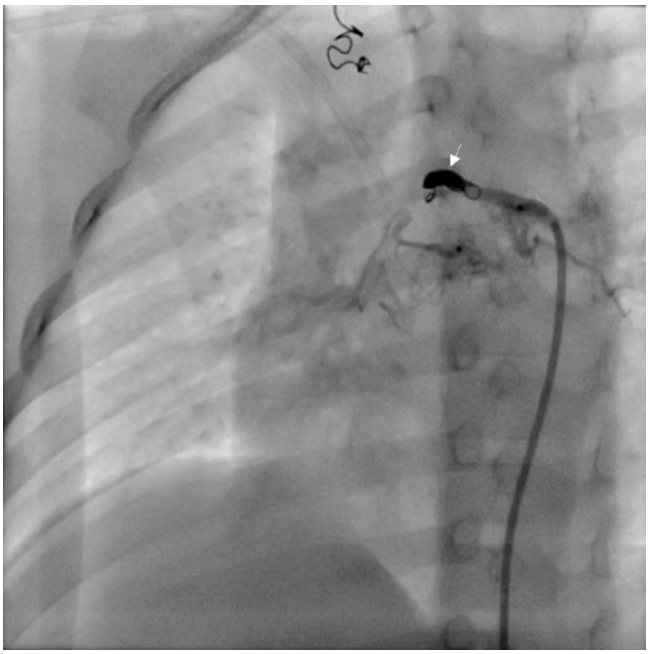

Fig. 22.19 Patient 2. Following implant of two MWCE-18S-6/2 Tornado coils (COOK, USA), this aortopulmonary collateral artery was completely occluded

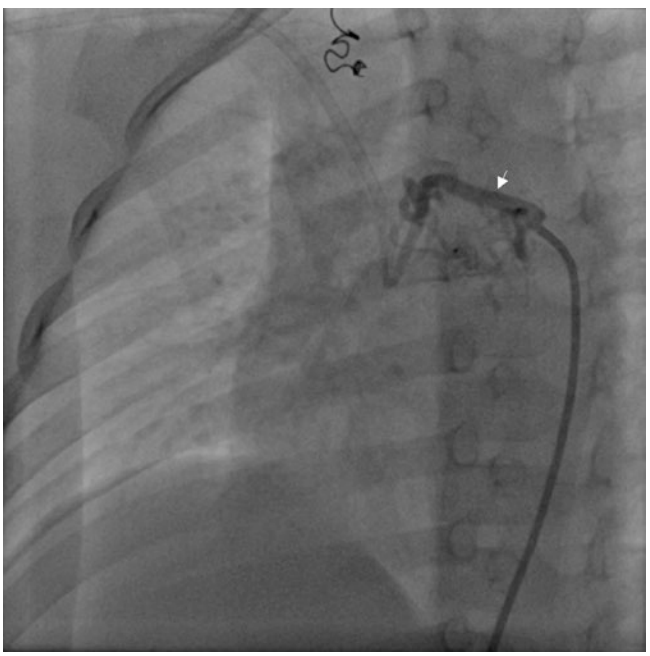

Fig. 22.18 Patient 2. An angiogram performed after the deployment of the AVP, indicating complete occlusion of the PDA, but there remains a large collateral artery above the AVP device (arrow)

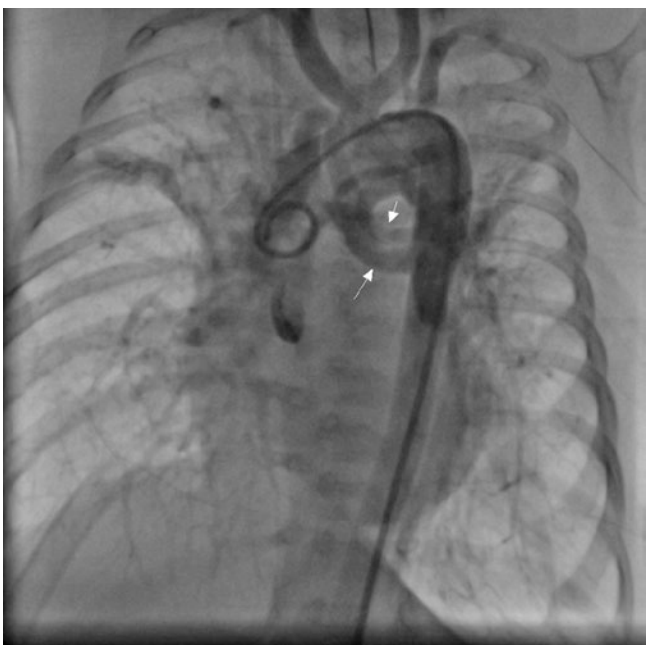

Fig. 22.20 Patient 3. A two-month-old boy (3.9 kg) diagnosed with ventricular septal defect (VSD) and pulmonary atresia (PA) was referred for transcatheter occlusion of APCs prior to surgical correction. An angiogram in the ascending aorta demonstrating the presence of multiple APCs (arrows) arising from the descending aorta, which supplying the left and right lungs

Fig. 22.21 Patient 3. The larger collateral vessel was entered using a 5-Fr Judkins right 4.0 guide catheter (Cordis, USA), and an appropriate sized AVP was deployed at the narrowest position of the collateral vessel

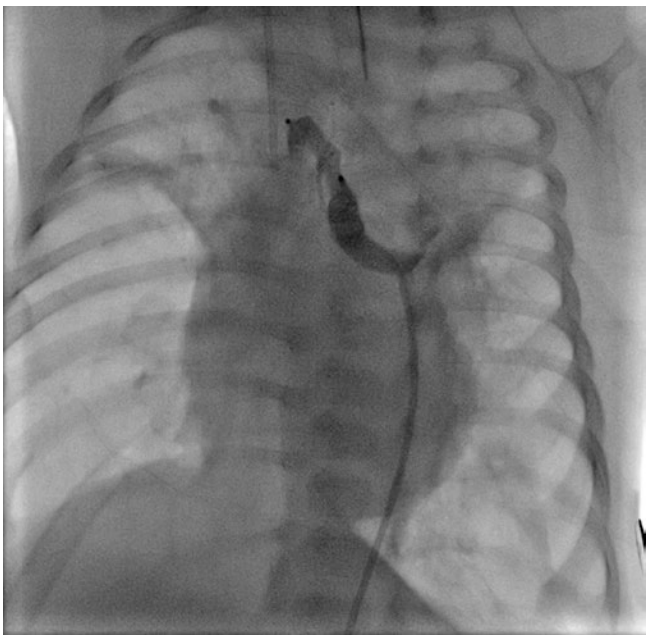

Fig. 22.23 Patient 3. Therefore, an addition MWCE-18S-8/5mm Tornado coil (COOK, USA) was implanted, resulting in immediate, complete occlusion of this vessel

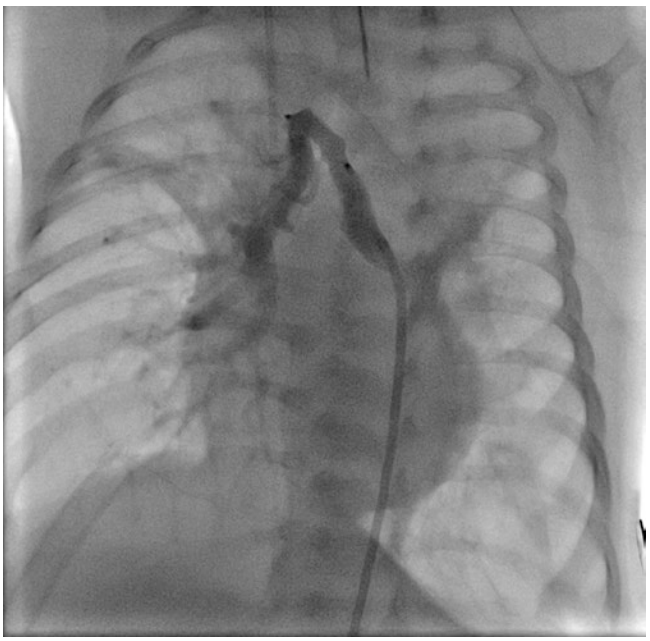

Fig. 22.22 Patient 3. An angiogram was performed 5 min later after the AVP released, indicating a considerable residual shunt remained through the device

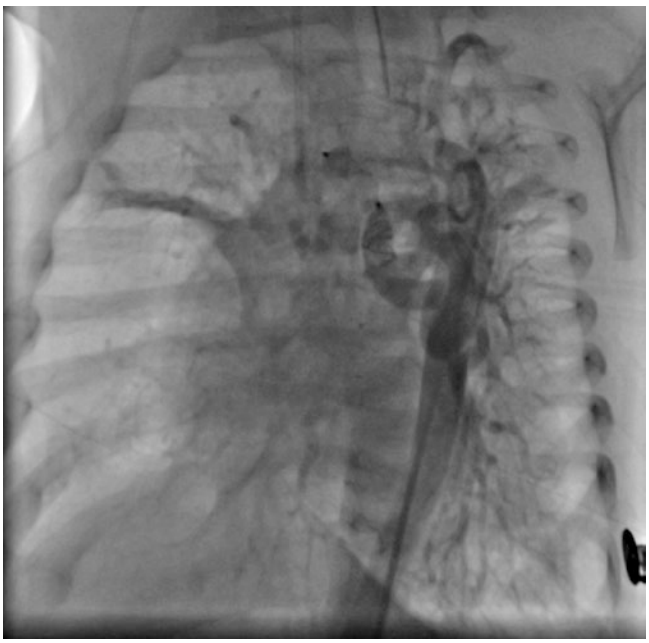

Fig. 22.24 Patient 3. Repeat descending aortogram performed 10 min later, demonstrating no residual shunting across this collateral vessel