Selection of Coil for Transcatheter Closure of Small Patent Ductus Arteriosus

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Abstract

The authors reported the results in transcatheter coil occlusion of patent ductus arteriosus (PDA) less than 4 mm, based on a policy in selection of the appropriate type and number of coils for size of PDA. The authors used one 0.035 inch detachable coil, 5 mm in diameter, in PDA less than or equal to 2 mm, and two 0.035 inch detachable coils or one controlled release 0.052 inch Gianturco coil in PDA larger than 2 mm. The present study included 32 pediatric patients. There were 31 cases of successful coil implantation and 1 case failed. Of the 31 successful cases, PDA size varied from 1.4 to 4.0 mm (mean of 2.7 $\pm$ 0.9 mm). Ten patients had a PDA size of less than or equal to 2 mm (group A), while the other 21 patients had a PDA size of larger than 2 mm (group B). In group A, 9 cases had single-detachable-coil occlusion and one case had double-detachable-coil occlusion. In group B, double-detachable-coil occlusion was performed in 17 cases and controlled release 0.052 inch coil in 4 cases. There were no cases of coil migration or other serious complications. The immediate complete occlusion rate was 58 per cent (18 of 31 cases), which rose to 97 per cent (30 of 31 cases) at the mean follow-up of 2.6 $\pm$ 2.5 months (range from 1 day to 9 months).

Transcatheter coil occlusion is an alternative to surgical closure of small PDA (less than 4 mm). Selection of type and number of coils appropriate to the size of PDA will allow safe and excellent results.

Key word : Patent Ductus Arteriosus, Coil Occlusion

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Small patent ductus arteriosus (PDA) should be closed, regardless of the patient's symptoms. Besides the surgical division and suture or ligation of PDA, transcatheter closure by various types of devices, including coil occlusion, has been reported in the literature[1-6]. Currently, coil occlusion has been found to be effective in the closure of small PDA (diameter less than 4 mm) with a high success rate and low incidence of complications[7-9]. With its much lower cost compared to other devices, transcatheter coil occlusion is an attractive catheter intervention for a PDA less than 4 mm[10].

The authors' early learning experience in coil occlusion of PDA with a satisfactory outcome has been reported[11]. From that study, it seemed that PDA size larger than 2 mm should be closed with two detachable coils for better occlusion result and less risk of coil migration. The result of transcatheter PDA closure should be the same as that of surgical closure, which has nearly a 100 per cent closure rate. So, protocol was set up for the goal of no coil migration and nearly 100 per cent closure rate, by using one 0.035 inch detachable coil, 5 mm in diameter, for closure of PDA size less than or equal to 2 mm, and two 0.0035 inch detachable coils for PDA larger than 2 mm. The detachable coil has the advantage that retrieval of the coil is possible up until the moment it is released from the delivery wire. This advantage promotes better control of the coil position and alignment at the PDA site. More recently, the authors also used one 0.052 inch Gianturco coil, with controlled delivery by using bioptome, for closure of a PDA larger than 2 mm in some of the later cases, because the cost of using one 0.052 inch Gianturco coil is cheaper than that of using two detachable coils. The advantage of the 0.052 inch coil is that it is sturdier which provides improved stability of coil position during implantation. In this report, the authors describe the result of the coil selection policy.

PATIENTS AND METHOD

Patient population

Between March 1998 and October 2002, all pediatric patients who had a clinical diagnosis of PDA and echocardiographic demonstration of PDA size less than 4 mm were selected to have transcatheter coil occlusion of PDA. Informed consent was obtained from legal guardians after the process and risk of the procedure was explained. There were 32 cases in this study.

Procedures

The patient received a combination of intravenous midazolam and morphine for sedation. Conventional right and left heart catheterizations were performed to assess hemodynamics. Heparin (30-50 U/kg) was administered intravenously. An aortography was obtained in the anteroposterior and lateral views to demonstrate the type and size of PDA. The narrowest diameter of PDA was measured in the lateral view.

The helical diameters of the detachable coils were available in 2 sizes, 5 and 8 mm. The coils should have a helical diameter of at least twofold the PDA size. In the single detachable coil case, retrograde delivery of a 5-mm coil, was performed from the femoral artery. In the double detachable coil case, the coils were delivered from the femoral artery and vein (Fig. 1) as described in our previous report[11].

In the case of the 0.052 inch Gianturco coil, the coil was loaded antegradely from the right heart through a 6 French multipurpose catheter (Cook). Before loading, the coil was prepared for a controlled release unit. The round ball on the proximal end of the coil was stretched out 0.5-1 mm away from the coil windings by using a hemostat. A 3 French bioptome (Cook) was passed through a 4 or 5 French sheath, using it as a delivery tube for the coil. The ball at the proximal end of the coil was firmly held by the jaw of the bioptome as a coil-bioptome unit, and it was pulled into the 4 or 5 French sheath. Then, the system was loaded through the 6 French multipurpose catheter in similar technique (Fig. 2) as that in the detachable coil.

Aortography was repeated 5-10 minutes after the coil implantation was done to evaluate the immediate result.

Follow-up

Physical examination, chest radiograph and echocardiograph were performed in all the patients during follow-up to assess the latest result of PDA occlusion, the position of the coils and any obstruction in the pulmonary arteries or aorta by the coils.

RESULTS

Of the 32 patients, 31 patients had successful coil implantation. The patient who failed the procedure was a 2 year old boy, with a PDA size of 3.5 mm. He was an early case of the study, and had a conical shaped PDA or type A according to Krichenko's angiographic classification[12]. Two detachable coils,

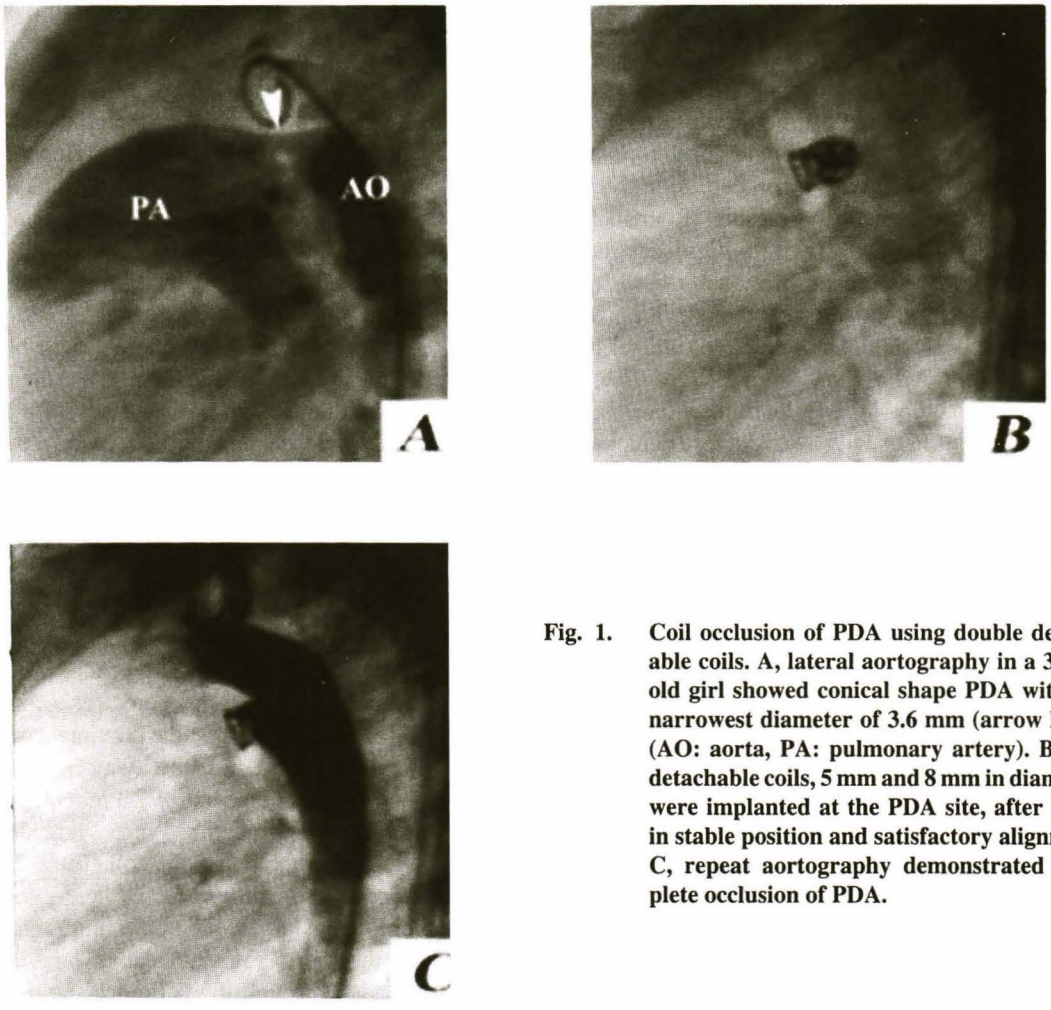

Fig. 1. Coil occlusion of PDA using double detachable coils. A, lateral aortography in a 3 year old girl showed conical shape PDA with the narrowest diameter of 3.6 mm (arrow head) (AO: aorta, PA: pulmonary artery). B, two detachable coils, 5 mm and 8 mm in diameter, were implanted at the PDA site, after being in stable position and satisfactory alignment. C, repeat aortography demonstrated complete occlusion of PDA.

5-mm and 8-mm, were used. Instability of the coils was found before they were released from the delivery wires, so both coils were pulled back into the loading catheters and out of the patient. After discussion with his parents, they decided to have PDA closure by surgery. The patient underwent surgical PDA closure on the following day with a good result.

The 31 successful coil implantation cases were 9 boys and 22 girls. Age at the time of procedure ranged from 1 year 8 months to 14 years (mean 6.2 ± 3.8 years), and weight ranged from 9.0 to 40 kg (mean 20.6 ± 9.7 kg). The PDA size ranged from 1.4 to 4.0 mm (mean 2.7 ± 0.9 mm). Ten cases had PDA ≤ 2 mm (group A) and 21 cases had PDA > 2 mm (group B). The outcome is summarized in Fig. 3.

In group A, 9 cases had a single 5-mm detachable coil implantation, with the result of immediate complete closure confirmed by aortography in 6 cases. The other 3 cases had delayed complete closure confirmed by echocardiography at 1 month, 2 months and 9 months of follow-up, respectively. One case had PDA closure by using two 5-mm-3-loop coils due to short PDA ampulla. Aortography showed immediate complete closure.

In group B, the double detachable coil technique was performed in 17 cases and 0.052 inch Gianturco coil technique in 4 cases. Eight of the 17 double coil technique cases had immediate complete closure confirmed by aortography. Of the remaining 9 cases, 8 cases had delayed complete closure confirmed by echocardiography at 1 month, 1 month, 6 months, 1 day, 2 months, 2 months, 1 month, and 3 months, of follow-up, respectively. One case still had a trivial leakage by color flow Doppler echocardio-

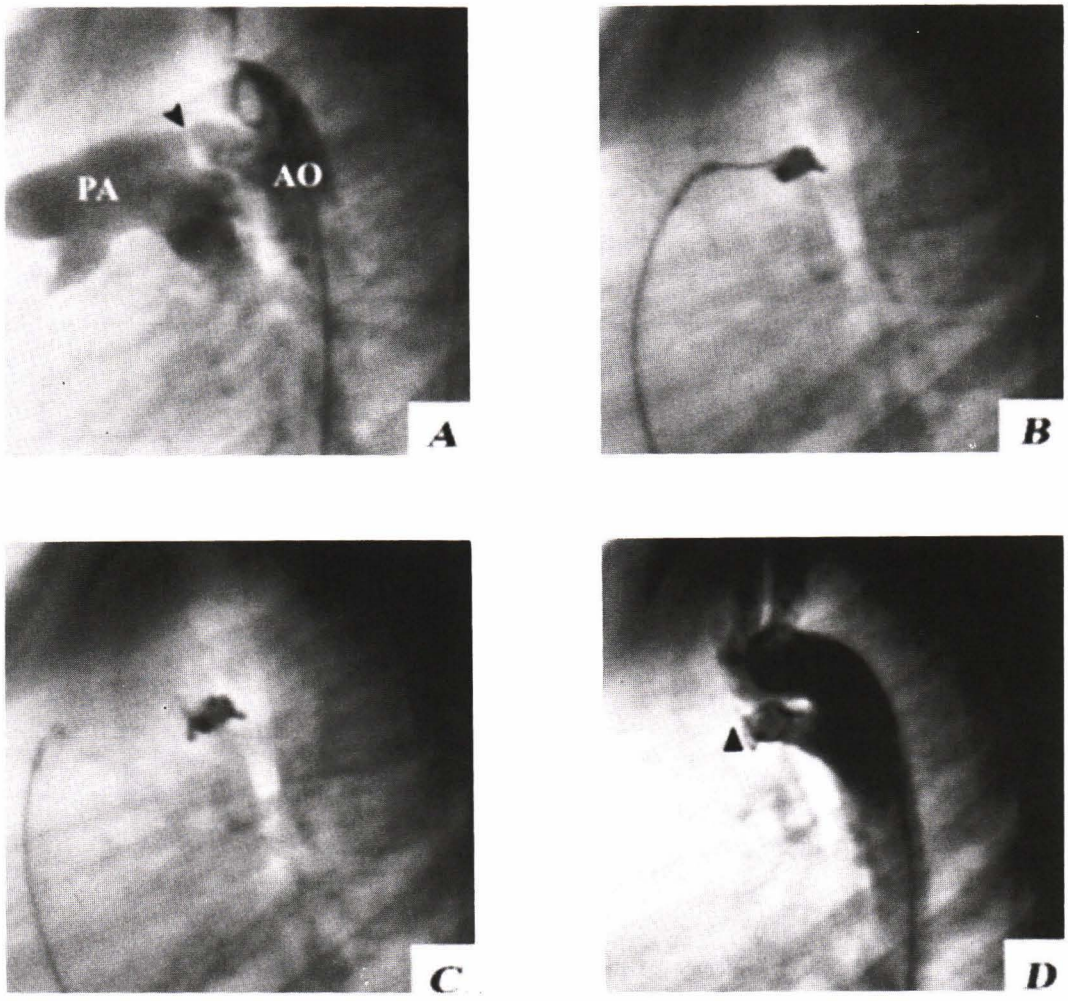

Fig. 2. Coil occlusion of PDA using 0.052 inch Gianturco coil. A, lateral aortography in a 5 year old boy showed elongated conical shape PDA with the narrowest diameter of 4 mm (arrow head). B, one 0.052 inch coil, 8 mm in diameter, formed tight loops in the aortic ampulla. The coil was still firmly grasped by the jaws of the bioptome. C, after being satisfied with the coil's position and its stability, the jaws of the bioptome were opened to release the coil. D, repeat aortography showed trivial residual PDA leakage as a Smokey appearance in the pulmonary end (arrow head). Echocardiograph, at the 3-month follow-up, showed complete occlusion of the PDA.

graphy but without any heart murmur (silent PDA) during the follow-up period of 20 months. Of the 4 cases using the 0.052 inch Gianturco coil, 3 cases had immediate closure and 1 case had delayed complete closure at 3 months of echocardiography follow-up.

In the present study, the immediate complete closure rate was 58 per cent (18 of 31 cases), which rose to 97 per cent (30 of 31 cases) within 9 months of follow-up (range from 1 day to 9 months, mean of 2.6 ± 2.5 months).

There was no case of coil migration to peripheral vessels and no serious complication in the present study, except one case of mild ecchymosis at the puncture site. There was no evidence of any obstruction in the pulmonary artery or aorta by the coils detectable during echocardiography follow-up.

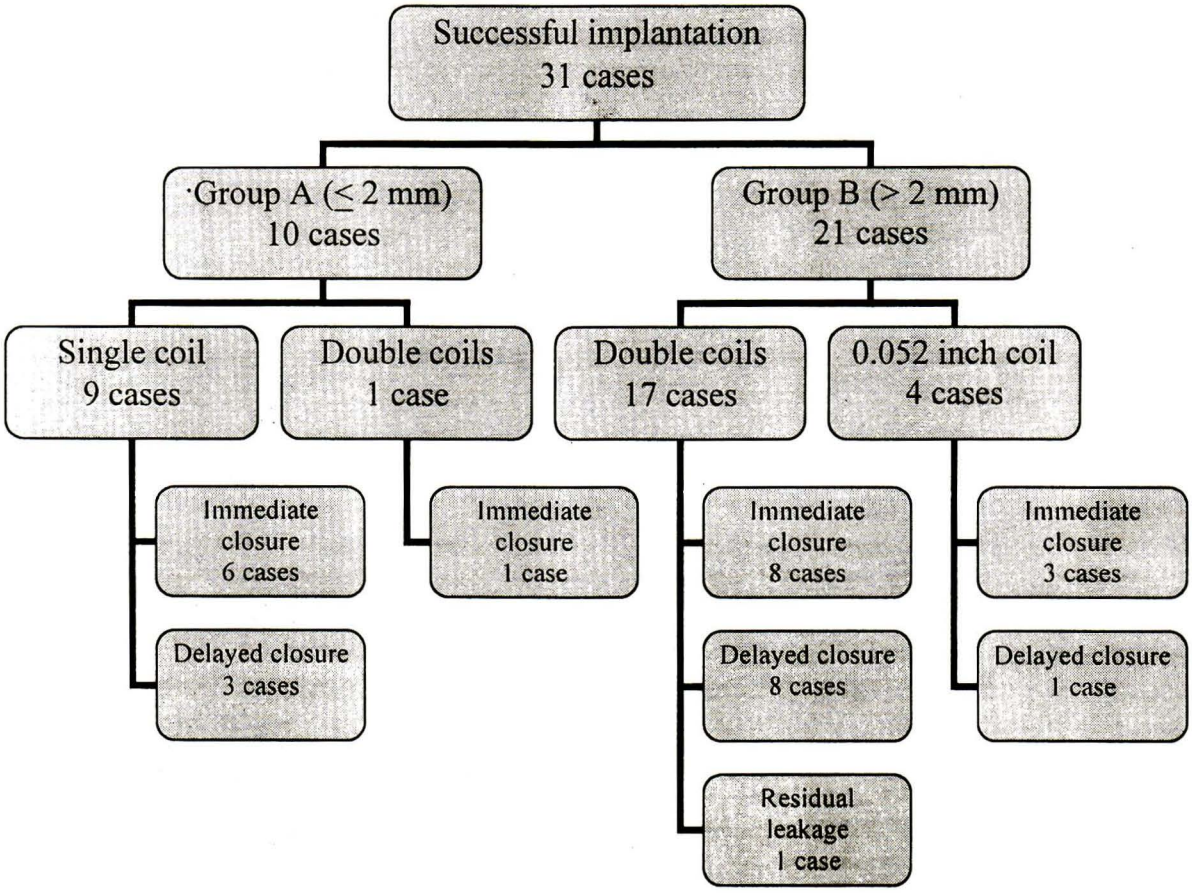

Fig. 3. Outcome of the 31 successful coil implantation cases.

DISCUSSION

Transcatheter coil occlusion of PDA is a feasible nonsurgical method for the closure of small PDA. For coil occlusion to be an accepted alternative to surgical closure, it should have a high complete closure rate and low incidence of complications. One important complication is coil migration from the PDA site after deployment[7-9]. In order to reduce the risk of coil migration, controlled release systems have been developed to provide satisfactory coil alignment and stable position at the PDA site[13-15]. From early experience in a previous study[11], the authors had 2 cases of coil migration and 14 cases of complete occlusion in a series of 17 cases. In the later cases of that study the authors decided to use 2 detachable coils in PDA > 2.5 mm.

In the present study, the authors tried to improve the outcome by using two detachable coils in PDA > 2 mm. A single detachable coil, 5 mm in diameter was used, in all except one case in group A (PDA ≤ 2 mm). The case that had two 5-mm coils had type B PDA with very short ampulla, so it was decided to use two 3-loop coils to avoid too much protrusion of the coil in the aorta after coil implantation. There was complete closure in all 10 cases of group A within 9 months after the procedure. In group B (PDA > 2 mm), there was complete occlusion in all except one case of residual silent PDA. In this case, two 5-mm-3-loop detachable coils were used for a PDA size of 3 mm. Looking back to this case, it seemed that the appropriate coils should have been one 8-mm-4-loop and one 5-mm-5-loop detachable coils.

The outcome of 523 patients (median PDA size of 2 mm) from a 38-center PDA registry in the USA included 75 per cent complete occlusion within

24 hours after the procedure, 5 per cent failure to implant the coil and 94.3 per cent complete occlusion at the mean follow-up of 8.1 ± 7.8 months[7,8]. From the results of the European registry (1,258 patients from 30 centers, with a mean PDA size of 2 mm), immediate occlusion rate was 59 per cent, which rose to 95 per cent at 1 year[9]. In the present study, immediate closure rate was 58 per cent, which rose to 97 per cent at the mean follow-up of 2.6 ± 2.5 months. The present result was comparable to both registries.

The authors have a setting for coil selection by using one 5-mm detachable coil in PDA ≤ 2 mm and two detachable coils, 8-mm and 5-mm for PDA > 2 mm. One 0.052 inch Gianturco coil may be used in PDA > 2 mm. The sturdier 0.052 inch coil maintains its tightly wound loop size and configuration which provides improved stability of coil position during implantation. It has been used successfully for closure of PDA > 3.5 mm[16]. The 0.052 inch Gianturco coils are available in 3 sizes in Thailand: 6, 8, and 10 mm in diameter. In PDA > 4 mm, more than one coil should be considered, by loading the 0.052 inch coil, 8 or 10 mm in diameter, from the right heart first as the initial anchor for the following coils.

In conclusion, transcatheter coil occlusion of PDA is an alternative to surgical closure of small PDA (less than 4 mm). Selection of type and number of coils appropriate to type and size of PDA will allow a safe and excellent outcome.

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การเลือกขดลวดในการปิด patent ductus arteriosus ด้วยขดลวดผ่านทางสายสวนหัวใจ

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ผู้รายงานได้ศึกษาผลการใช้ขดลวดปิด patent ductus arteriosus (PDA) ที่มีขนาดเล็กกว่า 4 มิลลิเมตร (มม) โดยตั้งเกณฑ์ในการกำหนดจำนวนและชนิดของขดลวดที่ใช้ตามขนาดของ PDA คือ เลือกใช้ 0.035 inch detachable coil จำนวน 1 ขด สำหรับ PDA ที่มีขนาดเล็กกว่าหรือเท่ากับ 2 มม (กลุ่ม ก) และใช้ 0.035 inch detachable coil จำนวน 2 ขด หรือใช้ 0.052 inch Gianturco coil ที่สามารถควบคุมการปล่อยได้ สำหรับปิด PDA ขนาดใหญ่กว่า 2 มม (กลุ่ม ข) ผลการศึกษาพบว่ามีผู้ป่วยเด็กจำนวน 32 ราย ได้รับการปิด PDA โดยการใช้ขดลวด ผู้ป่วย 31 รายสามารถทำการใส่ขดลวดได้สำเร็จ ผู้ป่วย 1 รายประสบความล้มเหลว ผู้ป่วยที่ประสบความสำเร็จมีขนาด PDA ตั้งแต่ 1.4–4.0 มม (ค่าเฉลี่ย 2.7 $\pm$ 0.9 มม) พบว่า กลุ่ม ก มีจำนวน 10 ราย โดย 9 รายได้รับการปิดด้วย detachable coil 1 ขด และ 1 รายได้รับการปิดด้วยขดลวด 2 ขด กลุ่ม ข มีจำนวน 21 ราย โดย 17 รายได้รับการปิดโดยใช้ detachable coil 2 ขด และ 4 รายได้รับการปิดโดยใช้ขดลวดขนาด 0.052 นิ้ว ในการศึกษาไม่พบภาวะแทรกซ้อนร้ายแรงใด พบว่า PDA ปิดสนิททันทีหลังใส่ขดลวดในผู้ป่วย 18 ราย (ร้อยละ 58) และปิดภายใน 1 วันถึง 9 เดือนหลังการรักษาในผู้ป่วย 30 ราย (ร้อยละ 97)

การเลือกชนิดและจำนวนขดลวดที่เหมาะสมกับขนาดของ PDA มีส่วนช่วยทำให้ได้ผลการรักษาที่ดีและปลอดภัย

คำสำคัญ : patent ductus arteriosus, การอุดด้วยขดลวด

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