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Intraaortic Spring Coil Loops: Early and Late Results

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Objectives. **Our aim was to determine the late fate of intraaortic spring coil loops after embolization of aortopulmonary vessels.**

Background. **In some aortopulmonary collateral vessels and patent ductus arteriosi, the narrowest segment is close to the aorta; coils used to close such vessels will "straddle" the lesion, allowing one or more coil loops to protrude into the aortic lumen. The consequences of this procedure are unknown.**

Methods. **We reviewed the cineangiograms of all patients who had at least one aortopulmonary collateral vessel or patent ductus arteriosus closure between January 1, 1988 and August 31, 1993. From this group, 53 patients had multiple-plane angiographic evidence of intraaortic coil loops. All subsequent cineangiograms were reviewed to determine coil position or movement and evidence of recanalization or endothelial coverage of the coil loop. We also reviewed each hospital record or communicated directly with referring physicians to identify any subsequent complications such as emboli or endocarditis.**

Results. **Of the 53 patients with intraaortic coil loops, 49 patients had closure of one or more aortopulmonary collateral vessels (59 vessels), and 4 had closure of a patent ductus arteriosus (4 vessels). Patient follow-up ranged from 1 day to 66 months (median 20 months); follow-up was not available in 6 patients. Five of the 53 patients (9.3%; 95% confidence limits [CL] 3.1% to 20.7%) died at operation or of end-stage heart failure. Patients with late angiography had no residual flow in 31 of 35 aortopulmonary collateral vessels (88.6%; 95% CL 73.3% to 96.8%), and 0.5 mm separated the coil and aortic contrast column in all 12 coils with adequate angiography, suggesting endothelial coverage of the intraaortic coil loop. No episodes of stroke, embolic events, endocarditis or coil migration were reported.**

Conclusions. **Although coil occlusion of aortopulmonary collateral vessels or patent ductus arteriosi may produce intraaortic coil loops, endothelialization appears routine. No late complications associated with intraaortic coil loops were observed.**

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Children with cyanotic congenital heart disease often have congenital or acquired aortopulmonary collateral vessels that may increase ineffective pulmonary blood flow and volume load to the left side of the heart. Although detachable silicon balloons (1–3), gel foam (2), and bucrylate adhesive (4) have been used to occlude collateral arteries, we (5,6) and others (7–16) have relied primarily on coils to occlude these vessels. The most common approach has been to place one or more coils in a long vascular channel. Occasionally, the narrowed segment of a collateral vessel is very close to the aortic lumen. To close such a vessel, one may place a coil to straddle the lesion, permitting part of the coil to protrude into the aortic lumen (Fig. 1). Although we have used this technique for nearly a decade, we do not know the consequences of intraaortic spring coil loops.

Recent studies have focused on the use of occluding spring emboli to close small patent ductus arteriosi (14,15). As with closure of collateral arteries, part of the coil occluder protrudes into the aorta or the ductus diverticulum. As coil occlusion of the small patent ductus arteriosus has become more common (16), determining the appearance and late consequences of such intraaortic coils has assumed increased importance. Because patients with a small patent ductus arteriosus rarely if ever require late angiography, the fate of these devices has necessarily been poorly studied. We therefore performed a retrospective study.

In the present study we attempted to determine the incidence and appearance of spring coil loop protrusion into the aorta. Our focus was on late angiographic appearance and documentation of late complications associated with such protrusion, especially the occurrence of stroke, embolic events, infection, endarteritis, coil migration or late recanalization.

Methods

Patients. We reviewed the computerized cardiology data base at the Children's Hospital, Boston to identify patients who underwent cardiac catheterization between January 1, 1988 and August 31, 1993 and had one of the following diagnoses: tetralogy of Fallot, tetralogy of Fallot with pulmonary atresia and pulmonary atresia with intact ventricular septum. Those who had had closure of at least one aortopulmonary collateral vessel were selected, and all cineangiograms were reviewed.

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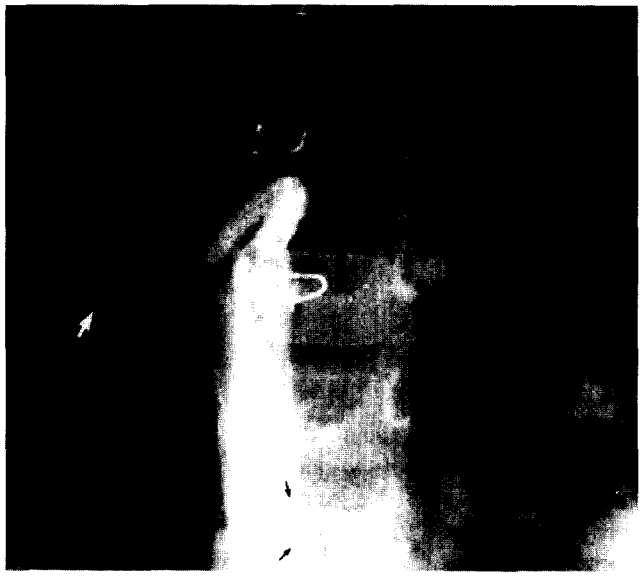

Figure 1. Coil occlusion of aortopulmonary collateral vessels with spring coil loop projection into the aorta. One vessel is occluded several centimeters distal to the exit point from the aorta (**white arrow**). The second more distal vessel is occluded with an intraaortic spring loop (**two black arrows**). The contrast column is well defined, and the coil projects past the plane of the vessel mouth.

Stainless steel, Dacron-stranded occluding spring emboli (Cook) were used for the occlusion procedures. The coils ranged from 0.064 to 0.097 cm (0.025 to 0.038 in.) in caliber, 2 to 5 cm in length and 2 to 12 mm in helical loop diameter. The technique of coil delivery has been described previously (6,17). We administered routine heparin (100 μm/kg body weight) and cefazolin (50 mg/kg) during cardiac catheterization but did not use anticoagulation or endocarditis prophylaxis after the procedure without other clinical indications. We also reviewed the cineangiograms of all patients who underwent coil occlusion of a patent ductus arteriosus during this period.

Anatomy. The anatomic location of the coil and the presence of protrusion into the aorta were determined from cineangiograms obtained in multiple planes. We determined, somewhat arbitrarily, that a coil loop protruded into the aortic lumen when the origin of the aortopulmonary collateral vessel was well profiled on angiography and the coil loop crossed the plane of the vessel mouth (Fig. 1). Coil loops that crossed the line were termed intraaortic. If an aortic diverticulum led to the vessel, the mouth of the vessel was deemed to be the point corresponding to the diameter of the downstream vessel. We sought evidence of residual flow in the aortopulmonary collateral vessel or patent ductus arteriosus on the initial angiograms. All subsequent cineangiograms were reviewed to determine coil position, coil movement or evidence of recanalization. Most important, we sought evidence of endothelial coverage in each patient by comparing the relation between the contrast column and the intraaortic coil loop as seen on late angiography with that seen on initial angiography.

We reviewed the hospital records or communicated directly with the referring physicians of each patient to determine the occurrence of stroke, embolic phenomena or endocarditis.

Results

Between January 1, 1988 and August 31, 1993, 234 patients underwent coil occlusion of an aortopulmonary collateral vessel (n = 227) or a patent ductus arteriosus (n = 7). Of these, 53 patients (22.6%; 95% confidence limits [CL] 17.5% to 28.6%) had protrusion of one or more intraaortic coil loops after closure of an aortopulmonary collateral vessel (49 patients, 59 vessels) or a patent ductus arteriosus (4 patients, 4 vessels). These 53 patients constitute the study group. None of the patients with coil occlusion of a patent ductus arteriosus had subsequent catheterization, whereas 33 patients with aortopulmonary collateral vessel coil placement had subsequent cineaortography.

Early results. Among the patients with intraaortic aortopulmonary collateral vessel coil loop protrusion, 52 coil loops protruded into the descending aorta, 6 into a proximal subclavian artery and 1 into the transverse arch. Immediately after the initial coil procedure, 54 of the 59 vessels had total occlusion. Of the remaining five vessels, one had subtotal occlusion, defined as a marked delay in washout of contrast medium injected proximal to the coils and failure of contrast medium flowing past the coils to opacify the distal vessels, three had partial occlusion, defined as markedly slowed washout with enough residual flow to faintly opacify the vessels distal to coils, and one had unsuccessful occlusion, defined as no perceptible difference in angiographic flow before and after the coil procedure.

Patient follow-up ranged from 1 day to 66 months (median 20 months) with a total follow-up of 95 patient-years. Documented follow-up was not available in 6 patients.

Late results. Of the 53 patients, 5 died (9.3%; 95% CL 3.1% to 20.7%), 4 because of complications related to operation or end-stage heart failure. The fifth patient, who had severe right ventricular dysfunction, died within hours of a subsequent cardiac catheterization during which extensive pulmonary artery dilation and stent placement were performed. One patient had occlusion of the right femoral artery due to coil migration at the initial procedure; the coil was retrieved at catheterization, and on subsequent angiography 37 months later, the right femoral artery was patent. No episodes of stroke, embolic events, endarteritis or coil migration were reported in any patient.

In 33 patients (35 aortopulmonary collateral vessels), subsequent cineangiography performed from 0.25 to 49 months later (median 10 months) showed no evidence of residual flow in 31 of 35 aortopulmonary collateral vessels (88.6%; 95% CL 73.3% to 96.8%). Additional coil placement resulted in complete occlusion of two collateral vessels and subtotal occlusion in the other two.

Angiography also demonstrated 0.5-mm separation of the coil and aortic contrast column in 12 of 31 coils (38.7%; 95% CL 21.8% to 57.8%) whose proximity to the aorta was well

JACC Vol. 25, No. 6
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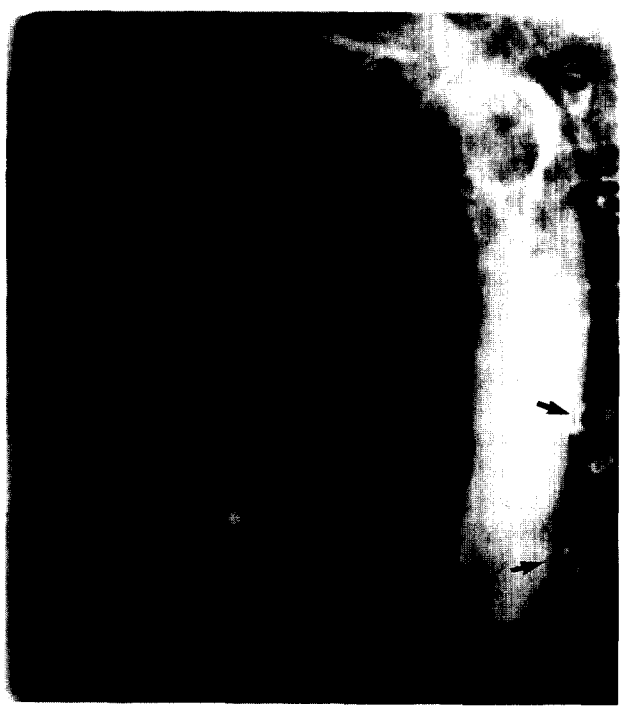
Figure 2. Left lateral aortogram immediately after coil occlusion of two vessels near the catheter tip. Both coils protrude partly into the aortic lumen. **Arrows** demonstrate coil loops that protrude into the contrast column.

profiled, suggesting endothelial coverage of the intraaortic coil loop (Fig. 2 and 3). In the remaining 19 coils, conclusive assessment of coil and aortic contrast column separation was not possible because the coil loops were inadequately profiled (n = 9) or a very short coil tip protruded into the aorta, making it difficult to accurately determine separation of contrast medium from the coil tip (n = 10). In no case did an intraaortic coil loop produce evidence of distortion in the aortic flow column.

Figure 3. A right lateral aortogram 17 months later, following other interventional procedures. The same two coils are profiled during aortography; the more proximal coil is separated by a thin black line from the contrast column, which becomes thicker downstream. **Arrows** show a separation between coil loops and contrast column.



Two of four patients with coil occlusion of a patent ductus arteriosus had a clinically insignificant residual shunt at the conclusion of the procedure. These had resolved within 1 year by echocardiographic follow-up. However, the relation between the coil and aortic lumen could not be documented echocardiographically.

Discussion

Occlusion of aortopulmonary collateral vessels or patent ductus arteriosi by use of the coil technique can be performed in a relatively safe and effective manner (1,2,6,9). Devices that have been developed to occlude patent ductus arteriosi often require large delivery catheters (18,19), and for anatomic reasons may not be applicable to occlusion of aortopulmonary collateral vessels. However, coil occlusion of aortopulmonary collateral vessels or patent ductus arteriosi may be routinely performed with the use of 4F or 5F end-hole catheters, and thus the technique can be used in neonates and infants. Similar coil occlusion techniques have been applied to close coronary artery fistulas (20,21), modified Blalock-Taussig shunts (6) and anomalous pulmonary vessels contributing to hemoptysis or pulmonary sequestration (6,9,10). In the present study, complete occlusion was achieved in 92% and immediate complications were minimal. At late cineangiography, complete closure was evident in 31 of 35 aortopulmonary collateral vessels without evidence of recanalization.

No significant long-term complication such as stroke, embolic phenomena or endarteritis was noted in any patient. In addition, angiographic evidence of endothelialization of the intraaortic coil loop was seen in the 12 vessels with adequate visualization. This apparent endothelialization may permit less turbulent flow in the aorta and minimize the risks of significant late thrombosis, hemolysis or infection. The number of patients in this study with adequate visualization of the coils on late follow-up prevents us from drawing firm conclusions; nonetheless, the presence of an intraaortic coil loop was not associated with late complications in 53 patients who were followed up for an average of 20 months, suggesting that coil occlusion may be a safe procedure for closure of small patent ductus arteriosi.

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