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Case Reports

Use of Interlock Fibered Detachable Coils for Occlusion of Collaterals, Coronary Artery Fistulae, and Patent Ductus Arteriosus

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Objective: To investigate the utility of Interlocking Detachable Coils™ (IDC) for transcatheter occlusion of vascular communications in congenital heart disease. Background: The IDC can be delivered in a retractable fashion through hydrophilic Renegade™ microcatheters. They incorporate thrombogenic synthetic fibers and cost less than comparable neurovascular coils. They are ideally suited for use in many forms of congenital heart disease. Methods: A retrospective review of all patients catheterized during the initial 18-month period of IDC availability at our institution was performed. Interlock coils were only used if traditional methods could not be used easily and safely. All congenital patients in whom IDC were used are described. Results: A total of 61 coils were deployed in 17 patients with various vessels not amenable to treatment with conventional coils. Coils were used in aortopulmonary collaterals (*n* = 7), veno-venous collaterals (*n* = 9), patent ductus arteriosus (*n* = 3), and coronary artery fistulae (CAF) (*n* = 2). Operators were able to control coils and withdraw into the catheter for repositioning without difficulty. Thirteen of 21 vessels demonstrated immediate occlusion. All late angiograms have demonstrated complete occlusion of all vessels, with one exception requiring reintervention. One coil migrated from a large CAF and was easily retrieved with a snare. No serious complications occurred. All patients had an uneventful postcatheterization course. Conclusions: Transcatheter vascular coil embolization with IDCs can be performed safely and effectively in a variety of circumstances.

Key words: pediatric interventions; collaterals; total occlusions; congenital heart disease in adults

INTRODUCTION

Since the introduction of the Gianturco coil in 1975 [1], transcatheter embolization of vascular anomalies has become a routine procedure in pediatric cardiology. Conventional coils vary in size from 0.038″ to 0.018″ and can be deployed in a variety of fistulous connections. These coils cannot be retracted once deployment has begun. These coils are at a higher risk for embolization or deployment in an unwanted position. Incorrectly deployed coils must then be retrieved.

The development of detachable coils has given operators much more control over coil delivery. The Guglielmi coil (Target Therapeutics, Fremont, CA) is an electrolytically detachable coil that has had good results in pediatric cardiology [2,3], but its use can be limited by cost and with the absence of fibers for thrombogenicity. The Flipper coil (Cook Medical, Bloomington, IN) represents a reasonably priced alternative to the Gianturco coil but requires delivery with catheters of a certain internal diameter (recommended size 0.041″). Alternatively, the interlocking fibered detachable coil (Boston Scientific, Natick, MA) is a similar platinum coil that is controlled via a

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mechanically detachable mechanism. It has fibers for thrombogenicity and can be delivered into catheters as small as 2.8 Fr. This allows for controlled embolization of large and small vessels, as well as highly tortuous communications that can be difficult to access with larger catheters. We report our experience with this coil and its utility in pediatric cardiac catheterization.

MATERIALS AND METHODS

Approval was obtained from the University of California Los Angeles IRB for retrospective review from September 2006 to March 2008. Patients were included for review if coil embolization or vessel occlusion was performed.

Each of the subjects was scheduled for cardiac catheterization with either the advance knowledge of collaterals/vascular communications or their suspected presence based on clinical information. All procedures were done under general anesthesia. Baseline hemodynamic measurements were taken in each patient, and cineangiography was performed to assess location, size, and anatomy of the target vessels. Based on the cineangiographic appearance of each vessel, it was determined if the target vessel could be safely and easily occluded with conventional methods. Interlock coils (IDC) were used only for embolizations in which other devices failed or for situations in which a detachable coil delivery via microcatheter was felt to be necessary. Coils were selected to be approximately twice the diameter of the target vessel. All patients received intravenous cefazolin; heparin was given at the discretion of the interventional cardiologist.

In each case, the target vessel was engaged with a directional catheter of internal diameter of 0.035″ or greater (JL, JR, Angle Glide, Bernstein), and the vessel was entered with an 0.014″ wire (BMW, IM, GrandSlam). The hydrophilic Renegade 2.8 French microcatheter (Boston Scientific, Natick, MA) was advanced then through the directional catheter over the 0.014″ wire into the collateral vessel or communication. The IDC's were introduced into the microcatheter and advanced into the collateral vessel with use of the delivery wire. Following deployment of the coils, repeat cineangiography was performed to confirm position of the coil and to assess occlusion of the target vessel. Multiple coils were used as needed to achieve either complete occlusion or a critical coil mass thought to be adequate for future complete occlusion.

RESULTS

During the study period, embolization was performed in a total of 89 patients. The IDC occlusion system was used exclusively in 15 patients (19% of total patients) and in combination with other devices in two patients. Other embolization devices used during this period include Amplatzer PDA Duct-Occluder (AGA Medical, Golden Valley, MN) ($n = 25$), Flipper coils (Cook Medical, Bloomington, IN) ($n = 42$) and AGA Vascular Plug (AGA Medical) ($n = 5$).

A total of 21 vessels were occluded with 61 coils using the IDC occlusion system. The patient characteristics and vessels coiled are described in Table I. Patients ranged in age from 4 months to 27 years. A variety of directional catheters were used as guides for the Renegade microcatheter (4 and 5 Fr Judkins right and left, 4 Fr Angle Glide and Bernstein). Coils ranged in size from 3 mm × 6 cm to 14 mm × 30 cm. Collaterals were accessed from femoral venous, arterial approaches, as well as via the internal jugular vein.

Embolized vessels were aortopulmonary collaterals ($n = 7$, see Fig. 2) , veno-venous collaterals ($n = 9$, see Figs. 3 and 4), patent ductus arteriosus ($n = 3$, see Fig. 5) and coronary artery fistulae ($n = 2$, see Fig. 6). Immediate occlusion was demonstrated in 13 patients and partial occlusion was demonstrated in eight patients, including both coronary arteriovenous fistulas. In all patients but one (Patient 6), complete occlusion was demonstrated in all vessels by either late angiograms, echocardiogram, or during subsequent catheterization. Patient 6 had repeat catheterization demonstrating partial occlusion of the larger veno-venous collateral; this collateral was occluded with additional IDC placement. Also during that case, an additional remote vessel was occluded with an Amplatzer vascular plug. Patient 9 required deployment of two additional Axium coils (Ev3, Plymouth, MN) to achieve complete occlusion of the target vessel.

Partial migration of one IDC occurred in one patient, with movement of one of the coil loops into the right ventricular end of a coronary AV fistula (Patient 11). This coil was retrieved with a Gooseneck snare without disruption of the other deployed coils. Repeated angiography was performed postretrieval to confirm position of the other coils. The patient was admitted overnight for observation, and the following morning, chest X-ray demonstrated the remaining coils in good position without evidence of migration.

No difficulties were encountered with respect to use of the apparatus. All of the coils were retracted and repositioned without difficulty as many times as needed to achieve optimal positioning prior to detachment. As stated above, one coil was retrieved after deployment due to migration within the desired vessel. No coils were exchanged for another coil of the same or different size. There were no embolized coils or emergency surgeries. All patients had uneventful postcatheterization course.

TABLE I. Patient Characteristics and Interlock Coils Deployed

Pt	Age, Sex	Wt (kg)	Congenital heart disease	Location of vessel	Size of vessel (mm)	Directional catheter	Coils used (mm/cm)
1	2, M	10.3	TOF/PA	AP Collateral	3.8	JR	10/20
2	2, F	12.3	HLHS s/p Norwood/Sano s/p Glenn	VVC	3.3	–	6/20 ×2, 8/20 ×2
3	2, F	12.2	TOF/PA	AP Collateral	1.6	Angle Glide	6/20
4	27, M	87	DORV s/p Fontan	VVC	5.3	–	14/20 ×3, 10/30 ×2, 12/20 ×2
5	24, M	104.8	PA-IVS	VVC	–	JR	5/15 ×2, 6/20 ×2, 5/15 ×2
6a	14, M	43.5	DORV s/p Fontan	VVC ×2	−7.8 −2.0	Berenstein	−14/30 ×2, 12/30, 18/20 −5/15, 12/20
6b	14, M	43.5	DORV s/p Fontan	VVC	4.2	JR, Angle Glide	3/6 ×3, 4/8 ×3
7	9, M	24.5	AV Canal with Pulmonary Stenosis, s/p Fontan	AP Collateral	1.8	JR	4/8, 4/12, 4/15, 3/6
8	19, F	54.4	AV Canal s/p Glenn	AP Collateral ×2	−5.3 −3.5	JR	−10/20, 12/20 −10/20, 8/20 ×2
9	17, M	45	TGA s/p Glenn	VVC ×2	−3.7 −3.2	JR	−10/20, 8/20 −12/20
10	0.3, M	5	TOF/PA	AP Collateral	2.1	JL	
11	2, F	12.3	Coronary Artery Fistula	Coronary Artery Fistula	6.3	JL, Angle Glide	14/30 ×4, 12/30
12	5, M	24.5	Coronary Artery Fistula	Coronary Artery Fistula	5.1	JR, Angle Glide	12/30
13	1.4, M	10.9	PDA	PDA	Ampulla 3.3, tapered to 0.5	Angle Glide	3/6
14	13, M	47.6	PDA	PDA	Ampulla 2.8, tapered to 0.5	Angle Glide	3/6
15	1, M	3.9	DILV, PS, PDA s/p BTTS	PDA	Ampulla 4.0, tapered to 1.4	JR	3/6
16	3, F	13.2	TO/PA/MAPCA s/p central shunt	AP Collateral	1.2	JR	14/20, 8/20 ×2, 6/10, 5/8
17	3, M	13.2	Heterotaxy, DORV, supracardiac TAPVR, PS, s/p TAPVR repair, s/p Glenn	VVC	3.8	Angle Glide	8/20 ×2, 6/20 ×2

BTTS, Blalock Taussig Thomas Shunt; DILV, double inlet left ventricle; DORV, double outlet right ventricle; HLHS, hypoplastic left heart syndrome; MAPCA, multiple aortopulmonary collateral arteries; PA-IVS, pulmonary atresia with intact ventricular septum; PS, pulmonary stenosis; TAPVR, total anomalous pulmonary venous return; TGA, transposition of the great arteries; TOF/PA, tetralogy of Fallot with pulmonary atresia; VVC, veno-venous collateral; JR, Judkins right; JL, Judkins left.

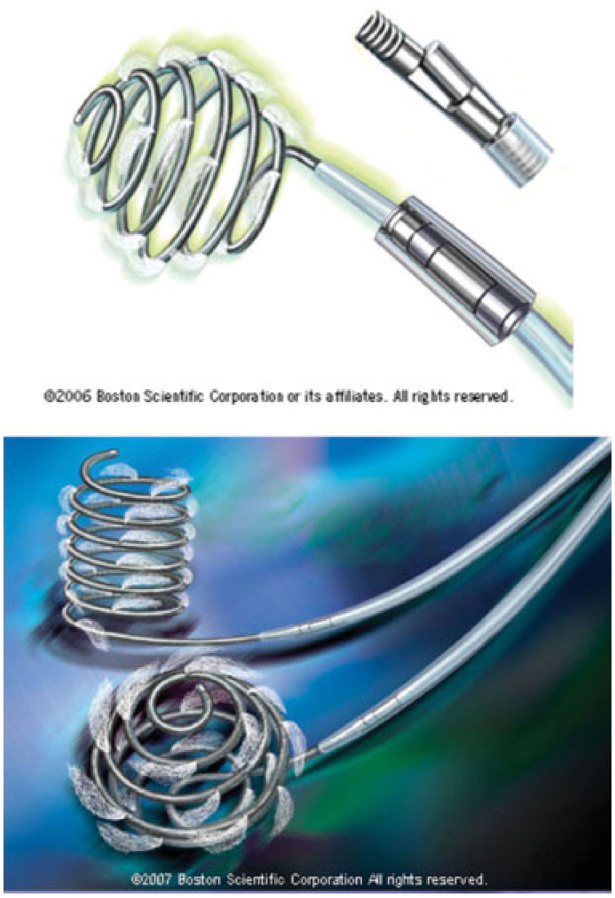

Fig. 1. (A) Interlocking Detachable Coils. The interlocking mechanism allows for retraction and repositioning of the coils before controlled deployment. (B) Interlocking Detachable Coils. The coils are fibered for thrombogenicity and come in a variety of shapes and sizes. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

DISCUSSION

Coil embolization has become a routine but essential part of care of the patient with congenital heart disease. Aortopulmonary connections, PDAs, and coronary AV fistulas cause left ventricular volume overload from left to right shunting. Veno-venous collaterals have the opposite effect, causing right to left shunting with resultant cyanosis and exercise limitation. In addition to improving hemodynamics, occlusion of these vessels can be a useful adjunct to surgery, to simplify procedures, and to eliminate sources of bleeding.

Current techniques of vascular embolization include mechanical devices such as coils and vascular plugs, as well as particulates and sclerosing agents [4]. The traditional steel and platinum coils vary in size and diameter and can be used in a variety of vessels. In many cases, their major limitation is inability to retrieve or retract the coil once deployment has begun. Additionally, the size and stiffness of these coils make them difficult to use in tortuous and/or small vessels, as they require delivery catheters that are not easily manipulated into these vessels.

The interlocking detachable coil provides a controlled method of delivery for coils in a variety of sizes in vessels difficult to access with larger (>3 Fr) catheters [5–12]. Position and stability can be continually assessed and manipulated throughout the deployment, until the coil is optimally situated. Embolization during deployment is eliminated by ability to retract and reposition each coil. Smaller and tortuous vessels can be accessed, as the delivery catheter is extremely low-profile and flexible. This flexibility has been cited as an

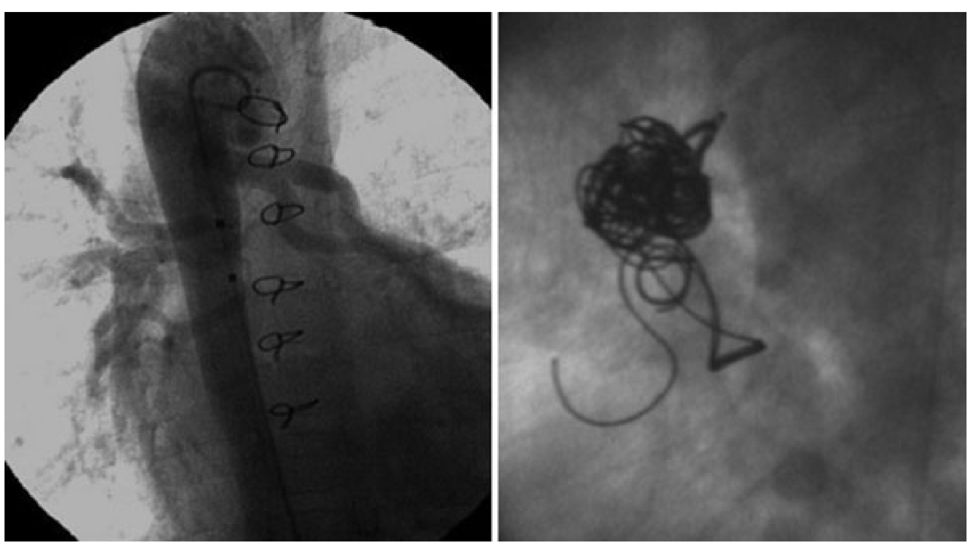

Fig. 2. Large aortopulmonary collateral in a patient with Tetralogy of Fallot with Pulmonary Atresia (Patient 16). Although the collateral itself was large the origin of the vessel was narrow and tortuous and not amenable to entry with 4 Fr catheters.

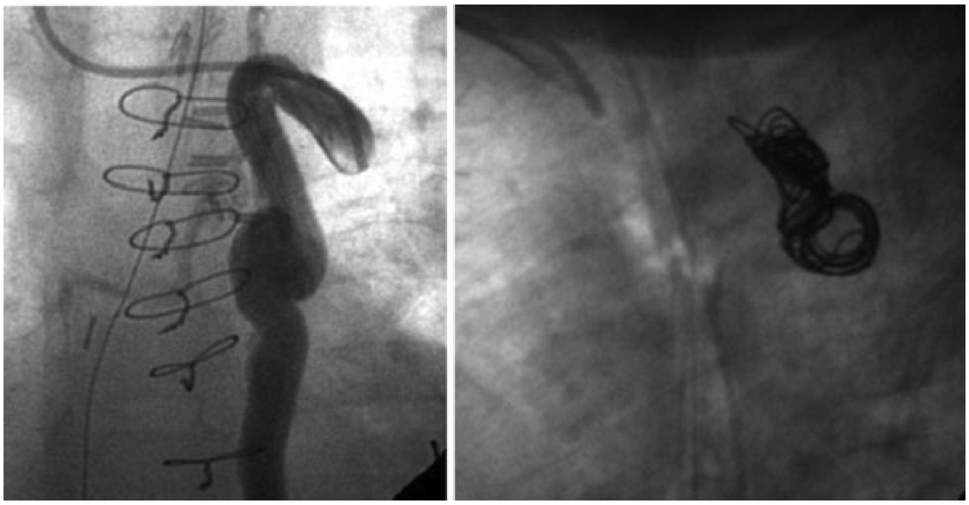

Fig. 3. Veno-venous collateral arising from the innominate vein and communicating with the inferior vena cava (Patient 17), occluded with two 8 mm × 20 cm and two 6 mm × 20 cm coils.

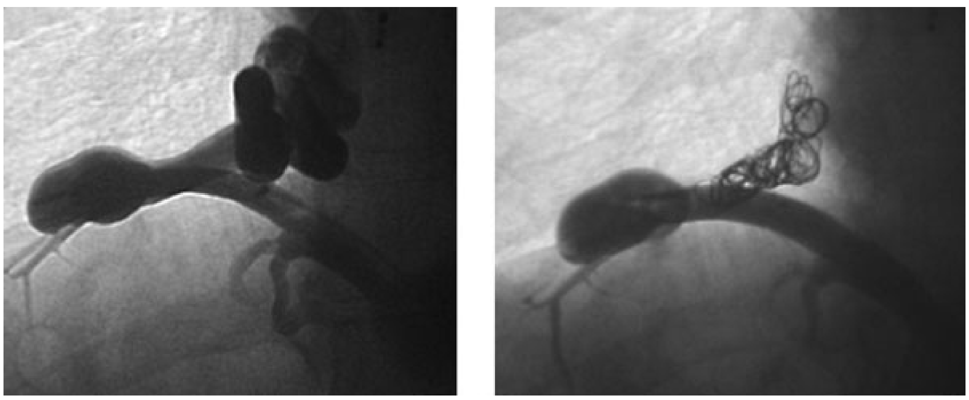

Fig. 4. Large hepatic veno-venous collateral in an adult patient with Fontan (Patient 4) occluded with multiple Interlock coils.

attractive feature when attempting to embolize more problematic lesions, such as coronary AV fistulas [10]. Interlock fibered detachable coils are available in a wide range of diameters, lengths, and shapes, so that both small and large target vessels can be readily occluded through the same microcatheters (Fig. 1A and B). Furthermore, these coils contain Dacron fibers that promote thrombogenicity; this element is missing from similar 0.018 coils such as the Axium and GDC.

Technique for occlusion varies based on the target vessel. The first method is similar to coil occlusion of a patent ductus arteriosus and is reserved for smaller vessels, in which the vessel has a narrowing. One or more loops are deployed to a distal stenosis, followed by withdrawal of the catheter to the proximal side and subsequent deployment of the remainder of the coil. The easy retractability of the IDC coils allow for repositioning and assessment of stability with decreased risk of embolization.

Alternatively, a larger vessel such as an aortopulmonary (AP) collateral with significant flow, can be coiled distally with a larger and longer coil that can be used as an anchor to prevent migration of subsequently placed smaller coils. After the stable deployment of a large IDC (14–16 mm diameter) a nest of smaller coils is created behind the larger one to promote thrombosis (Fig. 2). Of course, IDC's can also be used simply to occlude small AP and veno-venous collaterals as well.

There are several special cases in which IDC's have been especially useful. Patients with Pulmonary Atresia with VSD sometimes require embolizations of large collateral arteries, which have overlapping circulation with the true pulmonary arteries. In three cases, the IDC coils have allowed us to coil large collateral vessels at their origin from the aorta without interfering with distal flow into the collaterals via the true pulmonary arteries.

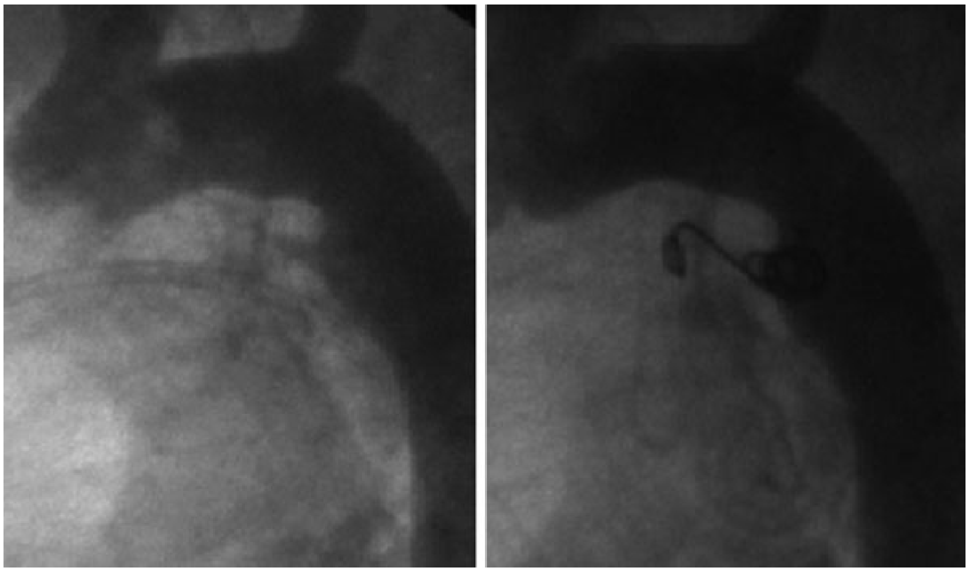

Fig. 5. Small patent ductus arteriosus with distal (pulmonary) end too narrow for catheter manipulation (Patient 14), occluded with 3 mm × 6 cm Interlock coil. The coil was confirmed to be in stable position without residual left to right flow.

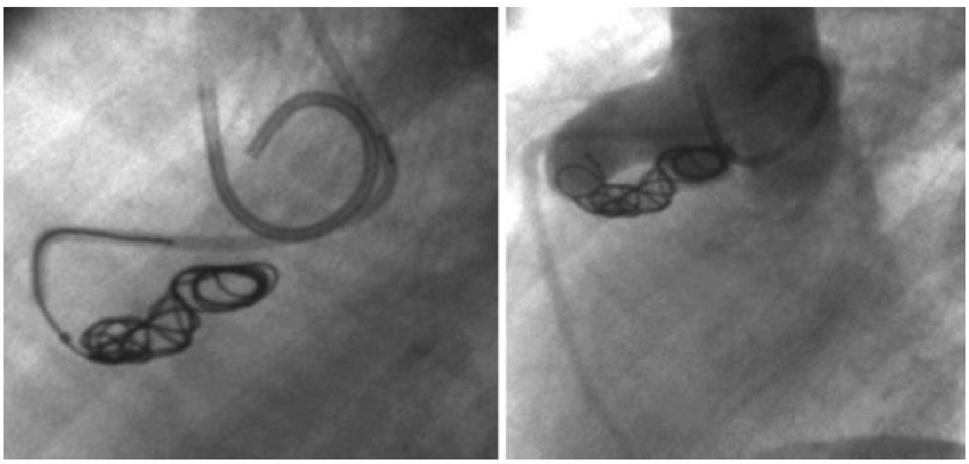

Fig. 6. Interlock coil in the process of deployment. The coil is inside of a Renegade micro-catheter which has been introduced retrograde (aortic root) via a JR catheter (Patient 12), occluded with 12 mm × 30 cm Interlock coil.

IDC's have also allowed for coil occlusion of three small PDAs, which were not able to be crossed with any available 4 Fr catheters. While these tiny PDAs would not normally warrant closure, all three patients in this series were an exception to the silent ductus in that two patients had already undergone surgery, in which the ductus was thought to have been ligated, and a third had a history of endocarditis. All three of the patients with PDA were referred by outside cardiologists, who were insistent that the residual ductus be closed. Clearly, the unique characteristics of the IDC would not be needed for routine PDA closure, and this coil would not necessarily be indicated as a primary device for this procedure.

The ease of use of the IDC allows for shorter fluoroscopy and procedure times. Although these coils are more expensive than Gianturco coils (the latter costing ~$25 per coil), their use can simplify procedures and decrease cost via time savings. Additionally, the Gianturco coil is not MRI compatible, while the IDC is. The IDC is considerably less expensive than GDC coils and other comparable neurovascular coils and is comparable to Flipper coils and AGA Vascular Plugs. A single Interlock coil or Amplatzer Vascular Plug costs $395. A single Flipper coils costs slightly less ($240); however, the deployment of multiple Flipper coils to achieve occlusion rapidly exceeds the price of a single Interlock coil in the same vessel. Because IDC's require a costly delivery catheter (we used the Renegade microcatheter, which costs $357) and often require the use of multiple coils, we continue to use plugs and cheaper coils when convenient. However, we promote the use of IDC's to quickly occlude vessels that are more difficult to access with other devices. Additionally, with option of coil length as great as 30 cm, one long coil can be used in place of multiple shorter, less costly coils that would eventually surpass the cost of a single IDC. We feel that knowledge of these coils and their use has been both time- and cost-effective in our catheterization laboratory.

CONCLUSIONS

Transcatheter vascular coil embolization with interlock fibered mechanical detachable coil system can be performed safely and effectively in a variety of circumstances. Their controlled release and delivery in small (<3 Fr) catheters allows for precise, stable placement of coils in small and large vessels not readily amenable to access via traditional catheters.

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