*Case Reports*

# Percutaneous Hydrogel Coil Embolization of Aneurysms and Coronary Artery Fistulae in Congenital Heart Disease

Steven J. Healan, MD, MSCI[1]; George Nicholson, MD[1]; Thomas Doyle, MD[1]; Dana Janssen, MD[1]

[1]Division of Pediatric Cardiology, Vanderbilt University Medical Center, Nashville, Tennessee

*Patients with congenital heart disease frequently have aneurysms or coronary artery fistulae that necessitate treatment. Metal vascular coils have been a mainstay of treatment for these lesions. In 2002, coils coated or filled with expandable hydrogel were introduced to treat cerebral aneurysms; however, the literature on their use in patients with congenital heart disease is limited. We present 5 cases in which large vascular lesions in children or adolescents with congenital heart disease were successfully occluded with hydrogel coils.* **(Tex Heart Inst J 2021;48(3):e207312)**

**P**ediatric patients with congenital heart disease often have vascular lesions such as aneurysms, pseudoaneurysms, and coronary fistulae that necessitate referral to the cardiac catheterization laboratory. The lesions may occur as complications of previous interventions or as a result of altered physiology, and various percutaneous techniques have been used to treat them.

Percutaneous coil embolization of vascular lesions became possible after the Gianturco steel coil was introduced in 1975.[1] In 2002, vascular coils coated with expandable hydrogel were introduced to embolize cerebral aneurysms.[2-5] These hydrogel coils occlude vessels mechanically as their gel coating expands in the bloodstream, thus decreasing reliance on clot formation. Since then, hydrogel coils have been used to occlude vascular lesions in patients with congenital heart disease, but the literature documenting this experience is limited.[6] Therefore, we report 5 cases in which children or adolescents with large vascular malformations were successfully treated with hydrogel coils, and we evaluate the advantages and drawbacks of their use.

---

## Case Reports

### Patient 1

A 17-year-old girl underwent routine magnetic resonance imaging (MRI) to evaluate an end-to-end anastamosis and patent ductus arteriosus ligation that had been performed 5 years previously to repair coarctation of the aorta. Her medical history also included Turner syndrome and a bicuspid aortic valve. The MRI revealed a large pseudoaneurysm beneath the aortic arch near the ductal ampulla. At catheterization, an angiogram revealed a 15 × 19-mm pseudoaneurysm that was 8 mm wide at its neck (Fig. 1A). The lesion was cannulated with a Cobra 2 catheter (AngioDynamics) and embolized with a 14-mm × 34-cm Azur framing coil (Terumo), followed by two 16-mm × 32-cm Azur CX coils and two 10-mm × 20-cm Azur hydrogel coils (Terumo). An angiogram obtained several minutes after the coils were deployed showed occlusion (Fig. 1B). At her 2-year follow-up visit, the patient was doing well.

### Patient 2

A 9-year-old boy was evaluated at our cardiac catheterization laboratory for repeat pulmonary angioplasty, 4 years after having undergone pulmonary valvuloplasty and

branch pulmonary angioplasty at another institution. His medical history included atrial septal defect, pulmonary valve stenosis, and branch pulmonary artery stenosis.
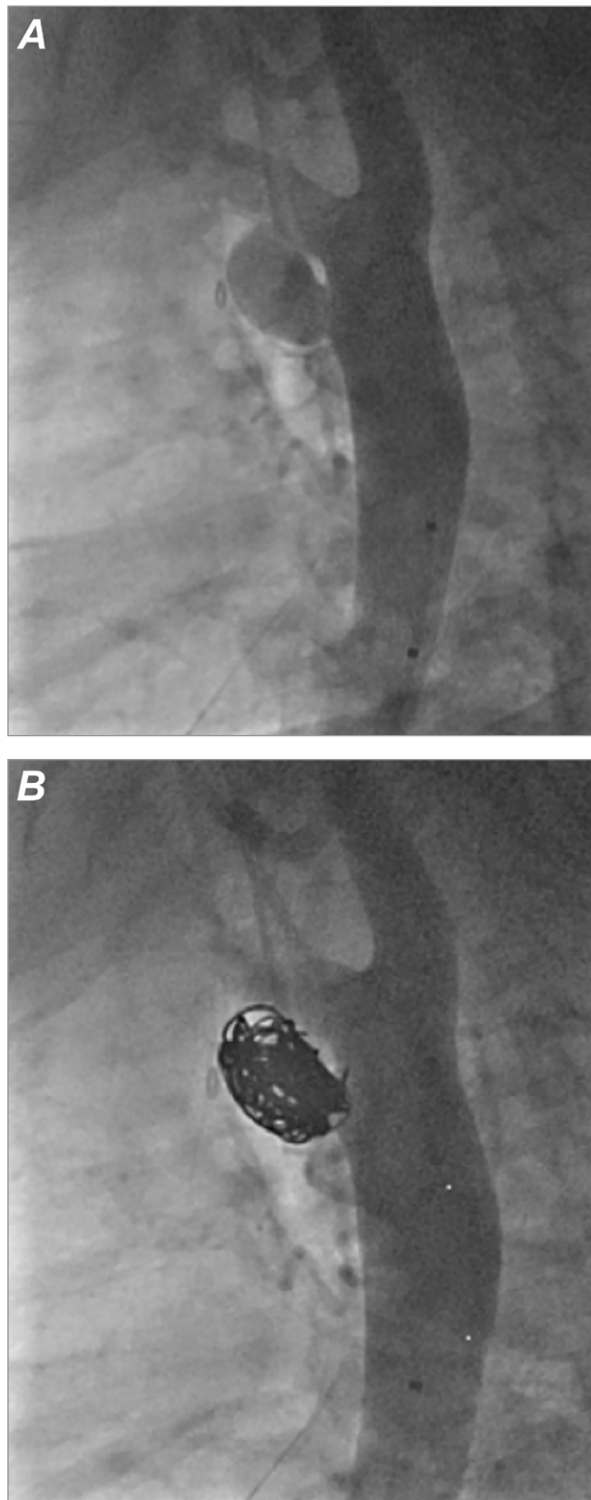


**Fig. 1** *Patient 1. Angiograms show **A**) a pseudoaneurysm beneath the aortic arch arising from the ductal ampulla, and **B**) the pseudoaneurysm after embolization with 5 assorted coils.*

The current angiogram revealed a large, heavily calcified pseudoaneurysm (27 × 35 mm with a 7.5-mm-wide neck) arising from the anterior branch of the right upper pulmonary artery (Fig. 2A). A 6F coronary guide catheter was positioned near the ostium, and a 4F glide catheter was advanced through it. The lesion was embolized by deploying two 20-mm × 50-cm Azur framing coils, followed by three 20-mm × 39-cm Azur CX coils, one 14-mm × 34-cm Azur framing coil, three 16-mm × 32-cm Azur CX coils, and finally two 13-mm × 24-cm Azur CX coils. An angiogram obtained immediately after coil delivery revealed trace residual blood flow into the lesion (Fig. 2B). Seventeen months later, the lesion was completely occluded.

### Patient 3
A 17-year-old girl with no relevant medical history was referred to our center for evaluation of a heart murmur.
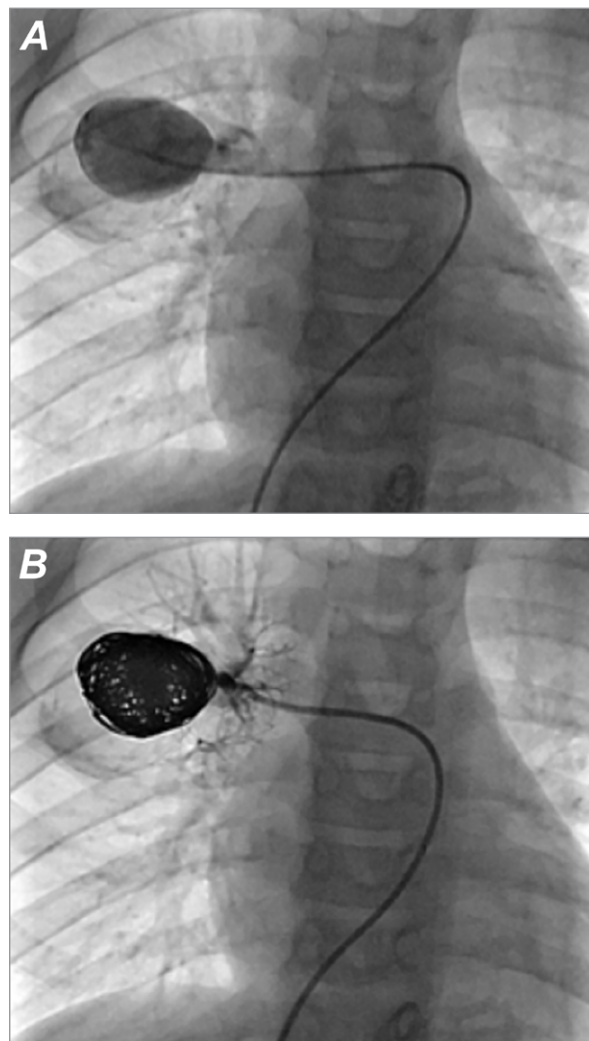


**Fig. 2** *Patient 2. Angiograms show **A**) a large calcified aneurysm arising from the anterior branch of the right upper pulmonary artery, and **B**) trace residual flow into the lesion after deployment of 11 assorted coils.*

A large coronary artery fistula was revealed on an echocardiogram and confirmed by cardiac MRI several months later. One month after that, the patient underwent cardiac catheterization for potential percutaneous closure of the fistula.

An angiogram revealed a coronary fistula that arose from the left sinus of Valsalva. The lesion, which extended 14 mm proximally, coursed another 6 mm before entering a large aneurysmal pouch (28 × 30 mm) and communicating with the right atrium (Fig. 3A). A 6F coronary guide catheter was positioned in the proximal fistula, and a 0.014-in Balance Middleweight (BMW) guidewire (Abbott Vascular) was passed through the fistula to the right atrium. The wire was snared and externalized through the venous sheath to create an arteriovenous rail. A balloon wedge pressure catheter was positioned within the fistula and inflated to test for occlusion. An angiogram confirmed normal flow to the left coronary artery system. A 12-mm Amplatzer Vascular Plug I (St. Jude Medical, an Abbott company) was deployed in the mid portion of the fistula. After release, the device migrated distally to the narrowest portion of the fistula, just proximal to the bulbous sac. With the vascular plug used as a backstop, the lesion was embolized by deploying a 20-mm × 39-cm Azur CX coil, followed by two 13-mm × 24-cm Azur CX coils, a 10-mm × 20-cm Azur hydrogel coil, a 12-mm × 20-cm Azur hydrogel coil, and a 10-mm × 19-cm Azur CX coil. An angiogram confirmed proper coil location, no flow through the fistula, and normal flow through the left coronary artery (Fig. 3B). The patient was prescribed aspirin and clopidogrel and was discharged from the hospital the next day. During 3 years of follow-up with her cardiologist, she remained well, showed no symptoms on exertion, and had normal echocardiograms, including a stress echocardiogram 21 months after discharge.

## Patient 4

A 16-year-old girl presented at our emergency department with chest pain that had developed during light exercise; her troponin I level was 2.51 ng/mL (normal, <0.03 ng/mL). Her medical history included pulmonary atresia with an intact ventricular septum and right ventricle-to-coronary artery connections, as well as Fontan palliation.

At catheterization, an angiogram revealed a fistulous connection between the left anterior descending coronary artery (LAD) and the right ventricle. The fistula was slightly wider than 2 mm at its neck and 11 mm at its widest (Fig. 4A). To evaluate whether the fistula was contributing to coronary perfusion, its neck was occluded with a 2.5-mm coronary balloon; echocardiographic monitoring for 10 minutes revealed no ST-segment changes. Subsequently, the fistulous lesion was embolized by deploying a 12-mm × 38-cm Azur CX coil, two

10-mm × 20-cm Azur hydrogel coils, and an 8-mm × 20-cm Azur hydrogel coil. An angiogram showed trivial residual flow through the fistula and normal flow through the rest of the left coronary system (Fig. 4B).
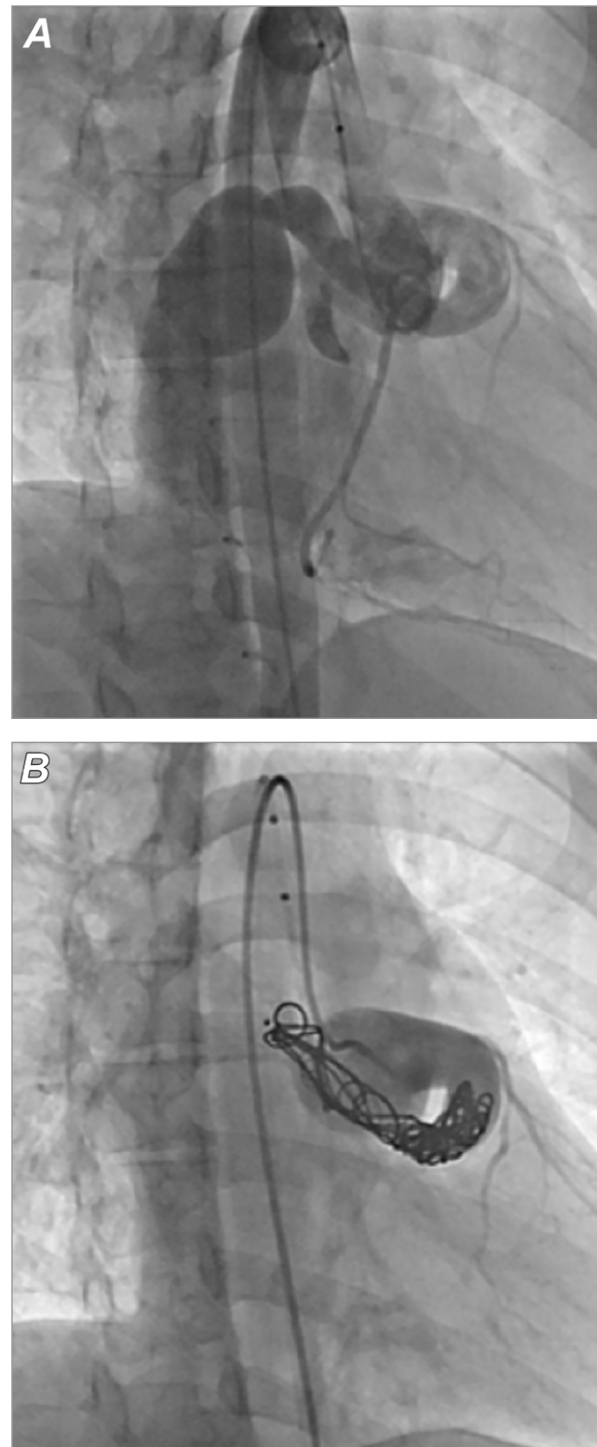


**Fig. 3** Patient 3. **A**) Angiogram shows a large coronary fistula arising from the left sinus of Valsalva and draining into the right atrium. **B**) Selective left main coronary artery angiogram shows the lesion after deployment of a 12-mm Amplatzer Vascular Plug I and 6 assorted coils.
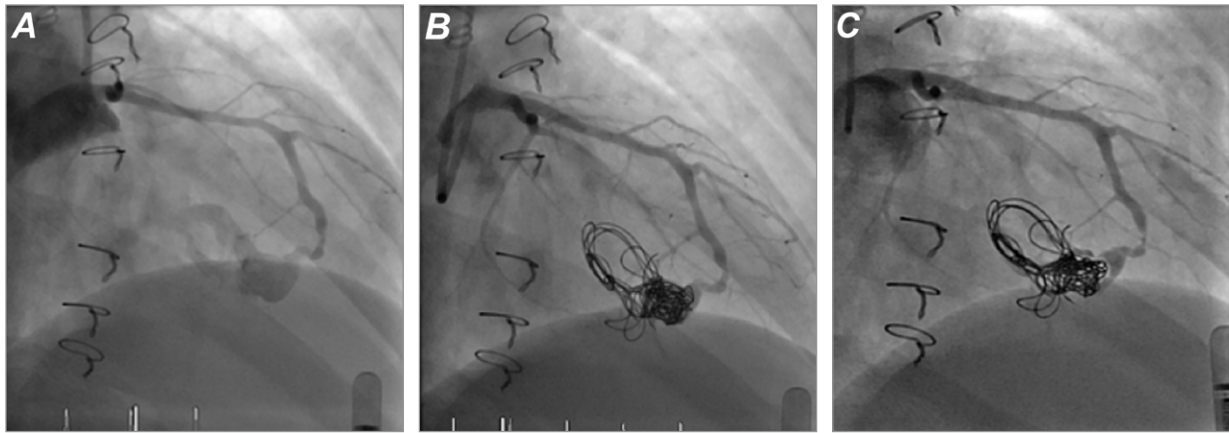
**Fig. 4** Patient 4. Angiograms show **A**) a moderately sized fistulous communication between the left anterior descending coronary artery and the right ventricle, and **B**) trivial flow into the lesion immediately after embolization with 4 assorted coils. **C**) Six months after embolization, there is trivial flow through the lesion.

The patient was prescribed aspirin and clopidogrel and was discharged from the hospital the next day. Six months later, an angiogram showed good coil position, scant flow through the fistulous connection, and no clot propagation (Fig. 4C). At her 11-month follow-up, the patient reported no chest pain and improved exercise tolerance.

## Patient 5

A 4-year-old boy was referred to our cardiac catheterization laboratory after echocardiographic findings at another institution raised concern for coronary fistula. His medical history included repairs of a ventricular septal defect and a double-chambered right ventricle at age 5 months and repeat ventricular septal defect repair after patch dehiscence at age 8 months.

Diagnostic catheterization revealed a 3-mm coronary fistula arising from the distal left main coronary artery and draining into a left ventricular aneurysm (Fig. 5A). A region of transmural delayed enhancement in the LAD territory, consistent with infarct, was seen on MRI. We decided to try closing the fistula percutaneously.

A 5F coronary guide catheter was positioned in the left main coronary artery, and a 0.014-in BMW guidewire and microcatheter were then inserted and advanced across the fistula into the left ventricle. The microcatheter was pulled back into the distal fistula, and a single 4-mm × 10-cm Azur hydrogel coil was packed tightly into the fistula. An angiogram obtained several minutes later showed no residual flow through the lesion and normal flow into the LAD (Fig. 5B). The patient had an uneventful postoperative course and was discharged from the hospital the next day. At his 20-month follow-up visit, he remained well and showed no symptoms on exertion.

## Discussion

Two types of hydrogel coils were used in our cases. The Azur CX coil for vascular lesions is filled with hydrogel, which forms a solid core after expansion and prevents blood flow through the coil. In contrast, the Azur coil has a hydrogel coating, which increases the effective diameter of the coil after expansion, making it suitable for packing aneurysms. Both models are available in 0.018- and 0.035-in versions with loop diameters ranging from 2 mm to 20 mm. Framing coils, which do not have hydrogel, can be used to create a cagelike structure in the vessel or aneurysm to contain the hydrogel coils.

The main advantage of hydrogel coils over coils constructed with thrombogenic fibers is that they mechanically obstruct blood flow as the gel coating expands in the bloodstream and are less reliant on clot formation. Since clots can break down over time, this feature of hydrogel coils may decrease risk of lesion recanalization or distal vessel thrombosis. The hydrogel coating allows a coil of 0.018 inches in diameter to assume a final diameter of greater than 0.035 inches once expanded in the bloodstream. As a result, fewer coils may be needed to occlude a large lesion. The expandable hydrogel may also improve the stability of the deployed coil and decrease the risk of the coil's moving from the desired site.[2,3,5] Finally, Azur hydrogel coils have an electronic release mechanism designed to improve the precision of coil positioning, thus increasing procedural accuracy and decreasing complication rates. Precision is especially important in patients with coronary fistulae to prevent blood flow in adjacent vessels from being disrupted.

The primary disadvantage of hydrogel coils is cost. A lesion can usually be embolized with fewer hydrogel coils than fibered platinum coils, but the substantially higher cost of hydrogel coils may offset this advantage.
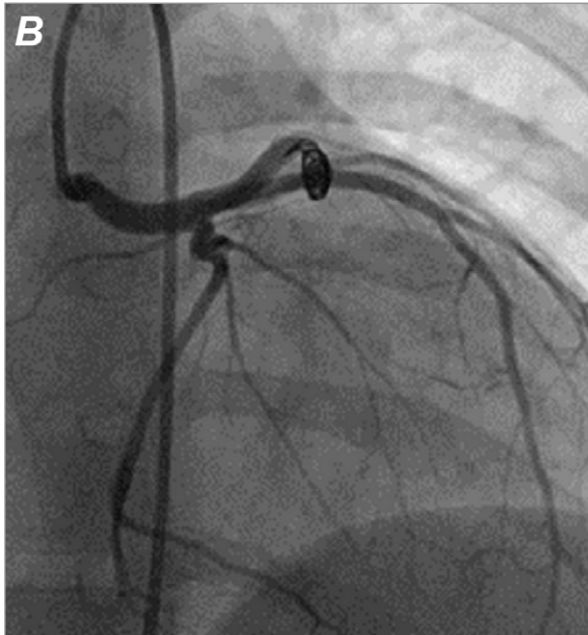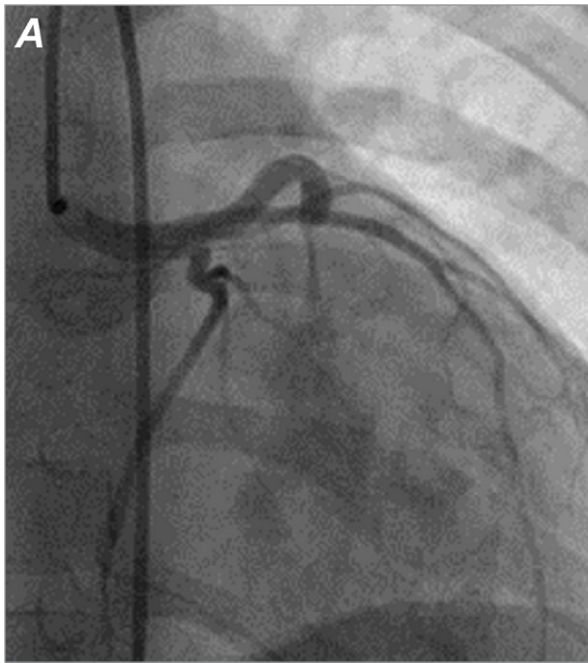
**Fig. 5** *Patient 5. Angiograms show **A**) a small fistulous connection between the left main coronary artery and the left ventricular outflow tract, and **B**) complete occlusion of the fistula and normal flow through the left anterior descending coronary artery several minutes after a hydrogel coil was deployed.*

## References

1. Gianturco C, Anderson JH, Wallace S. Mechanical devices for arterial occlusion. Am J Roentgenol Radium Ther Nucl Med 1975;124(3):428-35.
2. Cloft HJ, Kallmes DF. Aneurysm packing with HydroCoil Embolic System versus platinum coils: initial clinical experience. AJNR Am J Neuroradiol 2004;25(1):60-2.
3. Ding YH, Dai D, Lewis DA, Cloft HJ, Kallmes DF. Angiographic and histologic analysis of experimental aneurysms embolized with platinum coils, Matrix, and HydroCoil. AJNR Am J Neuroradiol 2005;26(7):1757-63.
4. White PM, Lewis SC, Nahser H, Sellar RJ, Goddard T, Gholkar A, HELPS Trial Collaboration. HydroCoil Endovascular Aneurysm Occlusion and Packing Study (HELPS trial): procedural safety and operator-assessed efficacy results. AJNR Am J Neuroradiol 2008;29(2):217-23.
5. Sluzewski M, van Rooij WJ, Slob MJ, Bescos JO, Slump CH, Wijnalda D. Relation between aneurysm volume, packing, and compaction in 145 cerebral aneurysms treated with coils. Radiology 2004;231(3):653-8.
6. Goldstein BH, Aiyagari R, Bocks ML, Armstrong AK. Hydrogel expandable coils for vascular occlusion in congenital cardiovascular disease: a single center experience. Congenit Heart Dis 2012;7(3):212-8.