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Article

Retrograde percutaneous closure of patent ductus arteriosus experience at the 20 de Noviembre National Medical Center

Experiencia de cierre percutáneo de conducto arterioso persistente vía retrógrada en el Hospital Centro Médico Nacional 20 de Noviembre

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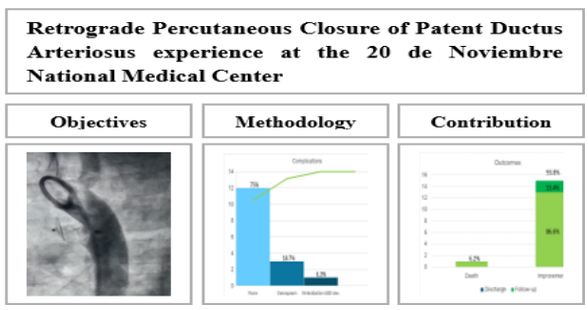
Abstract

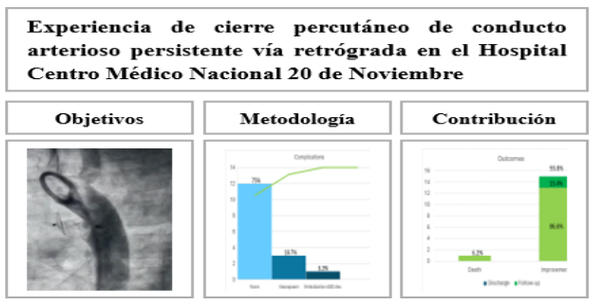
Patent ductus arteriosus (PDA) accounts for 5–10% of all congenital heart diseases. This study describes the experience with retrograde percutaneous closure of PDA in the Pediatric Cardiology Department at the Centro Médico Nacional 20 de Noviembre between 2015 and 2024. A retrospective cross-sectional study was conducted in 16 pediatric patients (mean age: 5.06 ± 4.4 years; weight: 22.2 ± 18.0 kg), 62.5% of whom presented with malnutrition and hemodynamic compromise. Retrograde closure was indicated due to small pulmonary artery end (56.2%), inability to cannulate the PDA (31.2%), and vascular anomalies such as interrupted inferior vena cava and aortic coarctation. Various devices were used, mainly ADO II and Coil. Minor complications (18.7%) and clinical improvement (93.8%) were observed. The study concludes that retrograde access is an effective alternative for PDA closure in patients with complex anatomy or when antegrade access is technically unfeasible.



Patent Ductus Arteriosus, Pulmonary End, Amplatzer Ductus Occluder II

Resumen

El conducto arterioso persistente (CAP) representa entre el 5 y 10% de las cardiopatías congénitas. Este estudio describe la experiencia del cierre percutáneo retrógrado de CAP en el servicio de Cardiología Pediátrica del Centro Médico Nacional 20 de Noviembre entre 2015 y 2024. Se realizó un estudio transversal y retrolectivo en 16 pacientes pediátricos (edad media: 5.06 ± 4.4 años; peso: 22.2 ± 18.0 kg), de los cuales el 62.5% presentaba desnutrición y repercusión hemodinámica. El cierre retrógrado fue indicado por tamaño reducido de la boca pulmonar (56.2%), imposibilidad de canulación (31.2%), y anomalías vasculares como interrupción de la VCI y coartación de aorta. Se utilizaron diversos dispositivos (ADO II y Coil, principalmente). Se reportaron complicaciones menores (18.7%) y una mejoría clínica en el 93.8% de los casos. Se concluye que el abordaje retrógrado es una alternativa efectiva ante anatomías complejas o limitaciones técnicas del acceso anterógrado.



Conducto Arterioso Persistente, Boca Pulmonar, Amplatzer Ductus Occluder II

Area: Advocacy and attention to national problems

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Introduction

The ductus arteriosus is a vital fetal vascular structure that connects the left pulmonary artery to the descending aorta. Persistence beyond three months of age defines a patent ductus arteriosus (PDA), with an estimated incidence of 1 in 2,000 live births (Allen, 2022), (Díaz Góngora, 2018). PDA accounts for 5% to 10% of all congenital heart defects and is more frequently observed at altitudes above 2,500 meters and in preterm infants, affecting 30% to 32% of those born after 32 weeks' gestation, 77% to 83% between 28 and 30 weeks, and up to 90% of those born before 28 weeks or weighing less than 1,200 grams (Attie, 2013), (Carey, 2003), (Park, 2021).

Echocardiography remains the first-line diagnostic tool, offering a comprehensive assessment of ductal anatomy, encompassing its size, configuration, and classification, while also providing critical insight into its hemodynamic consequences (Singh, 2020), (van Laere, 2018). Percutaneous closure is the treatment of choice, most commonly performed via an anterograde (venous) approach (Allen, 2022), (Attie, 2013), (Campanhã, 2012). A retrograde (arterial) approach is less frequently used but offers several potential advantages, including shorter procedure time and reduced radiation exposure (Dalby, 2024), (Damien K., 2012).

Although existing literature has compared anterograde and retrograde techniques in terms of procedural time, radiation exposure, and complications, few studies have addressed the clinical indications for choosing the retrograde approach. This study aims to describe and unify criteria for retrograde percutaneous PDA closure, with the goal of informing clinical decision-making and contributing to current evidence.

Given the high prevalence of PDA and the risk of serious long-term complications if left untreated including endarteritis, heart failure, pulmonary hypertension, Eisenmenger syndrome, and increased long-term mortality, timely diagnosis and appropriate intervention are essential (Díaz Góngora, 2018).

Methodology

A retrospective cross-sectional study was conducted involving pediatric patients who underwent retrograde percutaneous closure of PDA at the National Medical Center 20 de Noviembre between 2015 and 2024. Patients ranged in age from under 6 months to 15 years. Descriptive statistical analysis was performed using SPSS (Statistical Package for the Social Sciences).

Quantitative data were reported using measures of central tendency and dispersion (mean and standard deviation or median and percentiles), according to data distribution. Qualitative variables were presented as frequencies and percentages, based on the results of the Kolmogorov-Smirnov normality test. Graphs and tables were generated to illustrate findings according to the type of variables analyzed.

In the medical literature, approximately 15% of patients undergo percutaneous closure via the retrograde (arterial) approach. Assuming a similar proportion in the study population and using a sample size formula for proportions with a 95% confidence level, a study population of 16 patients was required.

$N=Z2 \cdot p \cdot q / e2$, where $Z = 1.96$, $p = 30\%$ and $e = 10\%$

Results

A total of 190 patients diagnosed with PDA were identified in the SIAH system (Sistema de Información de Autorizaciones Hospitalarias). Of these, 174 patients (91.5%) were excluded due to anterograde closure attempts, unsuccessful PDA closure, or diagnostic catheterizations. Twenty-five patients (13.1%) underwent retrograde PDA closure; however, 9 were further excluded because 5 records were unavailable in the system and 4 lacked video documentation, resulting in a final cohort of 16 patients (8.4%).

Data were collected from the SIAH system on 16 patients who underwent percutaneous retrograde PDA closure between 2015 and 2024. Ten patients (62.5%) were female and 6 (37.5%) were male, with a mean age of 5.06 ± 4.4 years.

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The mean weight was 22.2 ± 18.0 kg, and the mean height was 102.7 ± 33.9 cm. Functional class assessment revealed that 13 patients (81.2%) were classified as New York Heart Association (NYHA) functional class I/VI, and 3 patients (18.8%) as class II/VI. Physical appearance at inspection was recorded as gracile in 6 patients (37.5%), mesomorphic in 9 (56.3%), and endomorphic in 1 (6.2%).

Hemodynamic impact variables included heart rate, with a mean of 108.2 ± 19.0 beats per minute. Nutritional status assessment showed 10 patients (62.5%) were malnourished, while 6 (37.5%) were not.

Precordial palpation characteristics were defined as hyperdynamic in 9 patients (56.3%) and normodynamic in 7 patients (43.8%). Murmur characteristics were continuous in 8 patients (50%), systolic in 3 (18.8%), and absent in 5 (31.2%). Echocardiographic assessment revealed hemodynamic repercussion in 10 patients (62.5%), and no repercussion in 6 (37.5%).

Associated lesions requiring additional interventions alongside PDA closure were identified: 10 patients (62.5%) had no associated lesions, 3 (18.8%) had atrial septal defects (ASD), 2 (12.5%) had ventricular septal defects (VSD), and 1 (6.2%) had aortic coarctation (CoAo).

Angiographic classification of PDA types showed type A in 14 patients (87.5%) and type E in 2 patients (12.5%). The mean diameter of small PDAs was 1.7 ± 0.7 mm in 14 patients, whereas moderate-sized PDAs averaged 5.2 ± 1.4 mm in 2 patients.

Devices utilized for closure included ADO I in 1 patient (6.2%), ADO II in 6 patients (37.6%), Cera in 1 patient (6.2%), Coil in 6 patients (37.6%), Occlutech in 1 patient (6.2%), and Piccolo in 1 patient (6.2%) (Box 1).

Box 1

Table 1
Population characteristics

Variable	N	Min	Max	Mean ± SD
Age (years)	16	1	15	5.06 ± 4.4
Sex-n (%)				
Female	10 (62.5%)			
Male	6 (37.5%)			
Weight (kg)	16	2.3	65.2	22.2 ± 18.0
Height (cm)	16	48	168	102.7 ± 33.9
Heart rate (bpm)	16	80	140	108.2 ± 19.0
Functional class-n (%)				
I/VI	13 (81.2%)			
II/VI	3 (18.8%)			
Nutritional status-n (%)				
Undernourished	10 (62.5%)			
Well-nourished	6 (37.5%)			
Inspection-n (%)				
Ectomorphic	6 (37.5%)			
Mesomorphic	9 (56.3%)			
Endomorphic	1 (6.2%)			
Palpation-n (%)				
Hyperdynamic	9 (56.3%)			
Normodynamic	7 (43.8%)			
Auscultation-n (%) Murmur				
Continuous	8 (50%)			
Systolic	3 (18.8%)			
No murmur	5 (31.2%)			
Murmur grade-n (%)				
Grade I/VI	1 (6.3%)			
Grade II/VI	4 (25%)			
Grade III/VI	6 (37.5%)			
No murmur	5 (31.2%)			
Hemodynamic repercussion-n (%)				
Present	10 (62.5%)			
Absent	6 (37.5%)			
Associated lesions-n (%)				
ASD	3 (18.8%)			
CoAo	1 (6.2%)			
VSD	2 (12.5%)			
No Lesions	10 (62.5%)			
Ductal size (mm)				
Small (n=14)	14	0.5	2.8	1.7 ± 0.7
Moderate (n=2)	2	4.2	6.3	5.2 ± 1.4
Device type-n (%)				
ADO I	1 (6.2%)			
ADO II	6 (37.6%)			
Cera	1 (6.2%)			
Coil	6 (37.6%)			
Occlutech	1 (6.2%)			
Piccolo	1 (6.2%)			

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The characteristics of the pulmonary end (PE) and aortic end (AE) of the ductus arteriosus in patients undergoing retrograde percutaneous closure of a PDA were analyzed to identify the indications that led to this approach.

It was found that 3 patients (18.7%) had a PE diameter ≤1 mm, 7 patients (43.7%) had a PE diameter >1 mm and ≤2 mm, 4 patients (25%) had a PE diameter >2 mm and <3 mm, 1 patient (6.3%) had a PE diameter of 4.2 mm, and 1 patient (6.3%) had a PE diameter of 6.3 mm (Box 2, Figure 1).

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Box 2

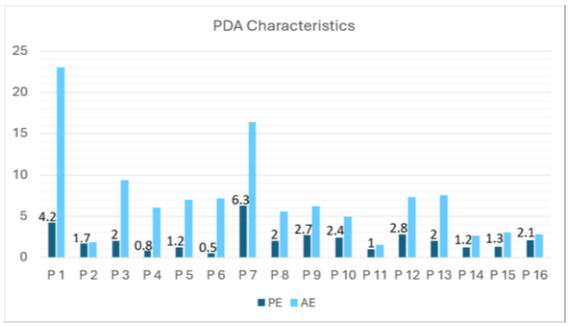

Figure 1
PDA Characteristics
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Based on these measurements, the ductus was classified as small in 14 patients (87.5%) and moderate in 2 patients (12.5%) (Box 3, Figure 2).

Box 3

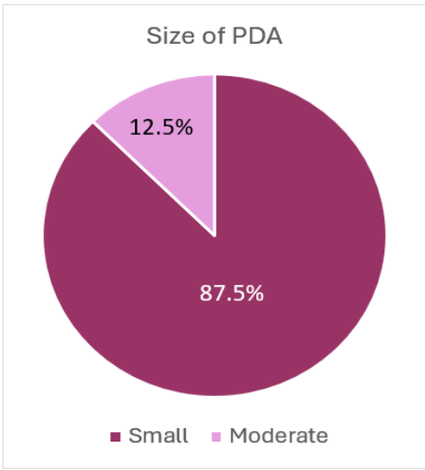

Figure 2
Definition according to the size of the PDA
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The indications leading to the decision for retrograde closure of the PDA were analyzed. Among the identified causes, 1 patient (6.3%) had an interrupted inferior vena cava (IVC), 1 patient (6.3%) had CoAo, 5 patients (31.2%) had failed attempts at anterograde cannulation of the PDA, and in 9 patients (56.2%) the decision was based on the size of the PE as defined by angiographic measurements (Box 4, Figure 3).

Box 4

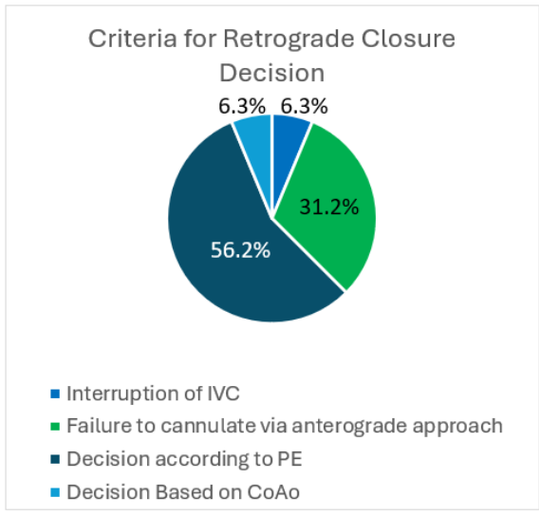

Figure 3
Criteria for Retrograde Closure Decision
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The devices used for retrograde percutaneous closure of PDA were as follows (Box 5, Figure 4): ADO I in 1 patient (6.2%), ADO II in 6 patients (37.6%) (Box 6, Figure 5), Cera in 1 patient (6.2%), Coil in 6 patients (37.6%) (Box 7, Figure 6), Occlutech in 1 patient (6.2%), and Piccolo in 1 patient (6.2%).

Box 5

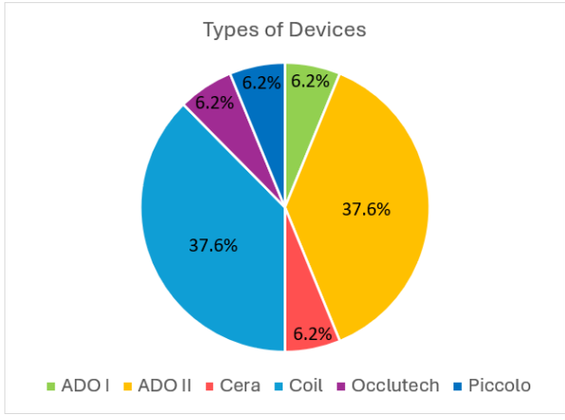

Figure 4
Types of Devices
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Box 6

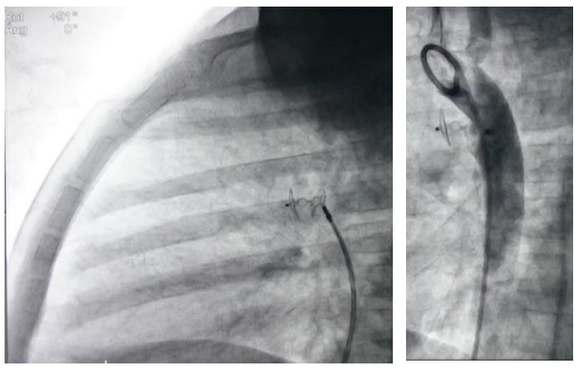

Figure 5
ADO II
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Box 7

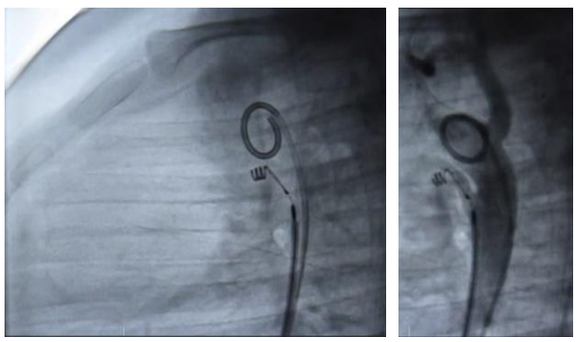

Figure 6
Coil
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The reported complications included vasospasm in 3 patients (18.7%), embolization of an ASD device in 1 patient (6.3%), and no complications in 12 patients (75%) (Box 8, Figure 7).

Box 8

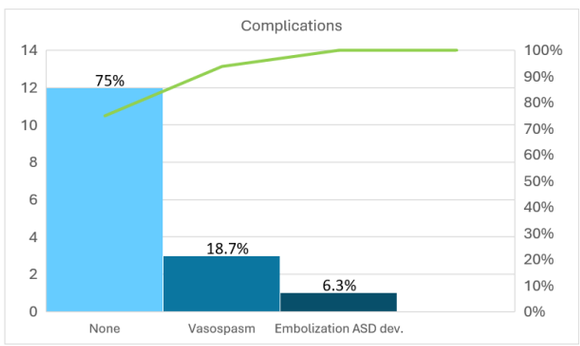

Figure 6
Complications of Retrograde Percutaneous Closure
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There was one reported death (6.2%), unrelated to the cardiac procedure, due to aplastic anemia one year after retrograde percutaneous PDA closure. The remaining 15 patients (93.8%) showed improvement in functional class, weight and height gain, preserved biventricular function, and absence of upper respiratory tract infections.

Of these, 13 patients (86.6%) were discharged at one-year follow-up, while 2 patients (13.4%) remain under ongoing follow-up (Box 9, Figure 7).

Box 9

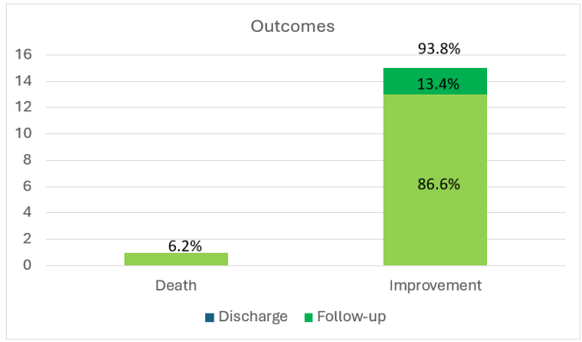

Figure 7
Outcomes of Patients Undergoing Retrograde Percutaneous Closure of PDA
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Discussions

Patent ductus arteriosus (PDA) is among the most common congenital heart defects in Mexico (Attie, 2013). Among the various treatment options, percutaneous closure has become the preferred approach since the first successful attempt by Porstmann in 1967, particularly following advances in closure techniques and the development of new occlusion devices. This method has proven effective across all age groups, from preterm neonates to adults (Campanhã, 2012), (Dalby, 2024).

Percutaneous closure can be performed using an anterograde or retrograde approach; however, literature lacks clear and specific indications for retrograde closure. Our results are consistent with both contemporary and historical literature, supporting that retrograde percutaneous closure is safe and associated with a lower complication rate. In this study, we aimed to identify and group both definitive and probable indications for the retrograde percutaneous approach.

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In our cohort, the mean age was 5.06 ± 4.4 years, with a predominance of female patients (62.5%, n = 10) like the reports by (Sarmento J., 2021), (Sathanandam S., 2020), (Ye Z., 2020), and (Gruenstein D., 2017).

The PDAs treated with retrograde percutaneous closure had a mean minimal pulmonary end (PE) diameter of 1.7 ± 0.7 mm, ranging from 0.5 mm to 6.3 mm. PDAs were classified as small in 87.5% of patients (0.5 to 2.8 mm) and moderate in 12.5% (4.2 and 6.3 mm). These findings are consistent with previous literature: (Zaoui N., 2023) and (Zhou Z., 2022) affirm that retrograde closure is feasible and appropriate for PDAs <3 mm; (Gruenstein D., 2017) described retrograde closure in 64 patients, primarily with small to moderate PDAs (<3 mm). (Sudhakar, 2018) reported the necessity of retrograde closure following surgical ligation of PDA with residual shunting and distortion, where anterograde access was limited, aiming to prevent infective endarteritis. Although Coil devices are typically recommended for PDAs <2.5 mm, he successfully closed a 4.5 mm PDA. In our study, Coils were used for PDAs with PE diameters from 1.0 to 2.8 mm.

Similarly (Campanhã, 2012), described retrograde percutaneous closure in PDAs measuring less than 3 mm. (Zaoui N., 2023) reported successful Coil closure in all their cases, comparable to our population, where 37.6% underwent retrograde Coil closure.

(Ye Z., 2020) performed retrograde closure in 32 patients using transthoracic echocardiography alone, avoiding angiography and radiation.

Unlike their study, which included only patients weighing >10 kg and with PDAs between 2–5 mm, our study included 3 patients weighing <10 kg (2.265 kg, 4.980 kg, and 9.7 kg), and successful closure was achieved with PE diameters as small as 0.5 mm, with a mean of 1.7 ± 0.7 mm.

(Zanjani K., 2017) reported retrograde closure in 43 patients, with PE diameters ranging from 0.4 to 2.8 mm and use of Coil devices, consistent with our findings. (Mahmoud H., 2016) reported on 95 patients with PDA sizes of 2.3 ± 0.6 mm and 2.2 ± 0.5 mm, treated with the ADO II device, achieving a 98.2% success rate.

In our cohort, ADO II was used in 37.6% of patients, with 100% success. They recommend using ADO II in patients >6 kg, consistent with our cohort, except for one patient (4.980 kg), who had no post-procedure complications. (Damien K., 2012) demonstrated safety of the ADO II in newborn piglets weighing 2.3–2.5 kg and later applied it in human infants as small as 1.7 kg. Their mean PDA size was 2.2 ± 0.7 mm. (Gruenstein D., 2017) also noted that ADO II was designed specifically for retrograde closure, aligning with our study population.

Although our study did not report abdominal aorta diameter, (Zhou Z., 2022) recommend that an abdominal aortic diameter >10 mm is desirable for safe ADO II delivery, minimizing the risk of severe arterial injury. They also affirm that elongated or tortuous PDAs (Krichenko type E) can be closed via the retrograde route like two of our patients (12.5%).

The Piccolo device was used in one patient weighing 2.265 kg, in line with Food and Drug Administration (FDA) approval (2019) for use in preterm infants ≥700 g, as reported by (Kavurt A., 2023). Most PDAs in our study (87.5%) were small, except in two cases (12.5%): one with an associated aortic coarctation (CoAo) and a PE diameter of 6.3 mm, closed during aortic balloon angioplasty with a 5/7 Occlutech device; and another with absent IVC, where a 4.2 mm PDA was successfully closed with a 12/10 Cera device.

Most patients (75%) had no complications. The most common was transient vasospasm in 3 patients (18.7%), resolved with Jones compression bandage and pentoxifylline. One patient (6.3%) had an unrelated complication embolization of an ASD closure device, which was retrieved without further issues. Literature describes complications such as device embolization, branch pulmonary artery or aortic obstruction, device infection, hemolysis, residual shunting, femoral AV fistula, hematoma, pseudoaneurysm (Sarmento J., 2021), (Sathanandam S., 2020), (Gruenstein D., 2017), (Zhou Z., 2022), (Kavurt A., 2023), (Zahn E., 2016), (Shah J., 2020). These complications were not observed in our study. Like (Gruenstein D., 2017), (Damien K., 2012), and (Shah J., 2020), vasospasm was identified as a rare, transient, and easily managed complication of retrograde closure.

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(Sivakumar K., 2007) reported a case of abnormal IVC drainage to the portal vein, preventing anterograde Access comparable to our case of absent IVC, which required retrograde closure. (Shah J., 2020) also reported failed anterograde closure due to IVC anomalies, comparable to our findings.

In agreement with the literature, 93.8% of our patients showed clinical improvement, including weight gain, and 86.6% were discharged. The strengths of our study lie in its exclusive focus on retrograde percutaneous PDA closure, with detailed sociodemographic data, PDA characteristics, and specific indications for the chosen approach, allowing us to address the primary objective.

Limitations include the absence of some planned variables, particularly the length of the PDA, which was not consistently reported via echocardiography or angiography despite being a criterion for retrograde closure in some literature. Future studies in our population should include these measurements to further refine the indications for retrograde percutaneous closure.

Conclusions

At the National Medical Center 20 de Noviembre, we routinely perform percutaneous closure of PDA, with retrograde closure being used less frequently and only in specific, well-defined clinical scenarios.

The most common ductal morphology was Krichenko type A, observed in 14 patients (87.5%), with PE diameters ranging from 0.5 to 6.3 mm. The mean diameter for small PDAs was 1.7 ± 0.7 mm, and 5.2 ± 1.4 mm for moderate PDAs.

We propose the following as definitive indications for the retrograde approach: PE diameter <3 mm, Krichenko type E tubular ducts, absence of the IVC, IVC-related malformations (e.g., anomalous venous drainage), and failed anterograde PDA cannulation.

Probable indications include the presence of aortic coarctation (CoA), to avoid multiple vascular punctures and reduce procedural time; residual postoperative shunts with distorted ductal anatomy; and body weight >2.0 kg and when the diameter of the abdominal aorta is >10 mm.

The devices that can be effectively used for retrograde percutaneous PDA closure include ADO I, ADO II, Coil, and Piccolo, particularly under the clinical conditions outlined above.

Retrograde percutaneous PDA closure is a safe and feasible procedure for patients of all ages. In our study cohort, the mean age was 5.06 ± 4.4 years, and all patients weighed more than 2.0 kg. The complication rate was low.

Most patients experienced no adverse events. The most frequent complication was transient arterial vasospasm, which resolved with local compression using a Jones bandage and pharmacologic therapy with pentoxifylline.

A total of 93.8% of patients showed improvement in functional class, weight gain, and height. At one-year follow-up, 86.6% were discharged from care, while 2 patients (13.4%) remained under clinical follow-up.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Fokine, Anna, Salgado, Antonio García: Contributed to the project idea, research method and technique.

Fokine, Anna: Was responsible for data collection, database management, statistical analysis, and contributed to the interpretation of the findings.

All authors critically reviewed the manuscript, contributed their comments, and subsequently approved the final version, affirming its authenticity and integrity.

Availability of data and materials

Indicate the availability of the data obtained in this research.

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Abbreviations

ADO I	Amplatzer Ductus Occluder I
ADO II	Amplatzer Ductus Occluder II
AE	Aortic End
ASD	Atrial Septal Defect
AVP II	Amplatzer Vascular Plug II
CoAo	Aortic Coarctation
FDA	Food and Drug Administration
Fr	French
IVC	Inferior Vena Cava
PDA	Patent Ductus Arteriosus
PE	Pulmonary End
SIAH	Sistema de Información de Autorizaciones Hospitalarias
SPSS	Statistical Package for the Social Sciences
VSD	Ventricular Septal Defect

References

Background

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