# Residual Patent Ductus Arteriosus Shunting After Single Gianturco Coil Occluding

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**Abstract**

Transcatheter occlusion with Gianturco coils has become the treatment of choice for small patent ductus arteriosus (PDA). Coil occlusion was attempted in 20 patients with ductus diameter less than 4 mm who did not require other cardiac surgery. Sixteen of 20 patients had successful implantation. The mean age was 4.2 years. Their mean weight was 14.1 ± 5.9 kg. The mean ductus diameter was 2.21 ± 0.91 mm (range 1-3.7 mm). Nine patients had complete occlusion but 7 had residual shunting immediately after the procedure. However, 4 patients had spontaneous resolution of residual shunts at 6 months after the procedure. The other 3 who had diameter of ductus greater than 3 mm still had significant residual shunt at 6 months and 1 year after the procedure. The second coil was successfully implanted in one of these 3 patients and the closure of PDA was accomplished. We concluded that the second coil should be implanted if the ductus diameter is greater than 3 mm and significant residual shunt is still demonstrated angiographically after the first coil implantation.

**Key word :** Patent Ductus Arteriosus, Coil Occlusion

In a multicenter co-operative study in Thailand in 1994, Pongpanich et al[1] found patent ductus arteriosus (PDA) to be the second most common congenital heart disease, found in 17.4 per cent of patients. Although congestive heart failure may not develop in patients with small PDA, Campbell[2] reported the risk having 0.45 per cent of bacterial endarteritis annually. It is still accepted generally that audible PDA should be closed after 6-12 months of age. Since Moore, et al[3] and Lloyd, et al[4] reported the use of single Gianturco coil delivered retrogradely to close the small PDA, this technique has become increasingly popular. Since 1995 when Khowsathit et al[5] reported the first case of percutaneous closure of PDA using Gianturco coil in Thailand, 20 cases of PDA occlusion with single Gianturco coil have been performed at Ramathibodi Hospital. We summarized our clinical expe-

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rience with transcatheter closure of PDA and hypothesized that the small leakage across PDA immediately after coil occluding should disappear when there was thrombus formation around the thrombogenic Dacron strands attached with the coil. This study presents the 1 year follow-up of residual PDA shunting after single Gianturco coil occluding in 16 patients at the Faculty of Medicine, Ramathibodi Hospital.

## PATIENTS AND METHOD

From January 1996 to May 1998, 20 patients with PDA diagnosed by physical examination, two-dimensional echocardiography and color flow imaging studies underwent cardiac catheterization and were enrolled in the study of PDA closure using Gianturco coil. Patients were included if the narrowest diameter of PDA was less than 4 mm by echocardiographic imaging. All patients had no associated cardiac anomalies except one who had valvular pulmonary stenosis which was dilated by balloon valvuloplasty in the same procedure.

### Occluder and delivery system

The occluder and delivery system are commercially available. Gianturco coils (Cook Incorporated, U.S.A.) were used as occluders in the early phase of the study. Then, detachable Gianturco coils (Cook Incorporated, U.S.A.) were used later. The properties of both types of coils were similar, double-helix stainless-steel spring coils attached with thrombogenic Dacron strands, but the detachable ones could be retracted or repositioned once even after partially deployed, and allowed full retrieval before final deployment. These coils were avaibable in several sizes (MWCE -38-5-3, MWCE -38-5-5, MWCE -38-8-3, MWCE -38-8-4, MWCE -38-8-5). The diameter of the extended coil in each device was 0.038 inch (0.096 cm). The diameters of coils were 5 and 8 mm while numbers of loops are 3, 4 and 5 respectively. The delivery system was a 6F Judkins Right 3.5 coronary catheter (Cordis Corp, U.S.A.). The standard Gianturco coil was pushed through the catheter with a 0.038 inch straight guide wire while the detachable Gianturco coil was pushed with its special delivery wire which could be screwed into the open spiral end of the coil.

### Procedure

Patients were sedated with Toronto mixture at appropriate dosage for weight. Under local anesthesia, 6F sheaths were placed in the femoral vein and artery. Heparin (30 units/kg body weight) was administered. Routine right and left heart pressure and oxygen saturation levels were measured. A 6F pigtail catheter was placed in the descending aorta just above the take off of the PDA. An aortic cineangiogram was performed in the anterior and true lateral projections. The narrowest internal dimension of the ductus was measured. The decision to proceed with coil occlusion was made. Then cefazolin (40 mg/kg) was given intravenously. A 6F Judkins Right 3.5 coronary catheter was placed in the descending aorta and advanced into the pulmonary artery via the ductus. A Gianturco coil was selected such that the diameter of the PDA was $\leq$ 50 per cent of the coil diameter. The coil was loaded into the Judkins catheter using the stiff end of a straight guide wire. After loading, the guide wire was reversed, the soft tip of the wire was used to push the coil through the catheter lumen. When a detachable coil was used, its special delivery wire was screwed into the distal spiral end of the coil. The coil was then loaded into the catheter and pushed through the catheter lumen. The delivery was monitored by lateral fluoroscopy. The coil was delivered 1.0 to 1.5 loops into the pulmonary arterial side and 2-4 loops into the aortic side of the PDA. The catheter was removed and hemostasis was obtained.

### Follow-up

The day after the procedure, a clinical evaluation and an echocardiographic study were performed before the patient was discharged from the hospital. Outpatient follow-up was at 3 and 6 months and yearly thereafter post procedure. During each of these visits, patients underwent a physical examination and an echocardiographic study.

## RESULTS

Of the 20 patients who underwent coil implantation, 16 had successful placement of coil in the PDA. There were no deaths nor significant morbidity.

Of the 16 patients who had successful placement, 13 presented with heart murmur without clinical signs of congestive heart failure and 3 had residual shunts from the previous surgical ligation of the PDA. Diagnosis in these patients was made by physical examination and confirmed by echocardiography. Their ages ranged from 1 to 10

years (mean 4.1 ± 2.4). Their weight ranged from 6.9 to 28 kg (mean 14.1 ± 5.86). Fifteen had an isolated PDA, and one had associated valvular pulmonary stenosis. The pulmonary balloon valvuloplasty was performed in this patient before the coil occlusion and the pressure gradient across the pulmonary valve was decreased from 56 to 24 mmHg. The smallest internal ductus diameter ranged from 1.0 to 3.7 mm (mean 2.21 ± 0.91). Three patients who had the diameter > 3 mm had mild pulmonary hypertension (pulmonary pressure > 30 mmHg). The other 13 who had the diameter ≤ 3 mm had pulmonary artery pressure in the normal range. By an angiographic classification of PDA as described by Krichenko et al[6], 11 patients had PDA with the narrowest segment at the pulmonary insertion and a cone-shaped aortic ampulla (type A), 2 patients had short PDA with the narrowest segment at the aortic end (type B), and 3 patients had PDA with the narrowest segment at the pulmonary insertion and an elongated cone-shaped aortic diverticula (type E). Nine patients had complete PDA occlusion noted by color flow mapping the day after the procedure but 7 patients had residual shunts immediately after the procedure. In 4 out of 7 patients, the color flow imaging demonstrated small residual leakage but complete closure was demonstrated within 6 months after the procedure. The remaining 3 patients still had audible murmur of PDA with visible of PDA by echocardiography at 6 months and 1 year after the procedure. All had the narrowest diameter of ductus greater than 3 mm and pulmonary artery pressure higher than 30 mmHg. The second coil occlusion was accomplished in one of these three patients without residual shunt. No complication has been noted in follow-up visits. The echocardiograms showed no turbulence in the descending aorta. Neither clinical evidence of embolic phenomena nor hemolysis was observed.

Four patients did not have successful implantation of coils in the PDA. Embolization of coil into the left pulmonary artery occurred in 2 of them. Both coils could not be retrieved. The position of loops of coil was inappropriate in the third patient, too many loops in the pulmonary end and partial obstruction of the left pulmonary artery was observed. The surgical ligation of the PDA was performed in this patient with removal of the coil during surgical procedure. Coil implantations in these 3 patients were carried out in the early phase of the study using non-detachable Gianturco coil. In the fourth patient, the PDA was too large to occlude with coil. The detachable coil was successfully retrieved before the coil was totally deployed.

## DISCUSSION

For decades cardiologists have sought an effective transcatheter method of closing the PDA. Porstmann et al[7] reported the successful occluding of PDA using Ivalon plug in 56 of 62 patients. Rashkind et al[8] devised a double disk, nonhooked prosthesis with successful implantation occurring in 72 per cent to 81 per cent of patients. But these devices require large delivery catheters and are expensive. More recently, Cambier et al[9] reported successful percutaneous occlusion of small PDA by implanting Gianturco coils. Since it is simple, effective and relatively inexpensive, the coil occlusion of the PDA has rapidly become the treatment of choice at many institutions[3,4,9-12]. We had achieved successful occlusion of PDA in 16 of 20 patients, with 7 had residual shunts immediately after the procedure. However, color flow Doppler demonstrated spontaneous resolution of residual shunts at 6 months after coil implantation in 4 patients who had the narrowest diameter of ductus less than 3 mm. The other 3 patients who had the diameter of greater than 3 mm still had audible murmur of PDA with residual PDA by echocardiography at 6 months and 1 year after the procedure. We had an opportunity to implant the second coil in one of these 3 patients and complete occlusion of PDA was accomplished demonstrating with color flow mapping. We speculate that the second coil implantation should be considered at the initial procedure if the narrowest diameter of PDA is greater than 3 mm and residual shunt is still demonstrated angiographically after the first coil implantation. In our study, the patients who still had clinical and echocardiographic evidences of residual PDA at 6 months after the procedure were unlikely to have their PDA spontaneously closed later. So we recommend that the additional coils should be applied in cases of residual PDA at 6 months after the first procedure.

As described by Cambier[9], the coil occlusion of PDA was suitable only for the small PDA. By using larger coils of 5 and 8 mm helical diameter, we are able to extend this procedure to patients with the narrowest diameter of PDA up to 4 mm. Our cases of technical failure occurred in the early phase of our study due to the usage of inappropriate coil size.

Gianturco coil occlusion of PDA is limited primarily by ductus size. Most recently, the closures of large PDA using single or multiple Gianturco coils were reported in 3 studies[13-15]. Additionally, patient size is not a limiting factor because the delivery catheter is small (6F), the catheter course is relatively straight, and the device is flexible. An important advantage of the detachable coil technique which we use recently is the ease of coil removal if its position is not satisfactory. A final benefit of the Gianturco coil over the other devices and the surgery is the lower cost. In the study of Singh et al[16], the cost of coil occlusion is about a half that of the surgical ligation of PDA. Complications related to PDA coil occlusion include a persistent residual shunt, embolization of a coil to the pulmonary artery requiring catheter retrieval, and very rarely hemolysis associated with a residual shunt.

## SUMMARY

This study demonstrates that PDA can be occluded using Gianturco coils. Follow-up data have shown that tiny residual shunts noted immediately after coil implantation often resolved spontaneously. The second coil implantation shoud be considered if the narrowest diameter of the ductus is greater than 3 mm and significant residual shunt is demonstrated angiographically after the first implantation. The cost of coil occlusion is much lower than that of the surgical ligation of PDA. Complications related to PDA coil occlusion are rare.

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# การศึกษาการรั่วของ patent ductus arteriosus หลังจากปิดด้วยขดลวด Gianturco

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ในปัจจุบันมีการนำขดลวด (Gianturco coil) มาใช้ปิด patent ductus arteriosus (PDA) ที่มีขนาดเล็กในขณะที่ทำการตรวจสวนหัวใจ ทดแทนการผ่าตัดมากขึ้นเรื่อยๆ ได้ทำการศึกษาการใส่ขดลวดดังกล่าวในผู้ป่วยเด็กที่มี PDA ขนาดเล็กกว่า 4 มม. จำนวน 20 ราย ที่คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี พบว่าขดลวดอยู่ในตำแหน่งที่เหมาะสม 16 ราย ในจำนวนนี้สามารถปิด PDA ได้สนิททันที 9 ราย ที่เหลืออีก 7 รายยังมีอาการแสดงของเลือดลัดวงจรหลังจากใส่ขดลวด ซึ่งตรวจพบโดยการฟังได้เสียงฟู่หรือโดยการตรวจคลื่นเสียงสะท้อนหัวใจ เมื่อติดตามการรักษาไป 6 เดือน พบว่าผู้ป่วย 4 ราย PDA ปิดสนิทได้เอง และผู้ป่วย 3 ราย ที่เหลือยังคงมีเลือดลัดวงจรไปจนถึง 1 ปีหลังจากใส่ขดลวด ทั้ง 3 รายมี PDA ขนาดใหญ่กว่า 3 มม. มีผู้ป่วย 1 ใน 3 รายนี้ที่ได้รับการใส่ขดลวดครั้งที่สองและสามารถปิด PDA ได้สนิท จึงเสนอแนะว่าในผู้ป่วยที่มี PDA ใหญ่เกิน 3 มม. และเมื่อใส่ขดลวดอันแรกไปแล้วควรฉีดสีดูว่าปิด PDA ได้สนิทหรือไม่ ถ้ายังมี PDA เหลืออยู่ ควรใส่ขดลวดอันที่สองไปเลย

**คำสำคัญ** : การปิด patent ductus arteriosus, ขดลวด Gianturco

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