



NAVIGATING COMPLEXITY IN PULMONARY AVM TREATMENT: CASE SERIES AND TECHNICAL HIGHLIGHTS

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ABSTRACT

Background: Pulmonary arteriovenous malformations (AVMs) are rare vascular anomalies that can lead to significant clinical consequences, including hypoxemia, paradoxical embolism, and stroke.

Endovascular treatment, particularly using embolization with vascular plugs, has emerged as a highly effective approach for managing pulmonary AVMs. **Purpose:** This case series highlights the clinical presentation, imaging findings, and interventional management of three distinct pulmonary AVM cases—simple AVM and complex AVM—emphasizing technical nuances and outcomes. **Methods:** Three patients presenting with symptomatic pulmonary AVMs underwent thorough clinical and imaging evaluation, followed by endovascular treatment using embolization techniques tailored to each case's complexity. Procedural details, complications, and follow-up outcomes were analyzed to evaluate the effectiveness of the interventions.

Results:

- In the case of the simple AVM, precise localization and vascular plug insertion of the feeder vessel resulted in successful occlusion with no complications.
- The complex AVM demonstrated high-flow dynamics and extensive collateral circulation, necessitating advanced planning, specialized equipment, and multidisciplinary collaboration for successful treatment.

All three cases showed favorable clinical outcomes, with resolution of symptoms and no recurrence or significant complications during follow-up. **Conclusion:** This case series underscores the importance of individualized endovascular approaches in the management of pulmonary AVMs, highlighting technical innovations and strategies for dealing with varying levels of complexity. These findings support the role of embolization as a safe and effective treatment modality, emphasizing its adaptability to both simple and challenging cases.

KEYWORDS : Pulmonary Arteriovenous Malformation (AVM), Endovascular Embolization, Amplatzer Vascular Plug, Pulmonary Angiography, High-Flow AVM, Complex AVM, Shunt Closure.

INTRODUCTION

Pulmonary arteriovenous malformations (AVMs) are rare vascular abnormalities characterized by direct communication between pulmonary arteries and veins, bypassing the capillary network. This abnormality can lead to significant clinical consequences, including hypoxemia, paradoxical embolism, and an increased risk of stroke and brain abscesses. Pulmonary AVMs may occur as isolated anomalies or in association with hereditary hemorrhagic telangiectasia (HHT), an autosomal dominant genetic disorder.

The primary goal of treatment for pulmonary AVMs is to prevent complications while alleviating symptoms. Endovascular embolization, a minimally invasive technique, has revolutionized the management of pulmonary AVMs, offering high success rates and reduced risk compared to surgical resection. This method involves the occlusion of feeding arteries using embolic materials such as vascular plugs, coils, or liquid embolic agents.

While simple AVMs, with a single feeding artery and draining vein, are often straightforward to treat, complex AVMs with high-flow dynamics and extensive collateral circulation pose significant challenges. Effective management of such lesions requires careful planning, advanced imaging techniques, and precise execution of interventional strategies.

In this case series, we present the interventional radiological management of three distinct pulmonary AVMs: one simple and two complex. The series highlights procedural techniques, technical challenges, and clinical outcomes,

underscoring the adaptability and effectiveness of endovascular embolization in managing varying complexities of pulmonary AVMs.

Case 1: 22-Year-Old Male with Hemoptysis

A 22-year-old male patient presented with a history of recurrent hemoptysis over the past few months, progressively worsening in the last week. The patient had no significant past medical history, with no family history of hereditary hemorrhagic telangiectasia (HHT) or other vascular anomalies. On clinical examination, he was afebrile with normal vital signs. Chest auscultation revealed fine crackles at the right lower lung base, but no wheezing or signs of consolidation. Hemoglobin levels were within normal range, and laboratory tests did not show evidence of active infection or bleeding disorders.



Figure 1 Shows Simple AVM – Single Feeding Artery and Single Draining Vein

Given the patient's persistent hemoptysis, contrast-enhanced CT angiography was performed to identify the underlying etiology. Imaging revealed a simple pulmonary AVM located in the right lower lobe, with a single feeding artery and draining vein. The AVM was small in size but identified as the likely source of the patient's hemoptysis.

The patient was subsequently scheduled for endovascular treatment. Under conscious sedation, a vascular plug (Amplatzer Vascular Plug) was successfully deployed into the feeding artery to occlude the shunt. Post-procedural angiography confirmed optimal occlusion with complete cessation of blood flow to the AVM. The patient was stable post-procedure and was monitored in the hospital for any immediate complications.



Figure 2 Shows Insertion of Vascular Plug into Feeding Artery

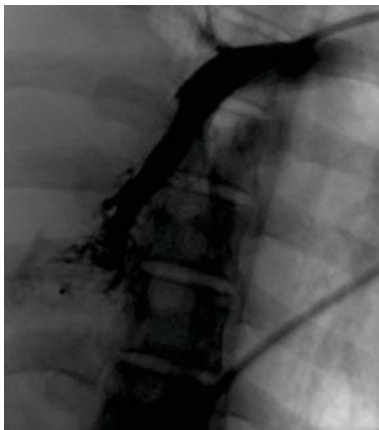


Figure 3 Shows Post Vascular Plug Insertion, Check Angio Reveals Optimal Occlusion

Case 2: 51-Year-Old Female with Dyspnea and Cyanosis

A 51-year-old female presented with progressive dyspnea on exertion for the past few years. On admission, her oxygen saturation (SpO₂) was critically low at 52% on room air, improving to 80% with bag-valve-mask (BMV) ventilation. The patient displayed orthodeoxia, with oxygen saturation improving in a supine position but not in a prone position. Cyanosis was also noted on examination. The patient had no history of significant cardiovascular or pulmonary disease.



Figure 4 Shows Pre-op Chest Radiograph Showing III-

defined Retrocardiac and Left Lower Zone Tubular Radio-opacities which are Obliterating the Left Cardiophrenic Angle

Pre-operative chest radiographs revealed ill-defined retrocardiac and left lower zone tubular radio-opacities, which were obliterating the left cardiophrenic angle. Contrast-enhanced CT pulmonary angiography (CTPA) demonstrated dilated vascular channels in the right middle lobe, left upper lobe, and left lower lobe, highly suggestive of pulmonary arteriovenous malformations (PAVM).

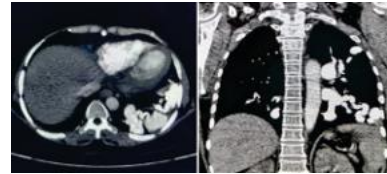


Figure 5 Shows PRE-OP Ctpa Shows Dilated Vascular Channels in RML,LUL AND LLL Suggestive OF PAVM.

Selective digital subtraction angiography (DSA) of the left lower lobar pulmonary artery revealed multiple high-flow AV shunts originating from segmental arteries. These arteries showed aneurysmal dilatation, and rapid venous washout suggested a pulmonary AV fistula. The first Amplatzer vascular plug was deployed into a segmental feeder artery of the left lower lobe. Post-deployment DSA of the left lower lobe revealed successful closure of the AV fistulas with two more vascular plugs placed into segmental branches. A lateral segmental branch showed flow diversion (marked with a red arrow), and subsequent DSA runs demonstrated no further blood flow in the AV fistulas.



Figure 6 Shows Saggital MIP Image Showing 3 AVF Having Feeding Arteries From Anterior, Middle and Posterior Segmental Arteries of Left Lobar Artery.

Chest radiographs post-procedure revealed effective plugging of the anterior, middle, and posterior segmental branches of the left lobar artery. The patient's oxygen saturation improved to 87% immediately following the procedure, and after one month, her saturation increased to 97%, with noticeable clinical improvement in cyanosis and dyspnea.

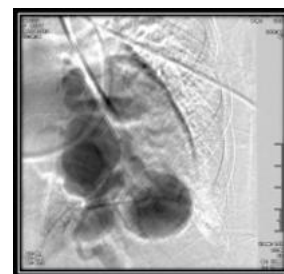


Figure 7 Shows Selective DSA of Left Lower Lobar

Pulmonary Artery Shows Multiple High Flow AV Shunting Arising From Segmental Arteries with Aneurysmal Dilatation and Rapid Washout on Venous Phase Suggestive of Pulmonary AVE. (Red Arrows)



Figure 8 Shows Deployment of 1ST Amplatzer Vascular Plug (Arrow) in Left Lower Lobe Segmental Feeder Artery.

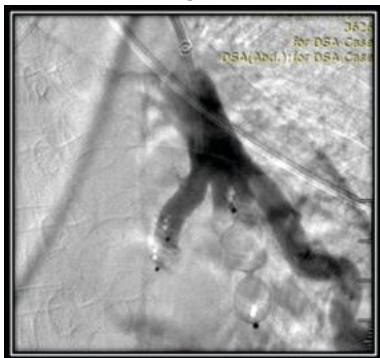


Figure 9 Shows Selective DSA of Left Lower Lobe Pulmonary Artery Post Insertion of Two Vascular Plugs (Yellow Arrows) in Segmental Branches Shows Complete Closure of AV Fistulas. Flow Diversion is Seen in Another Lateral Segmental Branch (Red Arrow).



Figure 10 Shows Post Procedure DSA Run Shows Complete Closure of Feeder Arteries with no Flow in AV Fistulas (Yellow Arrows Shows Vascular Plugs).



Figure 11 shows Chest Radiograph Shows Post Pulmonary Vascular Plugging of Anterior, Middle and Posterior Segmental Branches of Left Lobar Artery.

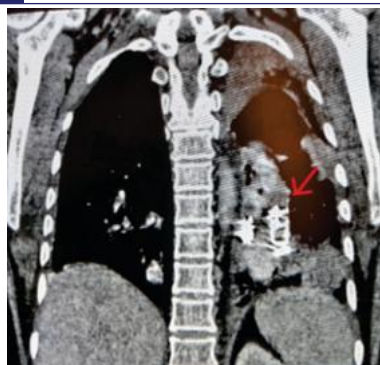


Figure 12 Shows Post Op CT Showing Placement of Vascular Plugs.

Case 3: 20-Year-Old Female with Dyspnea and Cyanosis

A 20-year-old female, known for dyspnea on exertion for the past 3-4 years, presented with worsening cyanosis and was admitted with altered mental status. On admission, her oxygen saturation (SpO₂) was critically low at 67%. She was diagnosed with high-output cardiac failure, and a thorough investigation was conducted to identify the underlying cause.



Figure 13 Shows Pulmonary Angiogram Reveals Abnormal Blush with Early Venous Drainage.

CT imaging revealed large, complex pulmonary AVMs located in the left upper and lower lobes, both of which exhibited abnormal vascular connections. The pulmonary angiogram demonstrated a characteristic abnormal blush with early venous drainage. Prominent feeders from the left descending pulmonary artery supplied tortuous vascular channels, displaying rapid venous drainage, consistent with pulmonary AVM.

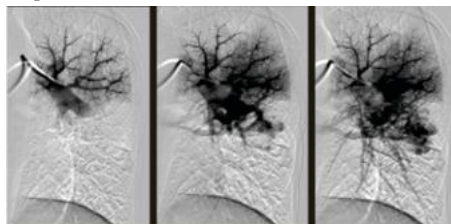


Figure 14 Shows Prominent Feeder From Left Descending Pulmonary Artery to Abnormal Tortuous Vascular Channels Showing Prompt Venous Drainage, Consistent With AVM.

Selective catheterization was performed, and measurements were taken to assess the precise anatomy of the AVMs. Initially, an Amplatzer vascular plug was deployed in the main feeder artery of the left lower lobe, with follow-up angiography confirming optimal occlusion and cessation of the AVM-related blood flow. Post-procedure, the patient experienced immediate improvement in oxygen saturation, rising to 96% on the table.

On Day 7, a second session was conducted for the left upper lobe AVM. Pre-procedure SpO₂ was 91%. A selective arteriogram was performed, and coil embolization was carried out for the dominant feeder vessel. An additional Amplatzer vascular plug was deployed in the main feeder artery, and residual feeders were embolized using coils. Post-procedure angiography showed a marked reduction in blush, confirming successful occlusion of the AVM. The patient's SpO₂ improved immediately to 98%, and follow-up imaging confirmed a significant reduction in abnormal vascular flow.

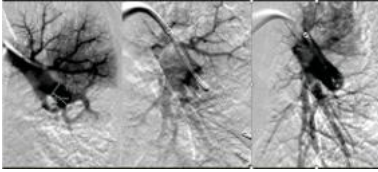


Figure 15 Shows Selective Catheterization, Placement of Amplatzer Vascular Plug, Check angiogram reveals good occlusion.



Figure 16 Shows Post Procedure Scan Shows Recruitment of an Arterial Feeder



Figure 17 - 2nd Session on Day 7, Coil Embolization of Dominant Feeder Vessel.

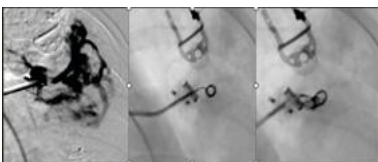


Figure 18 Shows Coil Embolization of the Residual Feeder



Figure 19 Shows Post Procedure Angio Reveals Markedly Decreased Blush of the AVM.

DISCUSSION

Pulmonary arteriovenous malformations (AVMs) are rare but significant vascular anomalies, with potential complications including hypoxemia, paradoxical embolism, and stroke. While pulmonary AVMs can be asymptomatic, many patients present with dyspnea, hemoptysis, or cyanosis, as seen in our case series. Endovascular embolization is considered the gold standard for treatment due to its high success rate and minimally invasive nature.

In Case 1, the simple AVM responded well to a single vascular plug deployment in the feeder artery, which resulted in successful occlusion and symptom relief. This highlights the efficacy of embolization in straightforward cases where a single feeder artery is involved.

Case 2 presented a more complex scenario with multiple high-flow AV shunts, requiring staged embolization with Amplatzer plugs and coils. Despite the complexity, this approach achieved complete closure of the AV fistulas, resulting in significant clinical improvement. Complex AVMs may require advanced imaging techniques and multiple interventional strategies, emphasizing the need for precise pre-procedural planning.

Case 3 demonstrated the challenges of managing large, complex AVMs with multiple feeders. Successful outcomes were achieved through a combination of plug deployment and coil embolization. Post-procedural improvements in oxygen saturation underscore the importance of personalized treatment plans tailored to the AVM's complexity. Overall, endovascular treatment remains a cornerstone in managing pulmonary AVMs, offering excellent outcomes with minimal morbidity.

Conflict of Interest Statement

The author(s) declare(s) no conflict of interest.

Funding Information

None.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Ethics Statement

Not applicable.

Informed Consent

The patient provided written informed consent at the time of entering this study.

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