

## Transcatheter Closure of Patent Ductus Arteriosus in Adolescents and Adults: A Case Series

**Sukman T. Putra, Mulyadi M. Djer, Nikmah S. Idris, Sudigdo Sastroasmoro**

Department of Pediatrics, Faculty of Medicine Universitas Indonesia - Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

**Corresponding author:**

Sukman Tulus Putra, MD., PhD, FACC. Department of Pediatrics and Child Health, Faculty of Medicine Universitas Indonesia - Cipto Mangunkusumo Hospital. Jl. Salemba 6 Jakarta 10430, Indonesia. email: sukmanputra@yahoo.com.

### ABSTRAK

Dalam kurun waktu 11 tahun antara 1 Januari 2005 sampai 31 Desember 2015 sebanyak 18 kasus PDA pada anak remaja dan dewasa dilakukan penutupan PDA dengan alat Amplatzer Duct Occluder (ADO). Terdapat 9 kasus anak remaja yang berumur antara 14-18 tahun dan 9 orang dewasa yang berumur di atas 18 tahun dengan umur yang tertua 46 tahun. Sebelum pelaksanaan tindakan, dilakukan pemeriksaan klinis, EKG dan foto toraks serta ekokardiografi transtorakal untuk konfirmasi diagnostik PDA. Prosedur implantasi ADO dilakukan dengan anastesi umum pada remaja dan anastesi lokal dan sedasi pada pasien dewasa. Ukuran diameter PDA berkisar antara 1,6 mm-11,1 mm. Berdasarkan klasifikasi Kritchenko terdiri dari 15 PDA tipe A1 dan 3 kasus tipe A2. Flow rati oantara sirkulasi pulmonal dan sirkulasi sistemik berkisar antara 1,1-5,9. Waktu pelaksanaan prosedur berkisar antara 60-189 menit dengan waktu florsokopi antara 7,1-77,3 menit. Tekanan rata-rata pada arteri pulmonalis berkisar antara 22-63 mmHg dengan tekanan tertinggi sebesar 63 mmHg terdapat pada 2 kasus (no 12 dan 13). Segera setelah prosedur tindakan menunjukkan penutupan total pada 14 kasus dan pada 4 kasus terdapat pirau residual minimal pada gambaran angiografi yang kemungkinan disebabkan kebocoron sementara melalui sela-sela device. Dalam 24 jam pertama setelah tindakan ditemukan penutupan total pada semua kasus (100%) dan hasil tersebut ditemukan sampai 1 bulan dan 6 bulan setelah tindakan. Selama kurun waktu tersebut tidak ditemukan sisa pirau (residual shunts) dan komplikasi berarti lainnya seperti embolisasi device atau rekanalisasi pada duktus.

Hasil studi seri kasus ini menunjukkan bahwa penutupan PDA dengan prosedur transkateter menggunakan ADO pada pasien remaja dan dewasa dalam jangka pendek sangat baik dan efektif serta tidak ada komplikasi yang berarti. Namundemikian masih diperlukan pemantauan jangka panjang untuk menilai efektivitas dan keamanan prosedur ini.

**Kata kunci:** penutupan transkateter; duktus arteriosus persisten, remaja, dewasa, Amplatzer duct occluder (ADO).

### ABSTRACT

During 11 years period from January 2005 to December 2015 there were 18 adolescent and adult patients who underwent transcatheter closure of PDA using PDA Amplatzer Duct Occluder (ADO). There were 9 cases with age of 14 to 18 years and 9 cases with age of more than 18 years where the oldest case was 46 years old. Two cases were male and 16 cases were female. Prior to procedures, clinical assessment, ECG, chest x-ray and transthoracic echocardiography (TTE) were performed to confirm the diagnosis of PDA. The procedures of device implantation was performed under conscious sedation in adults and using general anesthesia in adolescents. The size of PDA ranged from 1.6 mm to 11.1 mm. Based on Kritchenko classification, the type of PDA were

15 type A1 and 3 type A2. Flow ratio between pulmonary to systemic circulation was between 1.1 and 5.9. The procedure time ranged from 60-189 minutes and the fluoroscopic time 7.1-77.3 minutes. The PA pressure ranged from 22 to 63 mmHg. Immediate results after procedures as seen in angiography showed complete closure in 14 cases and smoky residual shunt or minimal residual shunts in 4 cases, which probably due to the temporary leaking through the devices. In 24 hours, complete closure was achieved in all cases (100%) and continued until 1 month. At 6 month follow up, there was no residual shunts detected and also there was no significant complications, such as device embolization or recanalization.

This case series suggest that transcatheter closure of PDA in adolescents and adults using Amplatzer duct occluder (ADO) is effective and has excellent results without significant complication. However, long-term follow up is required to assess long term efficacy and safety.

**Keywords:** transcatheter closure, patent ductus arteriosus, adolescent, adult, Amplatzer duct occluder.

## INTRODUCTION

Patent ductus arteriosus (PDA) is vascular structure that connects the left pulmonary artery near its origin to the descending aorta. This structure is important during fetal life and in full-term infants, about 90% closes spontaneously the 48 hours of life. PDA is considered a congenital heart defect if there is persistent patency beyond the third month of life in full term infants.<sup>1</sup> In infants and children, PDA can be associated with various congenital heart disease like ASD or VSD, but in adults, it is usually an isolated lesion. The incidence of PDA is approximately 1 per 2000 live birth, accounting for 5-10% of congenital heart diseases.<sup>2</sup> Most of the PDA were detected and treated in infancy and childhood. However, in the developing world, some cases could be detected very late in the adolescence or even in adulthood due to the lack of resources and access to cardiac centers.

The clinical significance of PDA depends largely on the size and the underlying cardiovascular status and co-morbidities of the patient. The PDA may be "silent" with no evidence of clinical symptoms (asymptomatic). The silent PDA is detected incidentally by primary care physician during other examination, in which the echocardiography was done for different reasons. The anatomy of PDA in adults may differ from children due to calcification or aneurysm, which may cause challenges in performing transcatheter closure of PDA and, therefore, a surgery is required. However, it has been reported that transcatheter closure of the PDA in adults may be safe and effective

but data is very limited.<sup>3</sup> The mortality rate of untreated PDA in adults is 1.8% per year.<sup>4</sup> There are also some additional complications, such as LV overload, pulmonary hypertension, infective endocarditis, calcification, aneurysm and rarely rupture.<sup>5</sup> Here we presented a case series on the short-term results of transcatheter closure of PDA in 18 adolescents and adults which consists of complete closure and complications from the years of 2005 to 2015.

## CASE ILLUSTRATION

During 11 years period from 2005 until 2015, there were 18 of adolescents and adults undergoing transcatheter closure of PDA using ADO. There were 9 adolescents between 14 and 18 years of age, while the remaining 9 patients were adults, among whom the oldest case was 46 years old. Most of the patients were female (**Table 1**).

The size of PDA ranged from 1.6 mm to 11.1 mm. Based on Kritchenko classification, the type of PDA were 14 of A1 type and 3 of A2 type. Flow ratio between pulmonary to systemic circulations ranged from 1.1 to 5.9. The procedure time was 60-189 minutes and the fluoroscopic time was 7.1-77.3 minutes. The range of PA pressure was 22-63 mmHg, in which the highest occurred in patient no. 12 and 13.

## Transcatheter Closure of PDA Procedure

This case study was performed retrospectively by reviewing the medical records of 18 adolescents and adults (2 male and 16 female) patients admitted between 2005

**Table 1.** Hemodynamic data and immediate results of transcatheter closure of PDA using ADO

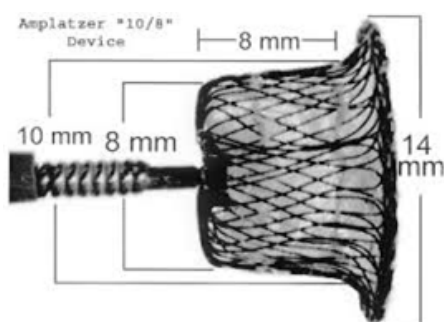
Pts No.	Sex/ Age	Year	Device	W (Kg)	PDA size	Type	FR	FT	PT	Comp.	Immediate result	PA sys	PA dias	PA mean
1	F/20	2006	ADO I	46.0	4.0	A1	3.2	7.1	71	nil	complete closure	58	17	37
2	F/14	2007	ADO I	54.5	3.35	A2	1.1	12.8	68	nil	complete closure	22	12	8
3	F/18	2008	ADO I	42.0	3.00	A1	2.2	43.3	125	nil	complete closure	26	17	21
4	F/23	2008	ADO I	48.0	5.67	A1	1.8	9.3	60	nil	smoky residual shunt	30	18	24
5	F/15	2009	ADO I	38.0	6.00	A2	2.9	33.6	170	nil	smoky residual shunt	67	35	49
6	M/14	2009	ADO I	43.0	7.00	A1	4.9	17.0	80	nil	complete closure	58	33	42
7	F/37	2010	ADO I	49.0	4.00	A1	3.0	38.3	120	nil	complete closure	22	9	15
8	F/14	2010	ADO I	23.0	2.60	A2	3.5	13.6	150	nil	smoky residual shunt	40	25	33
9	F/18	2012	ADO I	55.0	5.6	A1	1.2	22.1	133	nil	complete closure	48	27	37
10	M/15	2012	ADO I	33.0	6.02	A1	5.9	19.4	69	nil	complete closure	60	30	42
11	F/18	2012	ADO I	49.0	8.00	A1	1.9	17.1	68	nil	complete closure	45	10	27
12	F/23	2012	ADO I	47.0	6.0.0	A1	2.5	14.0	70	nil	smoky residual shunt	83	46	63
13	F/17	2013	ADO I	10.0	8.00	A1	3.2	17.8	120	nil	complete closure	90	36	63
14	F/16	2013	ADO I	43.0	10.00	A1	2.3	11.0	60	nil	complete closure	74	42	57
15	F/39	2013	ADO I	42.0	11.30	A1	1.4	77.3	189	nil	complete closure	30	14	26
16	F/20	2015	ADO I	53.0	6.50	A1	2.5	8.1	70	nil	complete closure	40	15	32
17	F/15	2014	ADO I	40.0	4.20	A1	2.0	12.0	60	nil	complete closure	38	15	30
18	F/46	2014	ADO I	61.5	6.96	A1	1.4	22.2	99	nil	complete closure	61	32	49

W: Weight; FR: Flow Ratio; FT: Flouroscopy Time; PT: Procedure Time; PA: Pulmonary artery; Comp: complication.

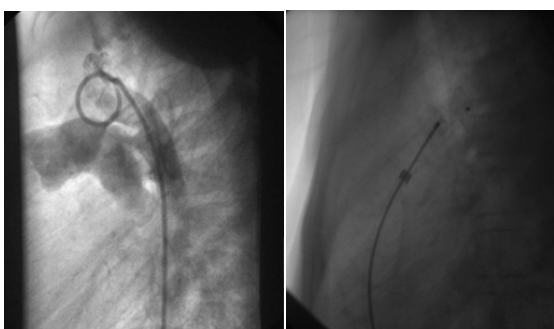
and 2015 at Integrated Cardiovascular Center (PJT), Dr. Cipto Mangunkusumo Hospital Jakarta. Prior to the intervention procedures, clinical assessment, ECG, chest X-ray, and trans-thoracic echocardiography (TTE) were performed to confirm the diagnosis of PDA. The procedures of the device implantation were performed under conscious sedation in adults and with general anesthesia in adolescents. A single dose of intravenous antibiotic is administered (cephalosporin) 30 mg/kg BW (max 1 gram) 30 minutes before the catheterization and

two subsequent doses at 8 and 16 hours after the procedure. A 100 international unit (IU)/kg (maximum 5000 IU) of sodium heparin were administered after insertion of catheter at the femoral artery. The right and left heart catheterization was performed and an aortogram with true lateral position was made to visualize the size and shape of the duct and to assess the minimum diameter, diameter of the aortic ampulla and the length of the duct (**Figure 1**). We used Amplatzer ductal occluder (ADO I) device, in which the size closed was at least 2 mm larger

than narrowest diameter of the duct. The device then was immersed into saline solution. After the device was screwed to the tip of the delivery cable, it was then loaded into the delivery catheter and the whole system is immersed into saline again (**Figure 2**). After this, the device was introduced and advanced through the sheath into the descending aorta by fluoroscopy guidance, and then the retention disk was deployed in the descending aorta. The sheath and the retention disk were pulled back firmly into the ampulla of the duct. At this position the rest of device was deployed by holding the delivery cable of the device while pulling back the delivery sheath. To confirm the correct position of the device, an aortogram was performed soon afterward, to ensure the retention disk sitting on the rim of the ductal ampulla and not obstructing the descending aorta. The device could be replaced by another device of different size as necessary. If everything is correct and the position of the device is stable, the device can be released by rotating the delivery cable in the anticlockwise direction.



**Figure 1.** Amplatzer duct occluder (ADO)



**Figure 2.** Angiography before and after implantation of ADO (before released)

### Device Profile

All of our patients had their PDA closed by ADO I. The ADO (AGA Medical Corporation, Golden Valley, MN) is a self-expanding and self-centering device made from 0.0004 (0.1mm) to 0.0005 inch nitinol wire mesh. It is mushroom-shaped with a low profile and consist of a flat retention disk and a cylindrical main body, into which polyester fibers are sewn (**Figure 1**).

ADO has a retention disk which is 4 mm larger than the main body which itself has a conical structure. The delivery system consists of a delivery cable, a Mullin-type sheath, loader and a pin vise. The size of the device used will be at least 2 mm larger than the size the narrowest diameter of the duct.

At the end of the procedures, the arterial and venous catheter were removed and the compression of the groin was done to achieve the hemostasis. Follow up echocardiogram was performed 24 hour post-procedure. The aim of repeating the echo was to demonstrate the orientation of the device (its relation to descending aorta and the branches of pulmonary arteries, and to visualize the degree of residual shunting. A chest x-ray in anterior/posterior and lateral projections was done prior to discharge. Further clinical follow up and echocardiography were undertaken at 24 hours, 1 months, and 6 months after the procedures.

### Follow-up

The immediate results after procedures as shown by angiography were complete closure in 14 patients and smoky residual or minimal residual shunts in 4 patients, which was probably due to temporary leak through the device.

At 24 hour follow up after the procedure, complete closure was achieved in all patients and persisted at 1 month follow up. The follow up after 6 months, there was no residual shunt detected and no significant complications occurred, such as device embolization or recanalization.

### DISCUSSION

Transcatheter closure of PDA has been performed worldwide since the first percutaneous closure of PDA by Porstman in 1967.<sup>6</sup> There were

various kind of duct occluder available, such as Rashkind occluder, Gianturco coils, Lifetech device, and ADO as the most commonly used device. The ADO is an expandable device that has been used in many centers with excellent results since early 2000. Bilkis et.al reported the safety and efficacy of closing the PDA using ADO in 209 patients, particularly in symptomatic infants and small children with relatively large PDA.<sup>3</sup> Most PDA are closed during infancy or childhood, when there were significant clinical symptoms and signs, which causes hemodynamic disturbances with left atrial and ventricle volume overload and pulmonary hypertension. Djer MM et.al reported good results of PDA closure using devices, mostly with ADO, with success rate of 97.3% in the period of 11 years.<sup>7</sup>

In adults, PDA is usually “silent” with no clinical symptoms or asymptomatic, which is detected incidentally during routine physical examination or echocardiography for other purposes. Therefore, the treatment of PDA in adults remains controversial.<sup>5</sup> PDA closure by surgical intervention has been the “gold standard” since 1939, especially for a large PDA.<sup>8,9</sup> However, in adults, surgical closure has some challenges and difficulties due to duct calcification, aneurysm, and other related comorbidities such as coronary atherosclerosis and renal diseases. Therefore, transcatheter closure of PDA in adults and adolescents is an alternative to surgery with good results. Wilson et.al (1993) reported effective results of PDA closure in adults and children.<sup>10</sup> Hong et al (2002) reported 36 out of 37 patients (97%) had successful ADO placement.<sup>11</sup>

In our study of 18 patients, 9 were adolescents and 9 were adults; all of them had successful ADO placement. Immediately after the procedures, complete closure was achieved in 14 of 18 patients, whereas the remaining four had minimal or “smoky” residual shunts. However, all of the patients had complete closure after 1 month and 6 months. There were no residual shunts at 6 month follow up. Mean pulmonary artery pressure increased in 7 of 18 patients, of whom all were adults. The PA pressure ranged between 42–63 mmHg was reversible to the administration of 100% oxygen with good results after PDA

closure. Transcatheter closure of PDA in adults with severe pulmonary artery hypertension seemed to be feasible, effective and safe as reported previously.<sup>13</sup>

In general, PDA transcatheter closure has been proven to be effective with excellent results, but there were several reported complications, such as embolization, narrowing of LPA, or aortic obstruction.<sup>12</sup> In general, the complications of transcatheter closure of PDA is very low both in children and adult patients.<sup>14</sup> The occurrence of embolization rate varies from 0% and 3.1%.<sup>12,15</sup> In our study, no device embolization occurred at all, which was probably related to careful case and device selections. There was no other complications observed in this study and the overall successful rate was high. A previous study reported an overall success rate of 98.1% among 69 adults undergoing percutaneous PDA closure.<sup>16</sup>

## CONCLUSION

Our study showed that transcatheter closure of PDA in adolescents and adults is effective and safe with excellent results in short-term follow up. No serious complications such as endocarditis or device embolization in the 6 month follow up. However, a long-term follow up is needed.

## REFERENCES

1. Forsey JT, Elamsry QA, Martin RP. Patent arterial duct. *Orphanet J Rare Dis.* 2009;4:17.
2. Mitchell SC, Korones SB, Berendes HW. Congenital heart disease in 56,109 births. Incidence and natural history. *Circulation.* 1971;43:323-32.
3. Bilkis AA, Alwi M, Hasri S, et al. The amplatzer duct occluder: Experience in 209 patients. *J Am Coll Cardiol.* 2001;37:258-61.
4. Campbell M. Natural history of patent ductus arteriosus. *Br Heart J.* 1968;30:4-13.
5. Inglessis I, Lanndzberg MJ. Interventional catheterization in adult congenital heart disease. *Circulation.* 2007;115:1622-33.
6. Portsmann W, Wierny L, Warnke H, et al. Catheter closure of patent ductus arteriosus: 62 cases treated without thoracotomy. *Radiol Clin North Am.* 1971;9:203-18.
7. Djer MM, Saputro DD, Putra ST, Idris NS. Transcatheter closure of patent ductus arteriosus: 11 years of clinical experiences in Cipto Mangunkusumo Hospital, Jakarta, Indonesia. *Pediatr Cardiol.* 2015;36:1070-4.

8. Fischer G, Stiech J, Uebing A, et al. Transcatheter closure of persistent ductus arteriosus in infants using the Amplatzer duct occluder. *Heart*. 2001;86:444-7.
9. Gross RE, Hubbard JP. Surgical ligation of patent ductus arteriosus. Report first successful case. *JAMA*. 1939;112:729-73.
10. Wilson NJ, Neutze JM, Mawson JB, Calder AL. Transcatheter closure of patent ductus arteriosus in children and adults. *N Z Med J*. 1993;106:299-301.
11. Hong TE, Hellenbrand WE, Hijazi ZM. Transcatheter closure of patent ductus arteriosus in adults using the Amplatzer duct occluder: initial results and follow up. *Indian Heart J*. 2002;54(4):384-9.
12. Jang GY, Son CS, Lee JW, Lee JY, Kim SJ. Complications after transcatheter closure of patent ductus arteriosus. *J Korean Med Sci*. 2007;22:484-90.
13. Zhang CJ, Huang YG, Huang XS, Huang T, Huang WH, Xia CL, Mo YJ. Transcatheter closure of large patent ductus arteriosus with severe pulmonary artery hypertension in adults: immediate and two year follow-up results. *Chin Med J (Engl)*. 2012;125(21):3844-50.
14. Yu ML, Huang XM, Wang JF, Qin YW, Zhao XX, Zheng X. Safety and efficacy of transcatheter closure of large patent ductus arteriosus in adults with self-expandable occluder. *Heart Vessels*. 2009;24:440-5.
15. Azhar AS, Abd El-Aziz AA, Habb HS. Transcatheter closure of patent ductus arteriosus: Evaluating the effect of the learning curve on the outcome. *Ann Pediatr Cardiol*. 2009;2:36-40.
16. Behjati-Ardakani M, Rafiei M, Behjati-Ardakani A, Vafaenasab M, Sarebanhassanabadi M. Long-term results of transcatheter closure of patent ductus arteriosus in adolescents and adults with Amplatzer duct occluder. *North Am J Med Sci*. 2015;7:208-11.