Transcatheter Coil Occlusion of Small Patent Ductus Arteriosus : Experience at Siriraj Hospital

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Abstract

Transcatheter coil occlusion of small-to-moderate-size patent ductus arteriosus (PDA, $\leq$ 3.5 mm) is well established as a procedure of first choice in many institutions. Its much lower cost compared with surgical ligation or other devices makes it an attractive option, especially in Thailand.

Patients and Method : Between September 1995 and June 2000, all patients diagnosed with PDA with audible murmur and echo-Doppler confirmation of diameter less than 3.5 mm were scheduled for transcatheter coil occlusion at the Department of Pediatrics, Faculty of Medicine Siriraj Hospital. The hemodynamic studies were obtained both pre and post occlusion. The immediate and late outcome, including complication were assessed.

Results : A total of 77 cases, 78 procedures of transcatheter PDA coil occlusion were performed. Seventy cases (90.9%), comprised of 19 males (27.1%) and 51 females (72.9%) were successfully deployed with coils. The remainder were unsuccessfully deployed and later referred to surgery. The median age of the successful group was 6 years and 6 months and median weight was 16.5 kg. Twenty cases (28.6%) had other associated intra and extracardiac anomalies. All patients were asymptomatic, except one case having bronchopulmonary dysplasia (BPD) from prolonged ventilation. Single-coil occlusions were performed in 74.3 per cent and double-coil occlusions in 25.7 per cent. Conventional 0.038-inch Gianturco coils were deployed in 86.5 per cent. The mean procedure time was 78.1 $\pm$ 35.1 minutes. The mean fluoroscopic time was 20.2 $\pm$ 15.6 minutes. The total complete occlusion rate was 87.7 per cent. Tiny residual flow of PDA was demonstrated by follow-up echocardiogram in 12.3 per cent. Seven per cent of the patients were lost to follow-up. There was no significant difference in PDA size and hemodynamics between the groups of patients with complete occlusion and having residual shunt. Minor complications occurred in 12.9 per cent, including mild left pulmonary artery stenosis (10%), coil embolization to distal pulmonary artery (8.6%), slippage of catheter with coil (2.9%) and decreased dorsalis pedis pulse (1.4%). One late death was found in a BPD patient from pneumonia 2 months after the procedure.

Conclusion : Transcatheter coil occlusion of PDA is as effective, feasible, safe and less costly than surgical ligation. With improvement in technique and device selection and appropriate case selection, there should be an increase rate of complete occlusion and a decrease in complications.

Key word : Transcatheter Coil Occlusion of Patent Ductus Arteriosus

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All patent ductus arteriosus (PDA) with audible continuous murmur and echo-Doppler confirmation should be closed, either by transcatheter or surgical method[1]. Preventing infective endocarditis has remained the principal indication, apart from hemodynamic reasons for PDA closure[2]. Open surgical ligation has proven to be a safe and effective method. Recent studies have suggested that percutaneous transcatheter and video-assisted thoracoscopic closure may be a better and more cost-effective technique[3,4], avoiding a lateral thoracotomy incision, and shortening hospitalization[5]. Thus, transcatheter closure of small-to-moderate-sized PDA is well established as a procedure of first choice in many institutions.

Conventional Gianturco coils (Cook, Bloomington, Indiana) were found effective in closure of small ducts (diameter $\leq$ 3.5 mm)[6]. It was recommended that the ductus diameter of greater than or equal to 2.5 mm should be closed by two or more coils[7,8] or 0.052-inch coil[9]. The success rate (complete occlusions) of PDA after coil embolization varies from 80-100 per cent[10-13]. At Siriraj Hospital, transcatheter coil embolizations of small PDA were performed commencing in 1995.

PATIENTS AND METHOD

Patient population

Between September 1995 and June 2000, all patients who were diagnosed with PDA with audible murmur and echo-Doppler confirmation of a diameter less than 3.5 mm and selected to have PDA closure by percutaneously transcatheter coil occlusion at Department of Pediatrics, Faculty of Medicine Siriraj Hospital were enrolled in this study. The process and risk of the procedure were explained and informed consent was obtained from legal guardians.

Coil occlusion protocols

All patients underwent routine right- and left-sided cardiac catheterizations. Heparin 50 U/kg was administered after the access. The patient was sedated with a mixture of pethidine and promethazine and supplemented with intermittent doses of midazolam to ensure adequate sedation. Cefazolin 50 mg/kg was intravenously administered $^1/_2$ - 1 hour before the procedure, then three doses of 25 mg/kg were given every 6 hours. The hemodynamic studies including Qp : Qs, pulmonary arterial pressure, pulse pressure were obtained, pre and post procedure. A lateral descending aortogram was recorded to evaluate the narrowest size (minimum), including the ratio of PDA size to body surface area (BSA, m^2) and PDA size to abdominal aorta at diaphragmatic level (Ao), position related to the tracheal air shadow, and type. The PDA type was classified as described by Krichenko et al[14]. The coil size was selected, at least twice the narrowest ductal diameter. Single or double coils were deployed, either transvenously [7,8] or transarterially[8,15-18], as described elsewhere. Snare-assisted modification[18,19] and detachable coils[10,11,13] were performed in some cases to reduce the risk of embolization.

Ten minutes after the coil implantation, repeated descending aortogram was performed to assess the result. The results were divided into immediate complete occlusion and residual shunt. The complication of the procedure was also recorded.

Clinical evaluation and chest X-ray were obtained the next day after the procedure and echo-Doppler studies were obtained at 1, 3, 6 and 12 months or over after the coil deployment to assess the intermediate result (delayed closure or residual shunt), left pulmonary artery (LPA) stenosis and descending aortic velocity.

Definition

• Successful coil deployment was defined as the proper implantation of coil(s) in PDA position.

• Unsuccessful coil deployment was defined as the unstable or improper position of coil (s), resulting in coil(s) displacement from PDA position or coil(s) dislodgment and finally, the abandoned procedure.

• Immediate success (complete occlusion) was defined as no residual angiographic shunt detected at ten-minute descending aortogram after the coil deployment.

• Residual shunt was defined as having color Doppler evidence of residual shunt after the coil deployment on the latest examination.

• Delayed closure was defined as having residual shunt at ten-minute descending aortogram after the coil deployment and absence of color Doppler evidence of residual shunt at the follow-up examination.

• Left pulmonary artery (LPA) stenosis was defined as having peak velocity $\geq$ 1.5 m/sec along LPA by Doppler echocardiography.

Statistical analysis

Continuous variables are reported as mean ± SD, except for patient age and weight, which exhibited a skewed distribution and are, therefore, reported as median and range.

The comparison between the two groups was assessed by using Mann-Whittney U test and Student *t*-test as appropriate. The correlation between the PDA sizes measured by echocardiogram and angiogram was performed by using regression analysis and correlation coefficient were also calculated. Analysis of variance was used for test of significance of regression model while correlation coefficient (r) was tested by using *t*-test. Statistical significance was defined as a p value < 0.05.

Table 1. The associated intra and extracardiac anomalies in the patients (n = 20).

Associated anomalies	Frequency (cases)
Intracardiac	6
Ventricular septal defect (small)	2
Atrial septal defect, secundum*	2
Bicuspid aortic valve	2
Branch pulmonary stenosis	2
Pulmonary stenosis, valvar**	1
Aortic stenosis (mild)	1
Double-chambered right ventricle	1
Mitral valve prolapse with moderate regurgitation	1
Post surgical ductal ligation	1
Right-sided aortic arch	1
Extracardiac	
Down syndrome	4
Congenital rubella	2
Bronchopulmonary dysplasia	1
Dysmorphic feature	1

One may associate with more than one anomaly.

* One case was reassessed after a successful procedure and found to have moderate shunt. She was thereafter referred for patch closure of the defect.

** One case underwent percutaneous balloon valvuloplasty at the same catheterization with good result.

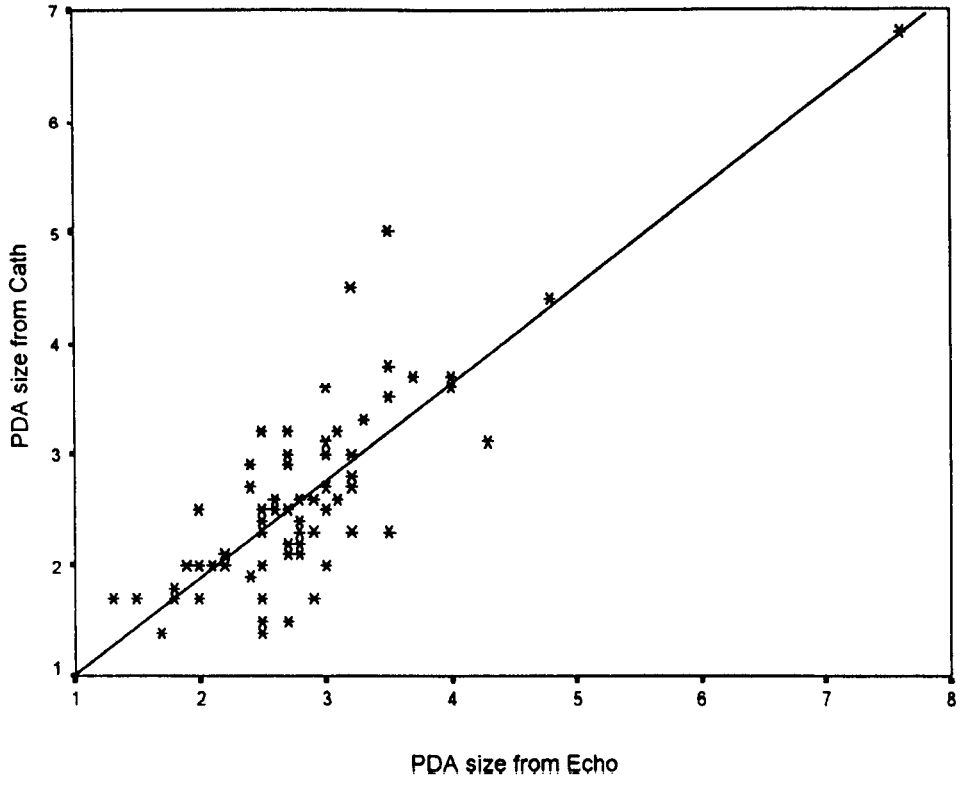

Fig. 1. The correlation of ductal (PDA) size measured by echocardiogram (Echo) and angiogram (Cath); PDA size measured by angiogram = 0.144 + 0.87 PDA size by echocardiogram.

RESULTS

A total of 77 cases, 78 procedures of percutaneously transcatheter coil occlusion of PDA were performed. In one case coil occlusion of PDA was attempted, unfortunately, the coil was embolized to the distal pulmonary artery at the first catheterization. She was rescheduled and at the second catheterization, the coil was successfully deployed with immediate complete occlusion. In seven cases (9.1%) coils were unsuccessfully deployed and later were referred for surgery. In seventy cases (90.9%) coils were successfully deployed, comprising 19 males (27.1%) and 51 females (72.9%). In the successful deployment group, their ages ranged from 3 months to 38 years (median 6 years and 6 months). The body weights ranged from 3.5 to 90.7 kg (median 16.5 kg).

Associated intra and extracardiac anomalies were found in 20 cases (28.6%). The details are shown in Table 1.

Preprocedural cardiac evaluation

All patients were asymptomatic and cardiac murmur was incidentally detected and referred to us for cardiac evaluation, except one case which was associated with bronchopulmonary dysplasia (BPD). Continuous murmur was heard in 56 cases (80%) and systolic murmur in 12 cases (17.1%). Two cases (2.9%) had both continuous and systolic murmurs of PDA and ventricular septal defect. All of those with systolic murmur were associated with other intracardiac lesions. Nineteen cases (27.1%) had borderline or mild cardiomegaly, documented by

chest roentgenogram and/or electrocardiogram. Echocardiogram revealed mild left atrial and ventricular enlargement in 51 cases (72.9%).

PDA size and hemodynamic data

The minimum PDA diameters measured by echocardiogram were significantly smaller than those obtained by angiogram (mean 2.64 ± 0.52 and 2.79 ± 0.83 mm, respectively, p = 0.033). However, using regression and correlation analysis, the minimum PDA diameters measured by angiogram were correlated to those measured by echocardiogram (r = 0.817, p = 0.000) as in Fig. 1.

The comparison of the hemodynamic data obtained from cardiac catheterization between the successful and unsuccessful coil deployment group is shown in Table 2. The PDA sizes were significantly larger in the unsuccessful deployment group (p = 0.005). There were no significant differences in PDA size and hemodynamic data between the groups of patients with complete occlusion and having residual flow as shown in Table 3.

According to Krichenko et al's angiographic classification of PDA,[14] the majority of the presented cases had PDA type A (90.9%), as shown in Table 4.

Coil occlusion procedure

Single-coil occlusions were performed in 52 cases (74.3%) and double-coil occlusions in the remainder (18 cases, 25.7%). In single-coil occlusions, transarterial (retrograde) approach was undertaken in 50 cases (96.2%) and transvenous (anterograde) approach in 2 cases (3.8%). In double-coil occlusions, the coils were simultaneously anterograde deployed in 9 cases (50.0%), simultaneously

Table 2. Comparison of the hemodynamic data obtained from cardiac catheterization between the successful and unsuccessful coil deployments of patent ductus arteriosus (PDA).

	Successful (n = 70)		Unsuccessful (n = 7)		P value
	Range	Mean	Range	Mean	
PDA size (mm)	1.40 - 3.70	2.39 ± 0.59	3.10 - 6.80	4.41 ± 1.24	0.005*
PDA / BSA	1.02 - 16.8	3.40 ± 2.04	3.60 - 7.08	4.85 ± 1.42	0.04*
PDA / Ao	0.10 - 0.64	0.21 ± 0.09	0.21 - 0.48	0.31 ± 0.09	0.10
Qp : Qs	1.10 - 3.50	1.71 ± 0.52	1.60 - 4.10	2.54 ± 1.14	0.101
PAP (mmHg)	15.0 - 75.0	27.1 ± 9.38	24.0 - 80.0	40.00 ± 18.80	0.003*
Pulse pressure (mmHg)	32.0 - 78.0	45.64 ± 8.90	44.0 - 60.0	50.86 ± 6.04	0.135

BSA, body surface area; Ao, descending aorta; Qp : Qs, the ratio of pulmonary to systemic blood flow; PAP, pulmonary artery pressure; *, statistical significantly (p < 0.05)

Table 3. Comparison of hemodynamic data obtained from cardiac catheterization between the completely coil occluded patients (group A) and those having residual flow after coil occlusion (group B).

	Group A (n = 54)		Group B (n = 11)		P value
	Range	Mean	Range	Mean	
PDA size (mm)	1.4 - 3.8	2.40 ± 0.57	1.4 - 3.7	2.17 ± 0.63	0.163
PDA / BSA	1.02 - 6.0	3.24 ± 1.26	1.31 - 6.27	3.17 ± 1.34	0.847
PDA / Ao	0.10 - 0.41	0.20 ± 0.08	0.10 - 0.39	0.20 ± 0.08	0.922
Qp / Qs_1	1.10 - 3.5	1.70 ± 0.50	1.10 - 3.0	1.65 ± 0.65	0.812
Qp / Qs_2	1.0 - 1.2	1.00 ± 0.03	1.0 - 1.7	1.12 ± 0.21	0.106
PAP_1	15 - 48	26.44 ± 7.21	20 - 45	27.27 ± 8.11	0.735
PAP_2	11 - 38	23.29 ± 6.40	20 - 35	24.75 ± 5.47	0.552
Pulse $pressure_1$	32 - 78	46.26 ± 9.59	35 - 55	43.82 ± 6.54	0.557
Pulse $pressure_2$	25 - 58	39.78 ± 8.67	26 - 50	37.30 ± 6.62	0.397

The abbreviations were same as in Table 2. 1, pre occlusion of PDA; 2, post occlusion of PDA

Table 4. The PDA type, according to Krichenko et al's angiographic classification of the patients[14].

PDA type	Total (n = 77)		Successful deployment (n = 70)		Unsuccessful deployment (n = 7)	
	Number	%	Number	%	Number	%
A	70	90.9	65	92.9	5	71.4
B	3	3.9	3	4.3	-	-
C	2	2.6	1	1.4	1	14.3
E	1	1.3	-	-	1	14.3
Unknown	1	1.3	1	1.4	-	-

anterograde and retrograde deployed in 7 cases (38.9%) and simultaneously retrograde deployed in 2 cases (11.1%). In majority of single-coil occlusions (45 cases, 86.5%), the conventional 0.038-inch Gianturco coils were deployed. The other types of coils used or technique performed in the remainder included 0.038-inch detachable coils (5 cases, 9.6%), 0.052-inch coils (3 cases, 5.2%) and snare-assisted technique (1 case, 1.9%). In double-coil occlusions, the detachable coils were used in conjunction with the conventional Gianturco coils in 4 cases (22.2%).

The procedure time ranged from 30 to 230 minutes (mean 78.1 ± 35.1 minutes). The fluoroscopic time ranged from 6 to 109 minutes (mean 20.2 ± 15.6 minutes). Duration included the retrieval time of the embolized coils.

Outcomes

Five cases (7.2%) were lost to follow-up, therefore, the result in these patients could not be stated. The total cases of complete coil occlusion of PDA (the success rate) were 57 cases out of 65 cases (87.7%), divided into the immediate success rate 40 cases (61.5%) and delayed closure 17 cases (26.2%) within the duration 1 to 12 months (mean 3.75 ± 3.62 months). One case of delayed closure was lost to follow-up until 2 years after the procedure. She came back and echocardiography was performed and revealed complete occlusion of PDA. A tiny residual flow of PDA was demonstrated by echocardiogram in 8 cases (12.3%) with the follow-up duration between 1 and 30 months.

Continuous murmur disappeared in every case of completely occluded PDA (56 cases). The remainder still have systolic murmur of the associated cardiac anomalies.

Complications

Immediate minor complications occurred in 10 cases (12.9%), including coil embolization to the distal pulmonary artery (6 cases, 8.6%), coil with catheter slipped to pulmonary artery or descending aorta (1 case of each, 1.4%) and decreased dorsalis pedis pulse (1 case, 1.4%). Coil embolization occurred in single-coil deployments in 3 cases and in double-coil deployments in 3 cases. Embolized coils were retrievable in 4 cases (66.7%). In the remainder, attempts were made to retrieve the embolized coils or it was decided not to retrieve them especially in the early phase of intervention (1995). However, the pulmonary angiogram revealed no significant obstruction of distal pulmonary artery and no pulmonary infarction detected on the CXR. In cases in which the catheter with coil slipped, the authors were able to remove the catheter with the coil without any complication. Thereafter, the coils were successfully deployed in the same procedure in both cases.

Mild LPA stenosis was detected by Doppler echocardiogram in 7 cases (10%), excluding 2 cases associated with congenital rubella. The mean peak velocity was 1.7 m/sec, ranging from 1.5 to 2.1 m/sec, only one case had LPA peak velocity greater than 2 m/sec. The PDA size of these patients ranged from 1.7 to 3.2 mm (mean 2.5 mm). Their body weight ranged from 12.5 to 27.8 kg (median 15.2 kg). In all of these cases, the 0.038-inch and 5 mm diameter coils were deployed (single-coil occlusion in 5 cases and double-coil occlusion in 2 cases). However, no significant murmur and clinical complication were present at the most recent follow-up. There was one case with peak velocity in the descending aorta of 1.6 m/sec without late adverse event.

One late death occurred, unrelated to the procedure. She was born prematurely and bronchopulmonary dysplasia developed after a prolonged period on a ventilator. The procedure was performed at the age of 3 months (3.5 kg). Her PDA size was 3.7 mm in diameter. The coil was successfully deployed with moderate residual flow. She could not be weaned from the ventilator and unfortunately, died 2 months later from pneumonia.

DISCUSSION

Transcatheter occlusion of small-to-moderate PDAs using Gianturco coils is feasible, safe, effective and less costly than surgical closure[3,4,20]. Although the recommended minimum PDA diameter for coil occlusion was ≤ 3-3.5 mm[6,21], due to their lack of manouverability and physical limitation of grip forceps, leading to risk of embolization [6], the larger size upto 6.8 mm was successfully deployed by using snare-assisted technique and multiple coils[19]. Echocardiography was performed to identify the candidates for coil occlusion. It was reported that the PDA sizes measured by Doppler-echocardiography often overestimated the sizes obtained by angiography and there was no correlation between the two methods[22]. In contrast, in the present study, it was found that the PDA sizes measured by echocardiogram was smaller than those obtained by angiogram and there was correlation between the methods.

Successful deployment of at least one coil was achieved in 94 per cent with a 98 per cent occlusion rate in PDA minimum diameter of equal to or less than 2.5 mm[23] and increased occlusion rate upto 100 per cent by using multiple coils[12]. The snare-assisted technique increased successful placement of coils upto 100 per cent, irrespective of size or angiographic type[19]. Immediate complete occlusion was found in 70.2 per cent, related to smaller sizes but not to angiographic type[19]. In the present study, the immediate complete occlusion rate was 61.5 per cent with a total occlusion rate of 87.7 per cent. The remainder (12.3%) had silent residual shunt without clinical evidence, similar to LeBlanc's report (13.3%)[23]. When compared with surgical ligation, the residual rate was found to vary from 6 to 23 per cent[24]. Technique improvement increased successful deployment and occlusion rate. Multiple coils allowed successful occlusion of moderate size upto 6.8 mm, irrespective to angiographic type[12,19]. The need of multiple coils was found in 26.9 per cent[19], close to the present study (25.7%).

The complications of transcatheter coil occlusion of PDA were few (3.5%) including hemolysis (0.1-3.6%),[25,26] and embolization of a coil to the pulmonary artery (2.3%)[25]. Although hemolysis is an important complication after coil implantation and related to large ducts[26], the authors have no experience in this event. In the present study, minor complications occurred in 12.9 per cent. The majority of the complications in the present study were mild left pulmonary artery stenosis (10%) and coil embolization to distal pulmonary artery (8.6%). Similar to the Galal et al's report, which found left pulmonary artery stenosis in 11 per cent [27]. In the authors' experience, a long tubular PDA with a minimum diameter of greater than 3 mm tended to expand during coil deployment, despite double-coil placement, resulting in coil dislodgement. The authors suggest that more coils or PDA device closure should be performed in such cases. Sanatani et al concluded that the maximum diameter of the PDA suitable for coil occlusion is approximately 3 mm[21]. Recently, it was reported that a giant aneurysm developed in an infant with Marfan syndrome following successful PDA coil occlusion [28]. Reopening of the PDA after complete occlusion may occur, associated with a short PDA length and type B[29] or with a three-loop Gianturco coil [30]. They recommended that using five-loop coils may produce a larger thrombus than using three-loop coils which result in no or less probability of recanalization of PDA during follow-up[30]. No procedural death of transcatheter coil occlusion was detected, in contrast, 0.4 per cent intra-operative deaths were reported[23].

SUMMARY

Transcatheter coil occlusion of patent ductus arteriosus with a diameter of less than 3.5 mm has proven to be an alternative therapy to surgical ligation or device closure. It is marginally less effective but significantly more cost-effective than conventional surgery. With improvement in technique, device selection and appropriate case selection, there should be a further increase in the rate of complete occlusion and decrease in complications with this strategy.

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การปิดหลอดเลือด ductus arteriosus ด้วยขดลวดขนาดเล็กทางสายสวนหัวใจ : ประสบการณ์ในโรงพยาบาลศิริราช

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ในปัจจุบันหลายสถาบันนิยมการปิดหลอดเลือด ductus arteriosus (PDA) ที่มีขนาดเล็ก (≤ 3.5 มม.) ด้วยขดลวดขนาดเล็กทางสายสวนหัวใจแทนการผ่าตัดรักษาเนื่องจากค่าใช้จ่ายที่ถูกกว่า โดยเฉพาะในประเทศไทย คณะผู้เขียนจึงขอนำเสนอประสบการณ์การรักษาด้วยวิธีนี้ในโรงพยาบาลศิริราช

ผู้ป่วยและวิธีการศึกษา : ศึกษาผู้ป่วยทุกรายที่ฟังเสียงหัวใจผิดปกติที่ได้รับการวินิจฉัยด้วยคลื่นเสียงสะท้อนความถี่สูงของหัวใจว่าเป็น PDA ขนาด ≤ 3.5 มม. และได้ทำการปิดหลอดเลือดด้วยขดลวดทางสายสวนหัวใจที่ภาควิชากุมารเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล ตั้งแต่เดือนกันยายน 2538 ถึง มิถุนายน 2543 โดยทำการศึกษา hemodynamic ก่อนและหลังการปิดหลอดเลือด ประเมินผลการรักษาในระยะเฉียบพลัน และระยะหลัง รวมทั้งภาวะแทรกซ้อน

ผลการศึกษา : ผู้ป่วยทั้งหมด 77 ราย ได้รับการปิดหลอดเลือดทางสายสวนหัวใจ 78 ครั้ง พบว่า 70 ราย (ร้อยละ 90.9) สามารถปิดหลอดเลือดได้ ประกอบด้วย เพศชาย 19 ราย (ร้อยละ 27.1) และเพศหญิง 51 ราย (ร้อยละ 72.9) อีก 7 รายที่ปิดไม่สำเร็จต้องส่งผู้ป่วยผ่าตัดรักษา ในรายที่สามารถปิดหลอดเลือดทางสายสวนหัวใจได้ มีอายุมัธยฐาน 6 ปี 6 เดือน น้ำหนักมัธยฐาน 16.5 กก. ร้อยละ 28.6 ของผู้ป่วยมีความผิดปกติอื่นร่วมทั้งภายในและ/หรือนอกหัวใจ ทุกรายไม่มีอาการผิดปกติ ยกเว้น 1 รายได้รับการช่วยหายใจเป็นเวลานานทำให้เป็นโรคปอดเรื้อรัง ร้อยละ 74.3 ได้รับการปิดหลอดเลือดด้วยขดลวด 1 เส้น ร้อยละ 25.7 ใช้ขดลวด 2 เส้น ระยะเวลาเฉลี่ยในการปิดหลอดเลือด 78.1 ± 35.1 นาที ระยะเวลาเฉลี่ยในการใช้ fluoroscope 20.2 ± 15.6 นาที อัตราสำเร็จในการปิดหลอดเลือดร้อยละ 87.7 จากการตรวจคลื่นเสียงสะท้อนความถี่สูงของหัวใจในระยะหลังพบว่า ร้อยละ 12.3 มีรอยรั่วของหลอดเลือดเหลือเล็กน้อย ร้อยละ 7 ของผู้ป่วยไม่ได้มาตรวจตามนัดหลังการรักษา ไม่พบความแตกต่างอย่างมีนัยสำคัญในขนาดและ hemodynamic ของกลุ่มผู้ป่วยที่สามารถปิดหลอดเลือดได้สนิทและกลุ่มที่ยังมีรอยรั่วเหลืออยู่ ภาวะแทรกซ้อนของการรักษาพบร้อยละ 12.9 ได้แก่ หลอดเลือดแดงปอดด้านซ้ายมีการตีบเล็กน้อย (ร้อยละ 10) ขดลวดหลุดไปในหลอดเลือดแดงปอด (ร้อยละ 8.6) มีการเลื่อนหลุดของสายสวนและขดลวด (ร้อยละ 2.9) ชีพจร dorsalis pedis เบา (ร้อยละ 1.4) 1 รายที่เป็น BPD เสียชีวิตจากปอดอักเสบภายหลังการปิดหลอดเลือด 2 เดือน

สรุป : การปิดหลอดเลือด ductus arteriosus ด้วยขดลวดขนาดเล็กทางสายสวนหัวใจ สามารถทำได้สะดวก ปลอดภัย มีประสิทธิภาพเท่าเทียมแต่ค่าใช้จ่ายถูกกว่าการผ่าตัด การพัฒนาด้านเทคนิค ชนิดของเครื่องมือที่ใช้ปิด และการเลือกผู้ป่วยอย่างเหมาะสม จะทำให้อัตราสำเร็จของการรักษาสูงขึ้นและภาวะแทรกซ้อนในการทำลดลง

คำสำคัญ : การปิดหลอดเลือด ductus arteriosus ทางสายสวนหัวใจ

ดวงมณี เลาหประสิทธิพร, อภิชาติ นานา, จารุพิมพ์ สูงสว่าง, และคณะ
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