Transcatheter Occlusion of Patent Ductus Arteriosus Using a 0.052-Inch Coil

— Immediate Results —

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Coil occlusion of a patent ductus arteriosus (PDA) was attempted with a 0.052-inch Gianturco coil. The patients' ages and body weights at occlusion ranged from 5.8 to 19.7 (12.3 ± 5.0 , mean $\pm$ SD) years and 18.9–99.1 (44.8 ± 23.7) kg, respectively. Three types of 0.052-inch Gianturco coils with loop diameters (mm) and coil lengths (cm) of 6 $\times$ 8 (diameter $\times$ length), 8 $\times$ 8, or 8 $\times$ 10 were used. The delivery system was prepared as reported by Hays et al with slight modification. The minimal diameter and the Qp/Qs of the PDA ranged from 2.3 to 4.7 (3.4 ± 0.7) mm, and 1.1–1.8 (1.5 ± 0.3), respectively. There were 7 cases with type A PDA and 3 with type B, and coils were successfully deployed in all. Complete occlusion in the catheter laboratory was achieved in 4 cases. A minor leak disappeared within 24h in 3 cases and at 3 months follow-up in 1 case. A tiny leak without a heart murmur persisted in 2 cases at 3 months' follow-up. No procedure-related complications occurred. This technique has significant advantages over previously reported techniques using a 0.038-inch coil for type B, or A PDA with a minimal diameter of 3–4 mm or more. (*Jpn Circ J* 2000; 64: 520–523)

Key Words: Coil occlusion; 0.052-inch Gianturco coil; Patent ductus arteriosus (PDA)

Transcatheter occlusion of a patent ductus arteriosus (PDA) using a spring coil is now widely accepted as the usual strategy for closing a small or medium-sized PDA.^{1–6} Several intermediate-term follow-up studies have documented a high rate of complete closure and low risk of late sequelae.^{7–10} Technical and technological modifications, such as the use of a preformed nitinol snare,^{11,12} balloon occlusion delivery,^{13,14} and a detachable PDA coil,^{15–18} have been described for safe and easy coil delivery. Hijazi et al reported the use of multiple coils to close large PDAs with diameters up to 7 mm.⁸ However, occasionally it is not easy to close a PDA with a diameter exceeding 3–4 mm with a standard 0.038-inch coil, and the procedure needs a relatively long fluoroscopy time. Furthermore there are reports of technical difficulty in placing a coil in a shallow, so called type B PDA.^{3–5} Although a few devices have been developed to overcome these limitations,^{19,20} currently in Japan, coil occlusion or the Porstmann method are the only options for transcatheter closure of PDA.⁶

We describe the clinical efficacy of a new technique using a 0.052-inch Gianturco coil with biopsy forceps.

Methods

Patients

From June through November 1999, we attempted coil occlusion for PDA using a 0.052-inch Gianturco coil (Cook, Inc, Bloomington, IN, USA) in 10 patients (who

provided written informed consent). We also explained concern for the safety of coils in a magnetic resonance imaging unit. All patients had clinical (continuous murmur) and echocardiographic findings of PDA. Their ages and body weights at occlusion ranged from 5.8 to 19.7 (12.3 ± 5.0 , mean $\pm$ SD) years and 18.9–99.1 (44.8 ± 23.7) kg, respectively (Table 1).

Procedures

The procedures were performed under local anesthesia with or without sedation by intravenous thiopental. After routine pressure studies and oxymetry, aortography was performed in the right anterior and either the lateral or the left posterior projection. The angiographic configuration of the PDA was classified according to Krichenko et al.²¹ The minimal diameter was measured from the lateral or the left posterior projection and corrected for magnification using an appropriately positioned grid.

We used 3 types of 0.052-inch Gianturco coils with a loop diameter (mm) and a coil length (cm) of 6 $\times$ 8 (diameter $\times$ length), 8 $\times$ 8, or 8 $\times$ 10. The 0.052-inch coils were delivered as reported by Hays et al with a slight modification.²² Briefly, we advanced a 3F 'cup' biopsy forceps device (Cook, Inc) through a 4F handmade sheath. The rounded-tipped leading end of the 0.052-inch coil was extruded beyond its metal housing and pulled slightly by mosquito forceps. The extended tip was then carefully grasped with biopsy forceps and after tightening the forceps, the coil was gently retracted into the sheath (Fig 1).

In the first 3 cases (Table 1) we used a 6F multipurpose guiding catheter (Envoy; Johnson & Johnson Cordis, Miami, FL, USA) for delivery. The soft tip of this catheter was too long, so we have used a Brite tip (Johnson & Johnson Cordis) with a shorter soft tip in the subsequent 7 cases (Table 1). In case 1, we added a detachable PDA coil using

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Table 1 Clinical Data

Case no.	Age (years)	Weight (kg)	PDA d (mm)	PDA type	Qp/Qs	Coil (mm×cm)	FT (min)	Outcome
1	11.0	42.8	3.6	A	1.7	8×8, 5×5 (PDA)	21	NS
2	5.8	19.5	3.2	A	1.6	8×8	25	NS
3	16.7	52.4	2.3	B	1.2	6×8	22	NS
4	19.7	60.4	3.2	A	1.2	6×8	25	NS
5	18.6	48.0	3.0	B	1.7	6×8	20	TS
6	15.7	99.1	2.8	B	1.1	6×8	21	NS
7	10.5	42.1	3.6	A	1.2	6×8	29	NS
8	10.4	42.1	3.6	A	1.8	8×10	29	TS
9	6.3	18.9	4.7	A	1.5	Double 8×10	35	NS
10	8.3	23.0	4.3	A	1.5	Double 8×10	22	NS

PDA d, minimal diameter of the PDA; PDA type, angiographic appearance of the PDA; Coil (mm×cm), loop diameter×length; PDA, detachable PDA coil, loop diameter×number of loops; FT, fluoroscopy time; NS, no residual shunt; TS, tiny residual shunt without heart murmur.

Fig 1. (Left) The round-tipped leading end of the 0.052-inch coil was extruded beyond its metal housing and pulled slightly by mosquito forceps. (Middle and Right) The extended tip was carefully grasped with biopsy forceps and, after tightening the forceps, the coil was gently retracted into the sheath.

the standard retrograde technique.

In the first 8 cases, we delivered a 0.052-inch coil with a diameter approximately twice the minimum diameter of the PDA either retrogradely (Fig 2, Table 1, cases 1–6) or antegradely (Table 1, cases 7,8). In the final 2 patients, in which the PDA had a minimal diameter greater than 4 mm, two 0.052-inch coils were simultaneously delivered through a combined approach (Fig 3, Table 1, cases 9,10). For the retrograde approach, 2 arterial sheaths were placed, one for coil delivery and the other for test angiography. If there was any difficulty in placing 2 arterial lines, we approached antegradely. With either approach, coil deployment was by the previously reported technique for either a standard 0.038-inch Gianturco coil^{1–5} or a detachable PDA coil.^{15–18} After the coil was fully deployed, a test injection to determine the position of the coil was done through a pigtail catheter in the descending aorta. Once a satisfactory position was achieved, the coil was released by simply opening the jaws of the forceps. When aortography, repeated 10 min later, documented either complete occlusion or a tiny leak

that was expected to disappear shortly, we finished the procedure. Doppler echocardiography was performed within 24 h of completion.

Results

The minimal diameter of the PDA and the Qp/Qs ranged from 2.3 to 4.7 (3.4 ± 0.7) mm, and 1.1–1.8 (1.5 ± 0.3), respectively. There were 7 cases with a type A PDA and 3 with type B. In case 8, the initial 6×8 coil dislodged to the left pulmonary artery before release and was easily retrieved, after which an 8×10 coil was successfully delivered. In the other 9 cases, the initially selected coils were deployed successfully. Fluoroscopy time, including routine cardiac catheterization and coil occlusion, ranged from 20 to 35 (25 ± 4.8) min. Although complete occlusion in the catheter laboratory was achieved in only 4 cases (cases 3, 7, 9, 10), a minor residual leak disappeared within 24 h in 3 cases (case 1, 2, 6) and at the 3 months' follow-up in case 4. A tiny leak without a murmur persisted in cases 5 and 8 at the 3-

Fig 2. Retrograde approach in case 2. (Left) Aortography shows type A PDA with a minimal diameter of 3.2 mm and good ampulla. (Middle) An 8x8 coil was delivered in the PDA. (Right) Aortography after release of the coil confirmed complete occlusion.

Fig 3. Antegrade and retrograde approach in case 9. (Left) Aortography shows type A PDA with a minimal diameter of 4.7 mm and good ampulla. (Middle) Two 8x10 coils were delivered in the PDA. (Right) Aortography after release of coils confirmed complete occlusion.

months' follow-up. No procedure-related complications occurred.

Discussion

The forceps delivery technique using a standard 0.038-inch Gianturco coil was first reported by Hays et al²² They loaded the coil into the delivery catheter, but we used the delivery sheath to separate the catheter and the retrievable coil system in order to allow manipulation of the delivery catheter with a guide wire. Consequently either a retrograde or antegrade approach to the PDA became easy. (Dr Ronald G. Grifka suggested the use of a 0.052-inch Gianturco coil combined with biopsy forceps to occlude a medium- to large-sized PDA.)

The stiff 0.052-inch coil wire makes firm and tight loops, so we occasionally experience some difficulty in controlling the number of loops deployed. However, once placed correctly the coil sticks tightly to both the aortic and pulmonary ends of the PDA. Because accidental detachment or release difficulties sometimes complicate the use of detachable PDA coils¹⁶ or snare assisted methods,^{11,12}

the simple release mechanism described here allows safe and reliable detachment. Although a 6x8 coil dislodged before release in case 8, delivery of a single 0.052-inch coil with a helical diameter of twice the minimal diameter of the PDA was generally safe and easy even in a PDA with a diameter of 3–4 mm. We believe at least two 0.038-inch coils are required to close such a PDA.

Although simultaneous deployment of multiple coils complicates the procedure, we successfully deployed two 0.052-inch coils simultaneously in cases 9 and 10, 2 cases in which there was a large PDA. Deployment is usually difficult when using standard 0.038-inch coils in such a big ductus, as the small coil wire makes only weak loops.

There are considerable reservations about coil occlusion of type B PDA^{3–5} because the shallow aortic ampulla not only limits the space for a coil, but also makes its delivery difficult. Even the new devices for PDA closure, such as the Amplatzer or Gianturco Grifka bag, have a limited application for this type of PDA and a double disc device, such as the Rashkind PDA occluder²³ has been considered to be only choice for its transcatheter closure. Although a tiny leak remained in one type B case in our series, there

were no technical problems with deployment in the other 2 cases of type B PDA. The stiff coil wire allows low profile loops that minimize protrusion of loops into the aortic side and so this technique could be the preferred choice for closing a type B PDA.

One case of type A PDA still had a tiny leak at the 3 months' follow-up. We believe that it might have been better to add another 0.038 or 0.052-inch coil in this particular case. However, additional ordinary 0.038 coils should allow complete closure if the leak persists, as it is not difficult to engage coils with a formerly deployed one, as long as at least one coil is placed in the PDA. At this time, we intend to minimize the residual leak in the catheter laboratory as long as coils can be placed in the ampulla.

Although the technical difficulty of deployment does not differ greatly between the antegrade and retrograde approach, we prefer to approach the PDA from the aortic side because it is easier to minimize the number of loops on the pulmonary side by this route, particularly when deploying the stiff 0.052-inch coil. One disadvantage of using a larger coil is the requirement for at least a 6F catheter with a large internal lumen whereas the standard 0.038-inch coil can be delivered with a 4F catheter. Consequently an antegrade approach may occasionally be preferred, especially in infants. If the antegrade approach is used care must be taken to make sufficient loops in the aorta.

In our small series, only one coil dislodged before release. Once accidental dislodgment occurs, the tight and firm loops may make retrieval more difficult than with an 0.038 inch coil, particularly when deploying multiple coils. Subsequently the interventionist must be skilled in not only deployment but also retrieval of coils.

We believe that using the 0.052-inch coil with biopsy forceps has significant advantages over previously reported techniques using a 0.038-inch coil for type B, or A PDA with a minimal diameter of 3–4 mm or more. Further clinical investigation may extend its indications.

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