

# Percutaneous Closure of Patent Ductus Arteriosus in Adults Using Different Devices

Ricardo Gamboa, Raúl E. Ríos-Méndez, Francisco P. Mollón, Graciela M. Arroyo, and Diego F. Gutiérrez

Sección de Cardiología Infantil, Hospital Universitario, Fundación Favaloro, Buenos Aires, Argentina

Surgical closure of patent ductus arteriosus in adults involves a number of risks because there are associated anatomic and histologic alterations. Between October 1992 and August 2008, 23 patients were referred to our department with isolated patent ductus arteriosus. Their age ranged from 16-75 years (median 25.5 years) and their weight from 52-80 kg (median 57 kg). The pulmonary diameter ranged from 1.8-5.8 mm (mean 3.5 mm), and pulmonary artery pressure, from 9-72 mmHg (mean 15 mmHg). The rate of ductal occlusion achieved with the Rashkind patent ductus arteriosus occluder was 85.7%, and it was 100% with the Amplatzer duct occluder and the Nit-Occlud coil. The average hospitalization time and follow-up duration were 24 hours and 2 years, respectively. The only immediate complication was an inguinal hematoma, and there were no late complications. In adults, closure of patent ductus arteriosus using a number of different devices, especially the latest generation devices, was safe and effective, regardless of morphologic and histologic characteristics.

**Key words:** Ductus arteriosus. Congenital heart disease. Cardiac catheterization. Adults.

## Cierre percutáneo del ductus con diferentes dispositivos en adultos

El cierre quirúrgico del conducto arterioso en adultos implica riesgos debido a sus cambios anatómicos e histológicos. Desde octubre de 1992 hasta agosto de 2008, fueron referidos a nuestro servicio 23 pacientes con conducto arterioso persistente aislado; edad, 16-75 años (mediana, 25,5); peso, 52-80 kg (mediana, 57); diámetro pulmonar, 1,8-5,8 mm (media, 3,5); presión media en la arteria pulmonar, 9-72 mmHg (media, 15). Las tasas de oclusión fueron del 85,7% con los dispositivos Rashkind-PDA y del 100% con Amplatzer Duct-Occluder y Nit-Occlud coil. Tiempo medio de internación y seguimiento: 24 h y 2 años respectivamente. La única complicación inmediata fue un hematoma inguinal; no hubo complicaciones alejadas. En adultos, el cierre del conducto arterioso con diferentes dispositivos, especialmente los de última generación, resultó seguro y eficaz, independientemente de su morfología y estado histológico.

**Palabras clave:** Ductus arterioso. Cardiopatía congénita. Cateterismo cardíaco. Adultos.

## INTRODUCTION

Surgical repair of patent ductus arteriosus (PDA) in adults is performed by left lateral thoracotomy, but may require a midline sternotomy, extracorporeal circulation, aortic cross-clamping, and other measures, with recovery in an intensive care unit. Surgical risk may be further increased by anatomic and histologic changes in the ductus, including calcification, aneurysm, diverticulum, shortening, and friability<sup>1,2</sup> and, therefore, percutaneous

occlusion as a first-line treatment is a valid option. If left untreated, PDA can foster the development of infective endarteritis, Eisenmenger syndrome, and other conditions, with an annual mortality rate of 1.8%.<sup>3</sup>

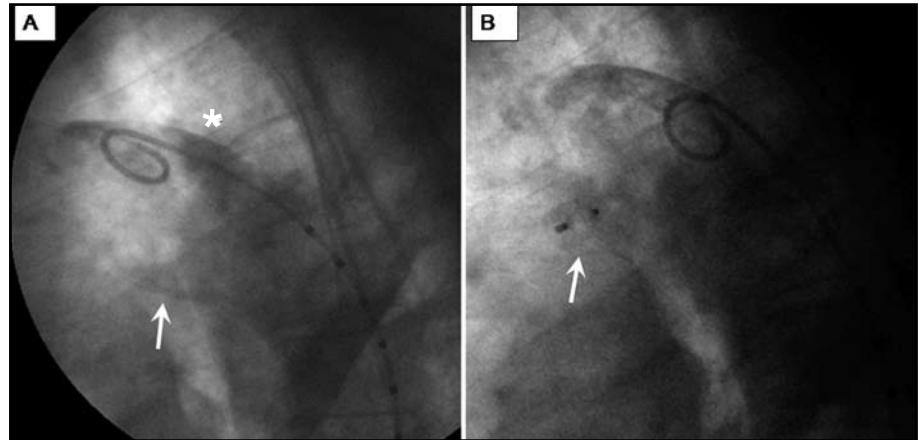
We report our experience with percutaneous treatment of PDA in adults using 3 different types of devices.

## METHODS

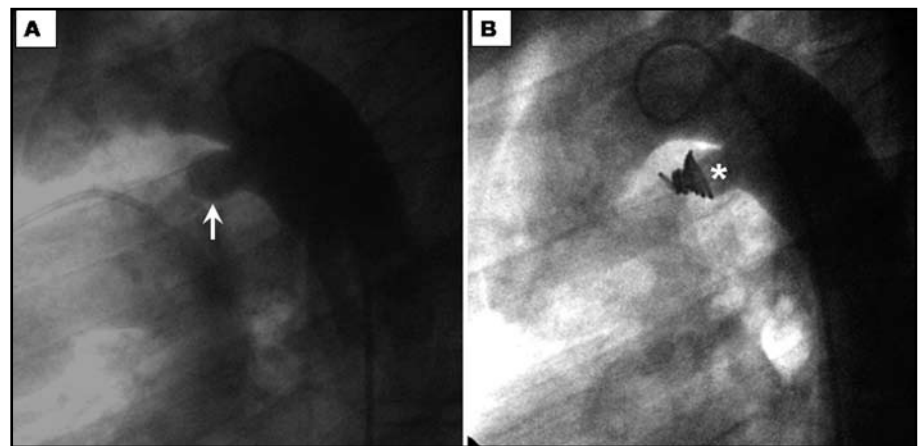
A cross-sectional, retrospective, descriptive study was carried out between October 1992 and August 2008, including 23 patients (17.4% men). All patients were referred to our department for isolated PDA diagnosed by clinical symptoms, echocardiography and, in some cases, catheterization. Median patient age was 24 years (range, 16-75) and median weight was 57 kg (range, 52-80).

Correspondence: Dr. R.E. Ríos-Méndez.  
Avda. Belgrano 1746, piso 5.º. (C1093AAS) Buenos Aires, Argentina.  
E-mail: riosmendez@intramed.net.ar

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**Figure 1.** Ductal occlusion with Amplatzer Duct-Occluder. A: calcified patent ductus arteriosus (arrow) and calcified aortic wall (asterisk). B: Amplatzer Duct-Occluder (arrow).



**Figure 2.** Ductal occlusion with Nit-Occlud coil. Patent ductus arteriosus (arrow) and Nit-Occlud coil (asterisk).

PDA repair was undertaken with the Rashkind-PDA (RAS) umbrella device in 9 patients; the cone-shaped Amplatzer Duct-Occluder (ADO) in 12, and the Nit-Occlud coil (NOc) in 2. All patients were followed up by clinical examination, radiologic study, and echocardiography.

Written informed consent was obtained for participation. In keeping with the protocol for these patients, general anesthesia was administered, introducer sheaths were positioned in the femoral artery and vein, and 5000 U of sodium heparin and intravenous antibiotic prophylaxis were administered. A single device, advanced from the femoral vein, was implanted in all patients. A hemodynamic study was performed, followed by thoracic aortography (right cephalic oblique and/or lateral projection using a 5-French pigtail catheter), in which the aortic and pulmonary artery diameters and the PDA length were measured. RAS devices of 12 and 17 mm were used for PDAs smaller than and larger than 2.5 mm, respectively, the ADO chosen was 2 mm

larger than the smallest ductal diameter, and the NOc was selected using the manufacturer's chart. Ten minutes after implantation, follow-up aortic angiography was performed (Figures 1 and 2).

## RESULTS

The PDA types observed in the study included type A (69.6%), type C (8.7%), type E (17.4%), and filiform (4.3%); 2 had wall calcification. The mean pulmonary artery pressure was 9-72 mmHg (mean, 15 mmHg), and the pulmonary and aortic artery diameters of the PDA were 1.8-5.8 (mean, 3.5) and 9-17 mm (mean, 15 mm), respectively. In the RAS group, occlusion was ruled out in 1 patient who had a mean pulmonary artery pressure of 72 mmHg with negative results in the balloon occlusion and 100% O<sub>2</sub> test. The procedure was successfully completed in 7 of the 8 remaining cases, yielding an intention-to-treat success rate of 87.5%. In the patient with filiform PDA, the procedure failed because the diameter did not allow catheter advancement to implant a coil.

**TABLA 1. Variables Related to the Devices and Occlusion Rate Progression**

	Implant Devices	Diameter, French	Occlusion			Follow-up, y
			Immediate	At 24 Hours	At Month 3	
RAS	7	8-12	57.1%	71.4%	85.7%	0.25-3
ADO	12	6-7	75%	91.6%	100%	0.25-6.5
NOc	2	6	50%	50%	100%	0.25-2.5

ADO indicates Amplatzer-Duct Occluder; NOc, Nit-Occlud coil; RAS, Rashkind-PDA.

In the ADO and NOc groups, implantation was successfully completed in all patients.

Immediate residual shunt was classified as a trace leak if the pulmonary end of the ductus showed slight contrast opacification, mild if the pulmonary artery but not the pulmonary valve was opacified, and moderate if the entire valve was delimited.<sup>4</sup>

In the RAS group, the immediate residual shunt was considered a trace leak in 2 cases and mild in 1; in the ADO group, mild in 2 cases and moderate in 1, and in the NOc group, mild in 1 case. The patients remained in a common ward and were discharged the day after the operation.

Table lists the occlusion rates following implantation of the devices. There were no cases of recanalization in any of the successfully occluded PDAs.<sup>5,6</sup>

Patients were followed up for 0.25 to 6.5 years (median, 2). The only immediate complication reported was inguinal bruising, and there were no late complications.

## DISCUSSION

As in other series,<sup>7,8</sup> our study population is small, in part because the condition is usually diagnosed and treated early in life. The most common PDA in our series was type A in the Krichenko<sup>9</sup> classification, a finding consistent with reports by other authors.

Although PDA should be closed once diagnosed, the management of silent PDA is still controversial. Patients may be referred because PDA was observed on color Doppler ultrasound; however, the angiographic diameter is the determining factor for coil implantation, as in our patients.

The high percentage of immediate residual shunt and low incidence of postprocedure occlusion observed in the RAS group are similar to the findings reported by other authors.<sup>10,11</sup> We stopped using this device in mid-1999 because other devices that have smaller sheaths and are simpler to implant became available, such as the ADO (AGA Medical Corporation, Golden Valley, Minnesota, United States) and the NOc (PFM, Cologne, Germany). We have no experience with the Sideris button

device for ductal occlusion in adults because it is not available in our setting.<sup>12</sup> Nor do we have experience with Gianturco coils because of the higher risk of migration and persistent residual shunt<sup>13</sup> or the Amplatzer Muscular VSD occluder, which has been successfully used in patients with pulmonary hypertension.<sup>14</sup>

As has been reported in other studies,<sup>4,15</sup> we also observed a high percentage of residual shunt in patients receiving the NOc, although the rate of postprocedure occlusion on immediate follow-up was substantially higher. We do not use this device in large PDAs (>4 mm) because of the greater probability of residual shunt or migration, although the manufacturer recommends it for PDAs with a diameter of up to 5 mm. In these cases, we prefer the ADO, which does not have these drawbacks.<sup>16</sup>

At the start of our experience (RAS group), 1 patient presented severe pulmonary hypertension with negative occlusion and hyperoxygenation tests; therefore, ductal closure was considered contraindicated. Nonetheless, current articles on the use of pulmonary vasodilator medication in patients with pulmonary hypertension and congenital heart disease report encouraging results.<sup>17-19</sup>

In our series, percutaneous closure of PDA in adults using several types of devices designed for this purpose, especially late-generation devices, was safe and effective, regardless of the morphologic and histologic characteristics of the defect.

## REFERENCES

1. Toda R, Moriyama Y, Yamashita M, Iguro Y, Matsumoto H, Yotsumoto G. Operation for adult patent ductus arteriosus using cardiopulmonary bypass. *Ann Thorac Surg.* 2000;70:1935-8.
2. Omari BO, Shapiro S, Ginzton L, Milliken JC, Baumgartner FJ. Closure of short, wide patent ductus arteriosus with cardiopulmonary bypass and balloon occlusion. *Ann Thorac Surg.* 1998;66:277-8.
3. García-Montes JA, Zabal-Cerdeira C, Calderón-Colmenero J, Juanico-Enríquez A, Cardona-Garza A, Colín-Ortiz JL, et al. Patent ductus arteriosus in the adult: transcatheter treatment immediate and medium term results. *Arch Cardiol Mex.* 2006;76:163-8.

4. Celiker A, Aypar E, Karagoz T, Dilber, Ceviz N. Transcatheter closure of patent ductus arteriosus with Nit-Occlud coils. *Catheter Cardiovasc Interv.* 2005;65:569-76.
5. Turner DR, Forbes TJ, Epstein ML, Vincent JA. Early reopening and recanalization after successful coil occlusion of the patent ductus arteriosus. *Am Heart J.* 2002;143:889-93.
6. Gildein HP, Mocellin R. Recanalization of Botalli's ductus arteriosus after catheter occlusion with a Rashkind double umbrella device. *Z Kardiol.* 1998;87:38-40.
7. Pas D, Missault L, Hollanders G, Suys B, De Wolf D. Persistent ductus arteriosus in the adult: clinical features and experience with percutaneous closure. *Acta Cardiol.* 2002;57:275-8.
8. Zabal C. Therapeutic catheterization in adults with congenital cardiopathy. *Arch Cardiol Mex.* 2002;72 Suppl 1:233-6.
9. Krichenko A, Benson LN, Burrows P, Moes CAF, McLaughlin P, Freedom RM. Angiographic classification of the isolated, persistently patent ductus arteriosus and implications for percutaneous catheter occlusion. *Am J Cardiol.* 1989;63:877-80.
10. Novo-García E, Bermúdez R, Herraiz I, Salgado A, Balaguer J, Moya JL, et al. Cierre de ductus en adultos mediante dispositivo de Rashkind: resultados comparativos. *Rev Esp Cardiol.* 1999;52:172-80.
11. Harrison DA, Benson LN, Lazzam C, Waters JE, Siu S, McLaughlin PR. Percutaneous catheter closure of the persistently patent ductus arteriosus in the adult. *Am J Cardiol.* 1996;77:1094-7.
12. Rao PS, Kim SH, Rey C, Onorato E, Sideris EB. Results of transvenous buttoned device occlusion of patent ductus arteriosus in adults. International Buttoned Device Trial Group. *Am J Cardiol.* 1998;82:827-9.
13. Wang JK, Liau CS, Huang JJ, Hsu KL, Lo PH, Hung JL, et al. Transcatheter closure of patent ductus arteriosus using Gianturco coils in adolescents and adults. *Catheter Cardiovasc Interv.* 2002;55:513-8.
14. Thanopoulos BD, Tsaousis GS, Djukic M, Al Hakim F, Eleftherakis NG, Simeunovic SD. Transcatheter closure of high pulmonary artery pressure persistent ductus arteriosus with the Amplatzer muscular ventricular septal defect occluder. *Heart.* 2002;87:260-3.
15. Gamboa R, Mollón FP, Rios-Méndez RE, Arroyo GM, Fogel A, Villa DM. Cierre del ductus arterioso permeable con un nuevo tipo de dispositivo: Nit-Occlud. *Rev Esp Cardiol.* 2007;60:445-8.
16. Masura J, Walsh KP, Thanopoulos BD, Chan C, Bass J, Goussous Y, et al. Catheter closure of moderate to large sized PDA using the new Amplatzer duct occluder: immediate and short-term results. *J Am Coll Cardiol.* 1998;3:878-82.
17. Ussia GP, Mule M, Caruso E, Aiello R, Tamburino C. Combined endothelin receptor antagonist and transcatheter interventional therapy of patent ductus arteriosus with severe pulmonary artery hypertension. *Int J Cardiol.* 2007;116:427-9.
18. Agapito AF, Sousa L, Oliveira JA, Feliciano J, Cacwla D, Quininha J. Eisenmenger syndrome in the adult —experience with new drugs for the treatment of pulmonary hypertension. *Rev Port Cardiol.* 2005;24:421-31.
19. Raposo-Sonnenfeld I, Otero-González I, Blanco-Aparicio M, Ferrer-Barba A, Medrano-López C. Tratamiento con sildenafil y/o bosentán en niños y jóvenes con hipertensión arterial pulmonar idiopática y síndrome de Eisenmenger. *Rev Esp Cardiol.* 2007;60:366-72.