DOI: 10.4274/anatoljmed.2025.06025
Anatol J Gen Med Res 2026;36(1):29-36

CLINICAL RESEARCH / KLİNİK ARAŞTIRMA

ANATOLIAN JOURNAL of GENERAL MEDICAL RESEARCH

Transcatheter Closure of Patent Ductus Arteriosus with Detachable Flipper Cook Coil: Single-center Experience

Pediatrik Hasta Grubunda Flipper Cook Coil ile Patent Duktus Arteriyozusun Transkateter Yöntemle Kapatılması: Tek Merkezli Deneyimi

Şeyma Şebnem Ön, Eser Doğan, Fırat Ergin, Mehmet Baki Beyter, Gülçin Kayan Kaşıkçı, Meral Yılmaz, Burcu Büşra Acar, Burcugül Karasulu Beci, Hakan Kurt, Zülal Ülger Tutar, Reşit Ertürk Levent

Ege University Faculty of Medicine, Department of Pediatric Cardiology, İzmir, Türkiye

Cite as: Ön ŞŞ, Doğan E, Ergin F, et al. Transcatheter closure of patent ductus arteriosus with detachable flipper cook coil: single-center experience. Anatol J Gen Med Res. 2026;36(1):29-36

Abstract

Objective: We evaluated the safety and effectiveness of the Flipper detachable Cook coil for transcatheter closure of small-to-medium-sized patent ductus arteriosus (PDA) in a large single-center cohort with long-term follow-up.

Methods: This retrospective study included consecutive patients who underwent PDA closure with a Flipper detachable Cook coil between 2004 and 2022. Indications for closure followed contemporary guidelines. Demographics, PDA morphology (Krichenko classification), procedural details, complications, and echocardiographic outcomes were recorded. Although cut-off values vary in the literature, for clarity in the present study, we considered PDAs <4 mm in diameter as small and ≥4 mm as large.

Results: A total of 201 patients were included (42.3% male). Mean age was 56.5±49.6 months and median weight was 15 kg (interquartile range: 11-23.5). Most PDAs were small (<4 mm; 69.7%), and type A morphology predominated (63.2%). Procedural success was achieved in 196/201 patients (97.5%). Complications were infrequent: coil embolization occurred in 4/201 (2.0%) and cardiac tamponade in 1/201 (0.5%). Residual shunt was detected in 2/201 (1.0%) on early echocardiography, with complete occlusion documented by ≤6 months in all cases. Mean echocardiographic follow-up was 121.8±49.4 months (~10.2 years).

Conclusion: Transcatheter closure of small-to-medium-sized PDA using the Flipper detachable Cook coil is safe and effective, with high procedural success and durable long-term outcomes in appropriately selected patients.

Keywords: Child, patent ductus arteriosus, Flipper detachable Cook coil, transcatheter occlusion

Öz

Amaç: Küçük ve orta boy patent duktus arteriyozus (PDA) kapatılmasında Flipper Cook coil kullanımının güvenliğini ve etkinliğini, uzun dönem takipli geniş bir tek merkez kohortunda değerlendirmeyi amaçladık.

Yöntem: Bu retrospektif çalışmaya, 2004-2022 yılları arasında Flipper Cook coil ile PDA kapatılan ardışık hastalar dahil edildi. Kapatma endikasyonları güncel kılavuzlara göre belirlendi. Demografik özellikler, PDA morfolojisi (Krichenko sınıflaması), işlem ayrıntıları, komplikasyonlar ve ekokardiyografik sonuçlar kaydedildi. Bulgular hem tüm grup hem de PDA boyutuna göre (<4 mm ve ≥ 4 mm) raporlandı.

Address for Correspondence/Yazışma Adresi: Şeyma Şebnem Ön, MD, Ege University Faculty of Medicine, Department of Pediatric Cardiology, İzmir, Türkiye
E-mail: dr.sebnem.on@gmail.com
ORCID ID: orcid.org/0000-0002-1352-7958

Received/Geliş tarihi: 20.12.2024
Accepted/Kabul tarihi: 01.10.2025
Published date/Yayınlanma tarihi: 30.04.2026

Öz

Bulgular: Çalışmaya toplam 201 hasta dahil edildi (%42,3 erkek). Ortalama yaş 56,5±49,6 ay, medyan vücut ağırlığı 15 kg (çeyrekler arası aralık 11-23,5) idi. Hastaların çoğunda PDA küçüktü (<4 mm; %69,7) ve en sık görülen morfoloji tip A idi (%63,2). İşlemsel başarı 196/201 hastada (%97,5) sağlandı. Komplikasyon oranı düşüktü: 4 hastada (%2,0) coil embolizasyonu, 1 hastada (%0,5) kardiyak tamponad görüldü. İki hastada (%1,0) erken dönemde rezidüel şant saptandı ve tümü 6 ay içinde spontan olarak kapandı. Ortalama ekokardiyografik takip süresi 121,8±49,4 ay (yaklaşık 10,2 yıl) idi.

Sonuç: Küçük ve orta boy PDA'ların Flipper Cook coil ile transkateter kapatılması, uygun seçilmiş hastalarda yüksek başarı oranı ve düşük komplikasyon riskiyle güvenli ve etkili bir yöntemdir.

Anahtar Kelimeler: Çocuk, patent duktus arteriyozus, Flipper Cook coil, transkateter kapatma

Introduction

Patent ductus arteriosus (PDA) is one of the most common congenital heart lesions and has been the focus of continuous therapeutic innovation. The first transcatheter attempt at angiographic PDA closure was reported in 1967 by Porstmann et al.[1], who used an Ivalon plug. In subsequent decades, several devices were introduced, including the Rashkind umbrella in 1979 and coil systems in the early 1990s; these devices enabled safe and effective closure of small-to-medium-sized ducts[2]. In 1998, the introduction of the Amplatzer duct occluder further expanded the transcatheter approach to larger PDAs, making catheter-based closure the treatment of choice in most patients[3-6].

Among transcatheter techniques, detachable coils are still widely used, particularly in patients with favorable anatomy[4-7]; moreover, although cut-off values vary across the literature, in the present study we defined PDAs <4 mm in diameter as small and those ≥4 mm as large.

Flipper detachable Cook coils offer specific advantages over earlier coil systems because they can be repositioned prior to detachment, improving procedural safety and accuracy[8-11]. While many studies have confirmed the feasibility of coil closure, most reports are limited by small sample sizes or short follow-up periods.

Our institution has employed detachable coils for PDA closure since 2004, with systematic echocardiographic follow-up. This study presents our single-center experience with 201 patients over an almost 20-year period, providing one of the largest cohorts and the longest reported follow-up to date. We describe procedural success, complications, and long-term outcomes and discuss these findings in the context of the existing literature.

Materials and Methods

Study Design and Population

We conducted a retrospective analysis of consecutive patients who underwent the transcatheter closure of PDA using a Flipper detachable Cook coil at the Pediatric Cardiology Department of Ege University between January 2004 and December 2022. The study was approved by the Ege University Institutional Ethics Committee (approval no: 24-3T/74, date: 07.03.2024) and written informed consent was obtained from the parents or legal guardians of all patients.

Inclusion and Exclusion Criteria

Indications for PDA closure were based on the American Heart Association Guidelines (1998 and 2011)[12,13]. Eligible patients included those with evidence of left heart volume overload (left atrial or ventricular enlargement on echocardiography), a continuous murmur, and/or significant ductal flow demonstrated by color and continuous-wave Doppler, even in the absence of an audible murmur.

Patients with associated congenital heart defects requiring surgical or interventional treatment were excluded. Specifically, cases with atrial septal defect, ventricular septal defect, tetralogy of Fallot, or significant valvular disease were not included. Patients with chronic comorbidities (such as chronic lung disease, severe systemic illness, or genetic syndromes) were also excluded.

Age and Weight Distribution

To clarify the demographic profile, patients were analyzed both as a single cohort and in strata defined by 5-year enrollment periods (2004-2008, 2009-2013, 2014-2018, and 2019-2022). This allowed the assessment of possible

temporal changes in patients' age and weight at the time of the procedure.

Flipper Detachable Coils

The coil occlusion technique has been utilized across various anatomical sites since its introduction in 1972[14-20]. The pioneering closure of PDA using Gianturco coils in 1992 marked a significant advancement in the field. The principle of embolization with coils involves selecting a coil whose loop diameter is larger than the PDA diameter. Upon deployment, the loops on each side of the PDA (at the pulmonary and aortic ends) secure the coil in place through its inherent spring effect. Over time, the coil fibers promote clot formation, effectively obstructing flow through the PDA. Subsequently, the coil and clot become endothelialized, contributing to the permanent closure of the PDA[16-18].

Flipper coils are made of stainless-steel spring wires that are coated with tetrafluoroethylene and lined along their entire length with synthetic Dacron fibers[18-20]. They are first deployed and then detached (unscrewed) from the delivery wire. This allows the coil to be retrieved if the delivery position is unsatisfactory. This is different from the classical Gianturco coils, which are pushed out of a delivery catheter by a coil pusher wire and, once deployed, cannot be retrieved except by a snare. Therefore, they are considered non-detachable.

Coils are available in various sizes, with the most commonly used sizes being 3x3, 3x4, 3x5, 5x3, 5x4, 5x5, 6.5x3, 6.5x4, and 6.5x5. In these measurements, the first number represents the coil loop diameter in millimeters, and the second number represents the number of loops in the coil. Larger sizes (8x3, 8x4, 8x5) are also available but are not commonly used. The selected coil diameter should be twice the diameter of the PDA at its narrowest point. The number of loops chosen depends on the size of the ductal ampulla at the aortic end-the deeper the ampulla, the more loops that can be packed into it.

PDA Closure Protocol

The procedure for PDA closure was performed under sedation in all patients. Following local anesthesia, arterial sheaths were placed in some patients and venous sheaths in others, both using a percutaneous technique. Patients were administered 50 I.U./kg of heparin. The anatomy and diameter of the PDA were determined by injecting contrast material with the patient initially in the 90° left lateral position, using appropriate catheters. If optimal images could not be obtained, injections were made in the 30-40° right-oblique+10-30° cranial positions. The PDA was classified angiographically according to the criteria defined by Krichenko et al.[14]. The preferred coil diameter should be 1.5-2 times that of the narrowest portion of the PDA. Closure is performed using transvenous and transarterial approaches. Before releasing the device, the device location and the presence of residual shunt were assessed by injection of contrast material in all patients (Figure 1.1 and Figure 1.2). The device was repositioned when necessary.

Post-procedural Care and Follow-up

After the procedure, all patients were admitted for overnight observation. Clinical assessment, chest X-ray, and echocardiography were performed before discharge. Follow-up echocardiography was conducted at 24 hours, 1 month, 6 months, 1 year, and annually thereafter. Residual shunt, left pulmonary artery stenosis, and aortic obstruction were specifically assessed. The mean follow-up duration was 121.8±49.4 months.

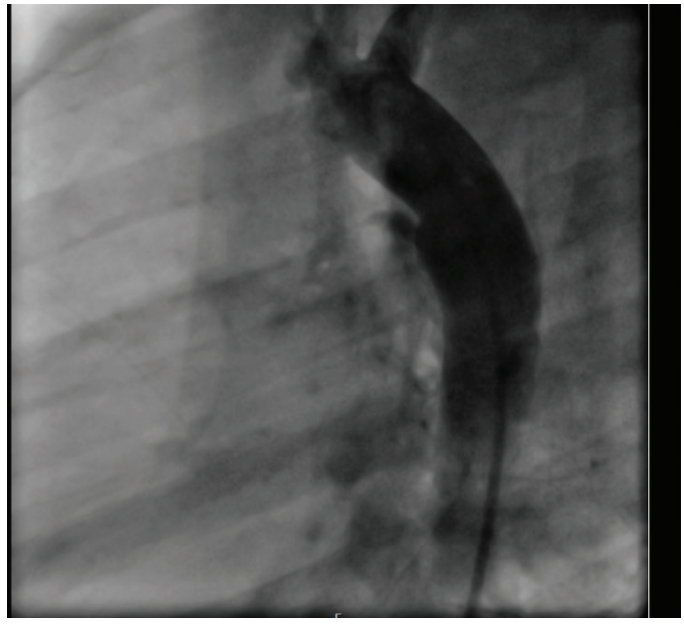

Figure 1.1. Angiographic visualization of PDA closed transcatheter with Cook coil device-detection of PDA with contrast medium before cook coil application

PDA: Patent ductus arteriosus

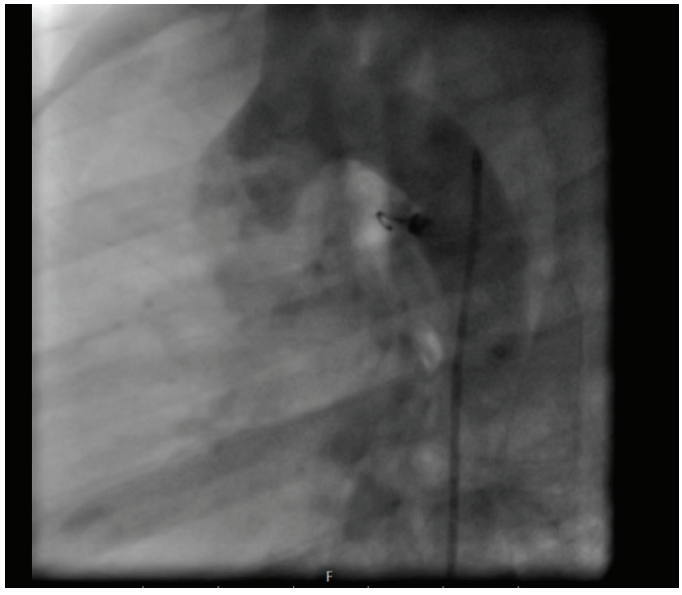

Figure 1.2. Control of the PDA occluded with Flipper detachable Cook coil with contrast medium

PDA: Patent ductus arteriosus

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Chicago, IL, USA). Categorical variables are presented as numbers and percentages. Continuous variables with normal distribution are reported as mean ± standard deviation (SD), and non-normally distributed variables as median with interquartile range (IQR). Comparative analyses were conducted between small (<4 mm) and large (≥ 4 mm) PDAs, as well as between type A and type E duct morphologies. Chi-square or Fisher's exact test was applied to categorical variables, student's t-test or Mann-Whitney U test was applied to continuous variables, and logistic regression was used to explore predictors of procedural success and complications. A p-value <0.05 was considered statistically significant.

Statistics

SPSS 22.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. In the analysis, categorical variables are presented as numbers and percentages. Normally distributed continuous variables were expressed as mean ± SD), and non-normally distributed variables were expressed as median and IQR.

Results

A total of 201 patients underwent attempted PDA closure with a Flipper detachable Cook coil. Of these, 85 (42.3%) were male and 116 (57.7%) were female. The mean age at the time of intervention was 56.5±49.6 months, and the median weight was 15 kg (IQR: 11-23.5). Patient age and weight at intervention were stable across the two decades, but subgroup analysis by 5-year enrollment periods showed a trend toward younger patients in the later years of the study.

PDA Size and Morphology

The median ductal diameter was 2 mm (IQR: 2-3). Based on size, 140 patients (69.7%) had a small PDA (<4 mm) and 61 (30.3%) had a large PDA (≥4 mm). Angiographic classification, according to the Krichenko criteria, revealed type A morphology in 127 (63.2%) patients, type E in 24 (11.9%), type C in 14 (7.0%), and types B, D, and F in 2 patients each (1.0% per type).

Procedural Success and Complications

Successful closure was achieved in 196 patients, yielding an overall success rate of 97.5%. In 192 (95.5%) patients, the coil was delivered via the arterial route, while 9 (4.5%) required a venous approach. The procedure failed in 5 patients (2.5%), all of whom were subsequently referred for alternative device closure.

Complications were rare. Coil embolization occurred in 4 patients (2.0%): one in the main pulmonary artery, two in the right pulmonary artery, and one in the descending aorta. Three were retrieved percutaneously, while one required surgical removal. One patient (0.5%) developed cardiac tamponade during the procedure, requiring urgent surgical intervention. Importantly, there were no deaths.

Residual Shunt and Follow-up Outcomes

Immediately after the procedure, trivial residual shunts were detected in 2 patients (1.0%). Both closed spontaneously within 6 months. At long-term echocardiographic follow-up (mean: 121.8±49.4 months, range: 29-230 months), complete closure was confirmed in all patients, and no cases of recanalization, hemolysis, endocarditis, pulmonary artery stenosis, or aortic obstruction were observed.

Subgroup Analyses

• **Small vs. Large PDA:** Procedural success was slightly higher in small PDAs (98.6% vs. 95.1%), though the difference was not statistically significant (p>0.05). Complications occurred more frequently in medium-sized ducts (4.9% vs. 1.4%), largely due to embolization.

• **Morphology (type A vs. type E):** Type A PDAs demonstrated higher closure rates and fewer complications than type E, although differences did not reach statistical significance.

Table 1. Patients demographic and angiographic datas

Patients demographic	And angiographic data
Gender	
Male	85 (%57.7)
Woman	116 (%42.3)
Age (month)	Mean 56.5 months (SD: 49.6)
Weight (kg)	Median 15 (IQR: 11-23.5)
Narrowest diameter of the duct (mm)	Median 2 mm (IQR: 2-3)
Moderate PDA (>2.5 mm PDA)	61 (%30.3)
Small PDA (≤2.5 mm PDA)	140 (%69.7)
Ductus shapes	
Type A	127 (%63.2)
Type B	2 (%1)
Type C	14 (%7)
Type D	2 (%1)
Type E	54 (%26.8)
Type F	2 (%1)
Ductus closure method	
Transarterial route	192 (% 95.5)
Transvenous route	9 (% 4.5)

SD: Standard deviation, IQR: Interquartile range, PDA: Patent ductus arteriosus

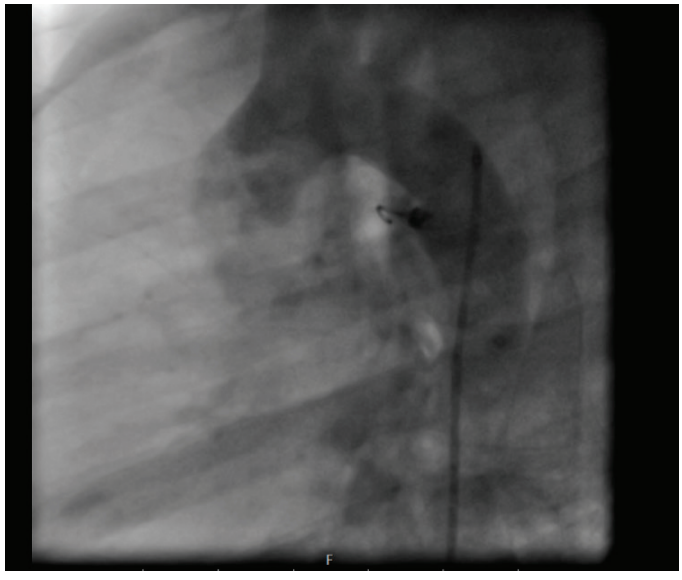

Figure 2. Schematization of success rates of patients undergoing coil closure and management of complications

Type A ductus was found in 127 patients (63.2%), type B in 2 (1%), type C in 14 (7%), type D in 2 (1%), type E in 24 (26.8%), and type F in 2 (1%) (Table 1). PDA was successfully closed with a coil in 196 patients. The duct was classified based on angiographic visualization. Type A ductus was found in 127 patients (63.2%), type B in 2 patients (1%), type C in 14 patients (7%), type D in 2 patients (1%), type E in 24 patients (26.8%), and type F in 2 patients (1%) (Table 1). PDA was successfully closed with a coil in 196 patients.

In 5 (2.48%) cases, the procedure was unsuccessful. Patients were followed up with echocardiography for an average of 121.8 months (SD±49.4). Only two patients had a residual shunt. Both of these patients experienced spontaneous closure during subsequent follow-ups.

The PDA was closed via the arterial route in 192 patients (95.5%) and via the venous route in 9 patients (4.5%). In our study, the procedure was unsuccessful in 5 cases (2.48%). Embolization occurred in four patients (1.9%). The coil embolized to the main pulmonary artery in one patient, to the right pulmonary artery in two patients, and to the aorta in another patient. The patient in whom the device embolized to the aorta was referred for cardiovascular surgery, and the coil was surgically removed. The embolized coils in the other three patients were removed using a transcatheter procedure. One patient (0.5%) developed tamponade during the procedure and required urgent intervention by the cardiovascular surgery team (Figure 2). Leakage was observed in two patients (1%) after closure of the PDA with a coil. In these patients, the ductus diameters were 3 mm and 4 mm, and the ductus lengths were 4 mm and 5 mm; all patients had type A ductus. The patients were monitored for any residual shunt, and none of them experienced complications such as hemolysis, infection, or thrombosis. Long-term follow-up also revealed no complications, such as ductus recanalization or stenosis of the pulmonary artery or aorta, in patients with complete occlusion.

Discussion

Transcatheter closure of PDA using detachable coils has been a well-established technique since the early 1990s[18-24].

Numerous studies have demonstrated its feasibility, safety, and cost-effectiveness, particularly in patients with small-to-medium ducts. However, most reports are limited by relatively small sample sizes and short follow-up durations. Our study, encompassing 201 patients with a mean follow-up of more than 10 years, represents one of the largest and longest single-center experiences with Flipper detachable Cook coils to date.

Clinical Outcomes and Procedural Success

Our overall procedural success rate of 97.5% aligns with previously published data, which reported coil closure success rates ranging from 89% to 100%. Similar to prior reports[20-26], we observed that complications were infrequent and that no mortality occurred. The durability of occlusion was excellent: residual shunt was documented in only 1% of patients during early echocardiography and resolved spontaneously in all cases within 6 months. Long-term follow-up confirmed sustained closure without recanalization, hemolysis, or device-related vascular obstruction.

Complications and Preventive Strategies

Device embolization remains the most frequent complication of coil closure, with reported rates varying between 0% and 6.5%[24-28]. In our series, embolization occurred in 2.0% of patients, typically in medium-sized ducts with a wider morphology. This finding reinforces the importance of careful coil sizing and angiographic assessment before release. The detachable feature of the Flipper coil likely contributed to our low embolization rate, as repositioning was possible in cases of suboptimal placement. One patient developed tamponade that required prompt surgical intervention and subsequently achieved a full recovery. These outcomes highlight that while complications are rare, procedural vigilance and immediate surgical backup remain essential.

Age, Weight, and Temporal Trends

The mean patient age in our cohort (56.5 months) is comparable to some reports in the literature[14-27], though higher than in other reports. This may reflect referral patterns over the nearly two-decade study period, as younger infants were increasingly treated in later years. Subgroup analysis across 5-year enrollment periods confirmed a trend toward earlier intervention in more recent years, consistent with global shifts in practice. The median weight (15 kg) also aligns with previous series, underscoring that coil closure can be safely performed in children across a broad weight range, provided the anatomy is suitable.

Morphology and Predictors of Outcome

As in prior reports, type A ducts were most common in our cohort (63.2%), followed by type E[21-29]. Success rates were slightly higher in type A than in type E, although the differences were not statistically significant. This suggests that ductal morphology remains an important consideration when selecting patients for coil closure, with elongated ducts (type E) presenting greater technical challenges.

Comparison with Other Devices

While detachable coils remain a reliable option for small-to-medium PDAs, newer occluder devices (e.g., Amplatzer duct occluder I and II) have gained favor for larger or more complex ducts[14,28-37]. Comparative studies suggest that occluders offer higher success rates and fewer reinterventions in such cases, though at greater cost[30-32]. Our study did not include direct comparisons with occluders, which is acknowledged as a limitation. Nevertheless, our long-term results confirm that coil closure remains an excellent therapeutic option in appropriately selected patients.

Contribution to the Literature

Recent publications (Ugan Atik and Saltık[17]; Adams et al.[21]; Narayan et al.[37] have emphasized the safety of PDA closure with both coils and occluders, but follow-up durations rarely exceed 3-5 years. Our cohort, with a mean follow-up of over 10 years, provides robust evidence that coil closure yields durable long-term outcomes without late complications. This finding strengthens the role of the Flipper Cook coil as a cost-effective and safe device for small-to-medium-sized PDAs, particularly in resource-limited settings.

Study Limitations

This study has several limitations that should be acknowledged. First, its retrospective and single-center design inherently limits the generalizability of the findings. Although the sample size was large, the absence of randomization introduces potential selection bias. Second, while the long-term follow-up was a major strength, we did not directly compare the Flipper Cook coil with other closure devices, such as the Amplatzer occluder family. As newer devices were increasingly used for larger and more complex PDAs, the relative advantages and disadvantages of

coils versus occluders could not be assessed in this cohort. Third, our patient population was restricted to patients with anatomically suitable PDAs, which may have contributed to the high procedural success rate and low complication rate. Despite meticulous echocardiographic follow-up, subclinical complications such as minimal vascular obstruction may have been underdetected. Future multicenter prospective studies comparing devices are warranted to confirm and extend our results.

Conclusion

Our long-term follow-up data demonstrate that transcatheter closure of small-to-medium-sized PDA with the Flipper detachable Cook coil is safe and effective, characterized by high procedural success and a very low complication rate. Complete occlusion was achieved in nearly all patients, and outcomes remained durable over more than a decade of follow-up. These findings support the continued use of this method as a reliable and cost-effective therapeutic option in appropriately selected patients.

Ethics

Ethics Committee Approval: The study was approved by the Ege University Institutional Ethics Committee (approval no: 24-3T/74, date: 07.03.2024).

Informed Consent: Written informed consent was obtained from the parents or legal guardians of all patients.

Footnotes

Authorship Contributions

Surgical and Medical Practises: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Concept: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Design: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Data Collection or Processing: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Analysis or Interpretation: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Literature Search: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L., Writing: Ş.Ş.Ö., E.D., F.E., M.B.B., G.K.K., M.Y., B.B.A., B.K.B., H.K., Z.Ü.T., R.E.L.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Porstmann W, Wierny L, Warnke H. Closure of persistent ductus arteriosus without thoracotomy. Ger Med Mon. 1967;12:259-61.
2. Rashkind WJ, Cuaso CC. Transcatheter closure of a patent ductus arteriosus: successful use in a 3.5 kg infant. Pediatr Cardiol. 1979;1:3-7.
3. Rashkind WJ, Mullins CE, Hellenbrand WE, Tait MA. Nonsurgical closure of patent ductus arteriosus: clinical application of the Rashkind PDA occluder system. Circulation. 1987;75:583-92.
4. Cambier PA, Kirby WC, Wortham DC, Moore JW. Percutaneous closure of the small (less than 2.5 mm) patent ductus arteriosus using coil embolization. Am J Cardiol. 1992;69:815-6.
5. Galal MO. Advantages and disadvantages of coils for transcatheter closure of patent ductus arteriosus. J Interv Cardiol. 2003;16:157-63.
6. Masura J, Walsh KP, Thanopoulous B, et al. Catheter closure of moderate- to large-sized patent ductus arteriosus using the new Amplatzer duct occluder: immediate and short-term results. J Am Coll Cardiol. 1998;31:878-82.
7. Rao PS, Balfour IC, Chen S. Effectiveness of five-loop coils to occlude patent ductus arteriosus. Am J Cardiol. 1997;80:1498-501.
8. Alwi M, Kang LM, Samion H, Latiff HA, Kandavel G, Zambahari R. Transcatheter occlusion of native persistent ductus arteriosus using conventional Gianturco coils. Am J Cardiol. 1997;79:1430-2.
9. Tomita H, Fuse S, Akagi T, et al. Coil occlusion for patent ductus arteriosus in Japan. Jpn Circ J. 1997;61:997-1003.
10. Furuyama H, Nakanishi T, Kondou C, et al. Transcatheter closure of patent ductus arteriosus using 0.052 Gianturco coils. Acta Cardiologica Paediatrica Japonica. 2000;16:751-61.
11. Tomita H, Takamuro M, Fuse S, et al. Coil occlusion of patent ductus arteriosus. Circ J. 2006;70:28-30.
12. Allen HD, Beekman RH 3rd, Garson A Jr, et al. Pediatric therapeutic cardiac catheterization: a statement for healthcare professionals from the Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 1998;97:609-25.
13. Feltes TF, Bacha E, Beekman RH 3rd, et al. Indications for cardiac catheterization and intervention in pediatric cardiac disease: a scientific statement from the American Heart Association. Circulation. 2011;123:2607-52.
14. Krichenko A, Benson LN, Burrows P, Möes CA, 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.
15. Aydoğan U, Dindar A, Cantez T, et al. Transcatheter closure of the ductus arteriosus in children and young adults. Turk J Pediatr. 1995;37:103-9.
16. Patel HT, Cao QL, Rhodes J, Hijazi ZM. Long-term outcome of transcatheter coil closure of small to large patent ductus arteriosus. Catheter Cardiovasc Interv. 1999;47:457-61.
17. Ugan Atik S, Saltık İL. Transcatheter coil occlusion of patent ductus arteriosus and follow-up results. Turk Kardiyol Dern Ars. 2019;47:265-72.
18. Galal MO, Bulbul Z, Kakadekar A, et al. Comparison between the safety profile and clinical results of the Cook detachable and Gianturco coils for transcatheter closure of patent ductus arteriosus in 272 patients. J Interv Cardiol. 2001;14:169-77.
19. Takata H, Higaki T, Sugiyama H, et al. Long-term outcome of coil occlusion in patients with patent ductus arteriosus. Circ J. 2011;75:407-12.

20. Grech V, Degiovanni J. Flipper coil closure of patent ductus arteriosus. Images Paediatr Cardiol. 2007;9:1-15.
21. Adams PE, Chersich MF, Cilliers A. Transcatheter closure of the patent ductus arteriosus at a public sector hospital in Soweto, South Africa: a review of patient outcomes over 15 years. Cardiovasc J Afr. 2018;29:246-51.
22. Podnar T, Gavora P, Masura J. Percutaneous closure of patent ductus arteriosus: complementary use of detachable Cook coils and Amplatzer duct occluders. Eur J Pediatr. 2000;159:293-6.
23. Faella HJ, Hijazi ZM. Closure of the patent ductus arteriosus with the amplatzer PDA device: immediate results of the international clinical trial. Catheter Cardiovasc Interv. 2000;51:50-4.
24. Galal O, de Moor M, Fadley F, et al. Problems encountered during introduction of Gianturco coils for transcatheter occlusion of the patent arterial duct. Eur Heart J. 1997;18:625-30.
25. Erdem A, Demir F, Sarıtaş T, et al. Results of patent ductus arteriosus closure during adulthood using different devices. Turk Gogus Kalp Damar Cerrahisi Derg. 2011;19:413-8.
26. Podnar T, Masura J. Transcatheter occlusion of residual patent ductus arteriosus after surgical ligation. Pediatr Cardiol. 1999;20:126-30.
27. Sørensen KE, Kristensen B, Hansen OK. Frequency of occurrence of residual ductal flow after surgical ligation by color-flow mapping. Am J Cardiol. 1991;67:653-4.
28. Zucker N, Qureshi SA, Baker EJ, Deverall PB, Tynan M. Residual patency of the arterial duct subsequent to surgical ligation. Cardiol Young. 1993;5:216-9.
29. Magee AG, Huggon IC, Seed PT, Qureshi SA, Tynan M; Association for European Cardiology. Transcatheter coil occlusion of the arterial duct; results of the European Registry. Eur Heart J. 2001;22:1817-21.
30. Akagi T, Mizumoto Y, Iemura M, et al. Catheter closure of moderate to large sized patent ductus arteriosus using the simultaneous double or triple coil technique. Pediatr Int. 2001;43:536-41.
31. Willcoxson FE, Viswanathan S, Thomson JD, Gibbs JL. Transcatheter closure of the arterial duct without arterial access. Cardiol Young. 2010;20:39-43.
32. Tynan M, Huggon I, Rosenthal E, Qureshi S, Baker E. Coil occlusion of the arterial duct. J Interv Cardiol. 1999;12:73-7.
33. Kapoor A, Radhakrishnan S, Shrivastava S. Severe intravascular haemolysis following coil occlusion of patent ductus arteriosus. Indian Heart J. 1996;48:173-4.
34. Pérez Rodríguez MJ, Quero Jiménez MC, Herraiz Sarachaga I, Gallego Cobos N, González Dieguez C, Quero Jiménez M. Intravascular hemolysis following percutaneous occlusion of the ductus arteriosus. Rev Esp Cardiol. 1999;52:449-50.
35. Lee C, Hsieh K, Huang T, Choong C. Spontaneous resolution of hemolysis after partial coil occlusion of ductus arteriosus. Pediatr Cardiol. 1999;20:371-2.
36. Demir T, Oztunç F, Cetin G, et al. Patency or recanalization of the arterial duct after surgical double ligation and transfixion. Cardiol Young. 2007;17:48-50.
37. Narayan SA, Elmahdi E, Rosenthal E, et al. Long-term follow-up is not indicated after routine interventional closure of persistent arterial ducts. Catheter Cardiovasc Interv. 2015;86:100-4.