

Percutaneous Occlusion of Patent Ductus Arteriosus

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ABSTRACT

Background: Patent ductus arteriosus is a congenital condition with high morbidity, especially in preterm infants of extremely low birth weight, representing 5% to 10% of congenital heart diseases. Our objective was to describe the approaches used at a reference hospital for the percutaneous occlusion of PDA. **Methods:** We conducted a retrospective study on the transcatheter treatment of patent ductus arteriosus from April of 2008 to April of 2010. **Results:** Forty-seven cases were reviewed and most of them (78.8%) were treated with Flipper™ coils while the remaining patients received the Amplatzer™ device. Ductal morphological configuration was Krichenko type A in 89.4% (34 in the Flipper™ coil group and 8 in the Amplatzer™ group), type D in 6.4% (2 in the Flipper™ coil group and 1 in the Amplatzer™ group) and type E in 4.2% (1 in each group) of patients. Pre-catheterization minimum diameters were 2.6 ± 0.8 mm and 3.8 ± 1.6 mm for the Flipper™ coil and Amplatzer™ groups, respectively. Immediate total occlusion of the defect was obtained in the control angiography in 72.3% of the patients. Seven patients treated with the Flipper™ coil received additional coils and two patients treated with the Amplatzer™ device presented minimal residual shunts. There were no procedure-related complications. In the follow-up after hospital discharge, one patient presented minimal residual shunt at the echography, 45 days after catheterization. **Conclusions:** Percutaneous patent ductus arteriosus occlusion has proven to be safe and effective in most cases.

DESCRIPTORS: Ductus arteriosus. Heart defects, congenital. Catheterization. Septal occluder device.

Ductus arteriosus is an essential fetal vascular structure that connects the proximal descending aorta to the pulmonary artery roof, near the origin of the left branch. It has been established that patent ductus arteriosus (PDA), by definition, is the

RESUMO

Oclusão Percutânea da Persistência do Ducto Arterioso

Introdução: A persistência do ducto arterioso é uma condição congênita de alta morbidade, especialmente em recém-nascidos prematuros de extremo baixo peso, representando 5 a 10% das cardiopatias congênitas. Nosso objetivo foi descrever as abordagens realizadas em hospital de referência para o tratamento da persistência do ducto arterioso com o método percutâneo de oclusão. **Métodos:** Foi realizado estudo retrospectivo do tratamento transcatheter da persistência do ducto arterioso no período de abril de 2008 a abril de 2010. **Resultados:** Foram revisados 47 casos, a maioria (78,8%) tratada com molas Flipper®; os demais tratados com a prótese Amplatzer®. A configuração morfológica ductal foi do tipo A de Krichenko em 89,4% (34 no grupo molas Flipper® e 8 no grupo Amplatzer®), tipo D em 6,4% (2 no grupo molas Flipper® e 1 no grupo Amplatzer®) e tipo E em 4,2% (1 em cada grupo) dos pacientes. Os diâmetros mínimos pré-cateterismo foram de $2,6 \pm 0,8$ mm e $3,8 \pm 1,6$ mm para os grupos de molas Flipper® e Amplatzer®, respectivamente. Obteve-se oclusão imediata total do defeito na angiografia de controle em 72,3% dos pacientes tratados. Sete pacientes tratados com molas Flipper® receberam molas adicionais e os tratados com prótese Amplatzer® mostraram apenas *shunts* residuais mínimos em dois casos. Não ocorreram complicações do procedimento. No acompanhamento após a alta, um paciente permaneceu com mínimo *shunt* residual à ecografia, 45 dias após o cateterismo. **Conclusões:** A oclusão da persistência do ducto arterioso por método percutâneo tem se mostrado segura e efetiva na maioria dos casos.

DESCRIPTORIOS: Canal arterial. Cardiopatias congênitas. Cateterismo. Dispositivo para oclusão septal.

persistent patency of the ductus arteriosus after the neonatal period.^{1,2}

PDA is the sixth most common congenital heart defect, accounting for 5% to 10% of cases, excluding

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preterm infants. It is a common and complex problem in preterm newborns, occurring in 60% of children younger than 28 weeks of gestational age.³⁻⁵

In large arteriovenous shunts, increased volume to the pulmonary vascular bed and into the left ventricle causes heart failure, and sudden death can occur, especially in preterm infants. A progressive injury to the pulmonary vascular bed may occur, but it is rarely irreversible in the first year of life.^{4,6}

Preterm infants present a high spontaneous PDA closure rate during the first two years. However, there has been a growing debate about whether to treat this condition in the neonatal period.⁷ Short- and long-term unfavorable outcomes of primary and secondary surgeries have been suggested when compared to patients treated with indomethacin.⁸ The use of prophylactic indomethacin decreased the incidence of PDA, severe periventricular and intraventricular hemorrhage, and early-onset severe pulmonary hemorrhage, but did not improve survival rate without neurological impairment at 18 months in extremely low birth weight newborns.^{9,10}

The indications for intervention in preterm infants, neonates, and underweight infants (< 6 kg) are restricted to the presence of respiratory disorder and/or heart failure due to hyperflow and not compensated by clinical treatment. Reports of percutaneous occlusion are often related to restrictive ductus arteriosus, occluded with small coils.¹¹ However, for children out of the neonatal period, transcatheter PDA occlusion may be an option.¹

This study aimed to describe the approaches conducted in a reference hospital for transcatheter management of PDA with occlusion devices, clinical outcomes, and method-related complications.

METHODS

This was a retrospective, observational, predominantly descriptive, case-series study. The sample consisted of consecutive patients who underwent percutaneous PDA occlusion with embolization devices, from 2008 to 2010, at Instituto de Cardiologia do Rio Grande do Sul – Fundação Universitária de Cardiologia (IC-FUC). This study was approved by the Research Ethics Committee of IC-FUC.

The medical records of patients treated with Flipper® Detachable Coil (Cook Medical Inc. – Bloomington, United States) or the Amplatzer Duct Occluder (AGA – Golden Valley, United States; Figure) were reviewed at the Statistics and Medical Care Service (Serviço de Atendimento Médico e Estatístico – SAME) of IC-FUC. There were no exclusion criteria of the research subjects.

Patients referred to the catheterization laboratory after clinical and echocardiographic diagnosis of PDA were submitted to esophageal manometry. Angiographies

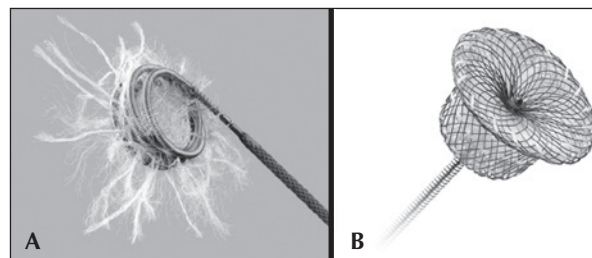


Figure – Devices for patent ductus arteriosus occlusion. (A) Flipper® Detachable Coil; (B) Amplatzer Duct Occluder. Source: Adapted from Haddad et al.¹¹

were performed in the right anterior oblique and profile views, aiming to measure the diameters of the aortic ampulla and pulmonary extremity of the defect. After prosthesis implantation, an aortography was performed to control any residual shunt. Successful prosthesis implantation was defined as absence of residual shunt immediately after device placement.

The collected variables were allocated in databases corresponding to: age, gender, weight, ductal morphology, type of prosthesis, residual shunt, and procedure-related complications. Data collection was performed by only one of the researchers, to prevent disparity. Results were expressed as absolute and relative frequencies of the sample. Quantitative variables are described as means and standard deviations. For age and weight variables, arithmetical mean, dispersion, and median were used.

RESULTS

A retrospective review of 47 percutaneous occlusions of ductus arteriosus showed that 78.8% were treated with detachable release coil (Flipper® springs) and the remaining were treated with the Amplatzer duct occluder device (Table).

The patients were a heterogeneous group in terms of age at the time of catheterization; however, preterm patients and neonates were not treated. The mean age was 103.2 (9-597) months and 183.8 (10-640) months for the groups who underwent occlusion with Flipper® and Amplatzer coils, respectively. In terms of absolute distribution, regardless of the devices, the median was 51 months.

The mean weight of patients undergoing the procedure with Flipper® coil was 28.1 kg (7-77 kg); in the Amplatzer occluder group, the mean weight was 38.1 kg (8.1 to 80 kg). In total, the mean weight was 36.9, with a median of 21 kg.

In 35 (74.5%) cases, there were no concomitant abnormalities at PDA diagnosis; however, seven (14.9%) patients showed associated congenital lesions and four (8.5%) had syndromic disorders. Only one patient with syndromic diagnosis had congenital heart disease associated with PDA, corresponding to an atrioventricular

TABLE
Clinical, angiographic, and procedure characteristics

Characteristics	Flipper® coil (n = 37)	Amplatzer® (n = 10)
Age, months	103.2 (9-597)	183.8 (10-640)
Male gender, n (%)	20 (54.1)	6 (60)
Weight, kg	28.1 (7-77)	38.1 (8.1-80)
Ductus arteriosus morphology, n (%)		
Type A	34 (91.9)	8 (80.0)
Type D	2 (5.4)	1 (10.0)
Type E	1 (2.7)	1 (10.0)
Minimum ductal diameter at the echocardiogram	2.6 ± 0.8	3.8 ± 1.6
Minimum ductal diameter on catheterization	1.4 ± 0.5	2.0 ± 1.0
Successful prosthesis implantation, n (%)	26 (70.2)	8 (80)
Immediate residual shunt, n (%)	11 (29.7)	2 (20)
Jet type	5	1
"bubble cloud" type*	6	1
Patients requiring additional coil implantation, n (%)	7 (18.9)	0 (0)
Shunting after new coils, n (%)	4 (10.8)*	0 (0)
Late shunting at the ultrasound, n (%)	1 (8.1) [†]	0 (0)
Complications, n (%)	0 (0)	0 (0)

* "Bubble cloud" shunting. [†] Minimal residual left-right shunt.

septal defect in one patient with trisomy 21 (Down syndrome). The associated congenital cardiovascular disorders involved pulmonary valve stenosis, patent foramen ovale, atrioventricular septal defect, congenital atrioventricular block, ostium secundum atrial septal defect, and ventricular septal defect. Only one case showed minimal association of muscular trabecular VSD, small ostium secundum ASD, and congenital atrioventricular block from a mother diagnosed with systemic lupus erythematosus.

Some patients had been previously treated with surgical ligation and others, with correction of associated heart defects. Three cases resulted from postoperative surgical ligation and another from pulmonary valvuloplasty with infundibulectomy and anomalous muscle band resection. Among the patients with PDA occlusion after correction procedures for congenital disorders, one occurred after pulmonary balloon valvuloplasty and another after total correction of atrioventricular septal defect.

Ductal morphological configuration assessed according to Krichenko classification was predominant for type A, which represented 89.4% of cases (42 patients; 34

in the Flipper® coil group and eight in the Amplatzer group); type D, 6.4% (3 patients, 2 in the Flipper® coil group and 1 in the Amplatzer group); and type E, 4.2% (2 patients, 1 in each group).

The mean of the smallest ductus arteriosus diameter, predominantly in the pulmonary extremity, measured at the pre-catheterization ultrasound, was 2.6 ± 0.8 mm in patients with Flipper® coil occlusion, and 3.8 ± 1.6 mm in patients with Amplatzer occlusion. The total mean of the minimum diameter, corresponding to all treated patients, was 2.8 ± 1.1 mm. On angiography, the mean of the smallest diameter was 1.4 ± 0.5 and 2.0 ± 1.0 mm, respectively, for the Flipper® and Amplatzer groups.

Of the 37 patients treated with Flipper® coils, five had jet-type residual shunt and six persisted with bubble cloud at the control aortography. Seven of these patients were treated with nine additional coils due to problems in device placement or to residual flow. Among these, bubble cloud residual flow was observed in four procedures. The procedures with Amplatzer duct occluder presented only minimal intraprosthesis residual shunts immediately after the release in two cases, one with a bubble cloud type and the other with a jet-type shunt.

At follow-up after discharge, one patient persisted with left-to-right minimal residual shunt, detected at the ultrasonography 45 days after catheterization. There were no complications during the study period, such as acute arterial occlusion, embolization, hemolysis, congestive heart failure, acute pulmonary edema, or bronchopneumonia.

DISCUSSION

In the present study, transcatheter occlusion of PDA with Amplatzer® device and Flipper® coils achieved an immediate success rate of 72.3%, observed in eight of ten patients treated with the Amplatzer® prosthesis and 26 of 37 patients treated with Flipper® coils, corroborating the percentage data found by Choi et al.¹² At the follow-up with echocardiographic examinations, only one patient persisted with minimal residual flow.¹³ The minimum diameter calculations at the pre-catheterization ultrasound resulted in 2.6 ± 0.8 mm and 3.8 ± 1.6 mm for the patients using Flipper® coils and Amplatzer duct occluder, respectively, confirming the indication for use of the Amplatzer device in ducts with a diameter > 2.5 mm. After occlusion, there were no severe complications resulting from the percutaneous treatment, and only minor technical problems were observed during the procedure, such as failure in releasing the device, inability to pass the catheter due to vaso-catheter disproportion, failure in prosthesis anchoring and bilateral vasospasm.

Traditional treatment options for preterm newborns with PDA are non-steroidal anti-inflammatory agents, surgical ligation, or clip. There are not enough data

related to benefits between surgery or indomethacin for symptomatic preterm infants with PDA. Surgical procedures involving thoracotomy (ductus ligation) are associated with increased risk of chronic pulmonary disease, retinopathy of prematurity and neurosensory impairment. This fact may be associated with the delayed surgical procedure and/or with perioperative care, as this population is susceptible to such risks.^{14,15}

Despite the advances in interventional techniques for occlusion of PDA, the occlusion of large ducts in young children remains a challenge. The occlusion by coils is only effective in small- to moderate-sized ducts, even if multiple coils are used.^{16,17} With better technical adaptations, occlusion by coils in selected symptomatic preterm newborns has been possible, as an alternative to surgical ligation.¹⁴

The perspectives show that types B and C ductus arteriosus (according to Kritchenko et al.¹⁸ classification) and larger diameters are predictors of failure in prosthesis implantation. When the devices are appropriately indicated, the success levels are > 90%.¹⁹

The transcatheter occlusion of large persistent ductus arteriosus using Amplatzer prosthesis has shown to be highly effective procedure in large series. However, the device implantation is a problem in children weighing < 5 kg. The main concern regarding morbidity is obstruction of the descending aorta and the left pulmonary artery. The pressure gradient must be constantly monitored in the catheterization lab, as marginal retention, in some cases, can cause aortic narrowing.²⁰ The complete occlusion of very large PDA very recently became possible, even in low-weight newborns, using an angular customized device in order to prevent the protrusion into the aorta, or a modified version of the Amplatzer® device.²¹

When analyzing the experience with device innovations, a 98% rate of complete defect occlusion has been observed, with low rates of major complications during the procedure or in the short-term follow-up.²²

CONCLUSIONS

The percutaneous occlusion of persistent ductus arteriosus has been shown to be safe and effective in most cases. The main complications are being overcome by technical innovations and occlusion devices that adapt to the ductal anatomy design. Clinical features and attention to specific technical details are essential for procedural success.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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None declared.

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