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Original Article

Transcatheter atrial septal defect closure in children weighing ≤15 kg: A single-center experience

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ABSTRACT

Objective: The aim of this study was to assess the feasibility, safety, and outcomes of transcatheter atrial septal defect (ASD) closure in children weighing ≤15 kg, a group in whom transcatheter intervention is often deferred due to limited evidence and perceived procedural risks.

Materials and Methods: This retrospective single-center study included 34 children weighing ≤15 kg who underwent transcatheter ASD closure. Demographic, echocardiographic, procedural, and post-procedural follow-up data were analyzed.

Results: The mean age was 4.14±1.16 years, and the mean ASD diameter on transthoracic echocardiography was 10.41± 2.96 mm. The median balloon-sized ASD diameter was 14.30 mm (IQR: 12–17). All procedures were performed using Amplatzer Septal Occluder devices, with a 100% procedural success rate. The mean pulmonary artery pressure was 19.50±5.01 mmHg, and median pulmonary vascular resistance was 0.97 Wood units (0.44-1.20). A transient episode of supraventricular tachycardia occurred in one patient (2.94%), with no device embolization or other major complications observed. In most patients, right ventricular dimensions normalized and no residual shunt was observed by the first postoperative day.

Conclusion: Transcatheter ASD closure in carefully selected children weighing ≤15 kg appears to be a safe and effective procedure, achieving high procedural success and low complication rates comparable to those observed in heavier patients. Early right ventricular remodeling and the absence of major adverse events further support the feasibility of this approach in appropriately selected cases.

Keywords: Atrial septal defect, body weight, cardiac catheterization, child

Introduction

Transcatheter closure of atrial septal defects (ASD) was first introduced in 1974 and has since become the preferred treatment modality over surgical repair in appropriately selected patients (1). Current guidelines, however, generally do not recommend transcatheter ASD closure in children weighing less than 15 kg due to the limited body of evidence and concerns regarding higher complication rates in this subgroup (2). In line with these concerns, both a large multicenter French study and a multicenter Swedish study have reported relatively frequent complications in children weighing under 15 kg (3, 4). Consequently, published studies focusing on transcatheter ASD closure in infants and small children remain scarce. The present study aimed to present our institutional experience with transcatheter ASD closure in patients weighing less than 15 kg, evaluating both procedural outcomes—including technical success, complication rates, and residual shunt—and outpatient follow-up findings, such as changes in right ventricular size, pulmonary artery pressure, and electrocardiographic abnormalities.

Materials and Methods

This retrospective, single-center study was conducted at a Ankara Bilkent City Hospital. Medical records of patients weighing less than 15 kg who underwent transcatheter ASD closure between January 2022 and August 2025 were

reviewed. All procedures were performed under general anesthesia with transthoracic echocardiographic guidance, and in selected cases, transesophageal echocardiography was additionally utilized. Pre-procedural echocardiography, electrocardiography (ECG), catheterization reports, and post-procedural echocardiographic and ECG findings were systematically collected and analyzed.

Statistical analysis

The data obtained in the study were evaluated using descriptive statistics. Continuous variables were presented as mean and standard deviation (SD) if normally distributed, and as median (minimum–maximum or interquartile range [IQR]) if not normally distributed. Categorical variables were expressed as numbers and percentages. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 147 patients underwent transcatheter ASD closure during the study period, of whom 34 weighed ≤15 kg. The mean age was 4.14±1.16 years, and the median weight was 14.25 kg (range: 12–15). Of the cohort, 15 were male and 19 were female. The primary indications for transcatheter ASD closure were failure to thrive in 15 patients, recurrent respiratory tract infections in five patients, and a history of transient ischemic attack (TIA) in one patient, as summarized in Table I. The remaining patients were older than four years of age and weighed close to 15 kilograms, for whom the decision for closure was made based on clinical and echocardiographic findings. The mean ASD diameter measured by transthoracic echocardiography was 10.41±2.96 mm and the mean preprocedural right-to-left ventricular end-diastolic diameter ratio was 1.13±0.02. Tricuspid regurgitation was moderate in three patients. Rim deficiencies were observed in five aortic, three inferior vena cava, and one posterior rim.

Table I: Baseline demographic and echocardiographic characteristics

Total number of patients	34
Gender	
Female	19
Male	15
Age, years*	4.14±1.16
Weight, kg†	14.25 (12-15)
ASD diameter, mm TTE*	10.41±2.96
Deficient rims‡	
Aortic	5 (14.70)
IVC	3 (8.82)
Posterior	1 (2.94)
Clinical indications‡	
Failure to thrive	15 (44.11)
Frequent respiratory infections	5 (14.70)
History of transient ischemic attack	1 (2.94)
RA/RV enlargement in echocardiography‡	33 (97.06)
Associated congenital cardiac findings‡	
Small additional ASD	3 (8.82)
Pulmonary valve stenosis	3 (8.82)
Ventricular septal defect (muscular, small)	1 (2.94)
PDA (small)	1 (2.94)
Bicuspid aortic valve	1 (2.94)
APCA (small)	1 (2.94)

: mean±SD, †: median (IQR), ‡: n(%), **ASD: atrial septal defect, **TTE:** transtorasic echocardiography, **IVC:** inferior vena cava, **RA/RV:** right atrium/right ventricle, **PDA:** patent ductus arteriosus, **APCA:** aortopulmonary collateral artery*

Associated cardiac and extracardiac findings

Additional cardiac anomalies were present in 16 patients. These included small ASDs (n=3), pulmonary valve stenosis (n=3), small muscular ventricular septal defect (n=1), mild mitral regurgitation (n=3), mitral valve prolapses (n=1), bicuspid aortic valve (n=1), trivial aortic regurgitation (n=1), small patent ductus arteriosus (PDA, n=1), previously closed PDA (n=1), and a small aortopulmonary collateral artery (n=1). Extracardiac comorbidities included Down syndrome (n=2), biotinidase deficiency (n=1), and operated omphalocele (n=1).

Electrocardiographic findings

Right axis deviation was present in 10 patients, and signs of right ventricular hypertrophy were observed in 2 patients. At baseline, one patient had a diagnosis of junctional ectopic tachycardia (JET), confirmed by Holter monitoring and electrophysiological study, demonstrating atrioventricular dissociation with a ventricular rate of approximately 100 bpm, and no significant QT prolongation or ST–T changes. The patient had been managed with a triple antiarrhythmic regimen consisting of amiodarone, propranolol, and flecainide, and ASD closure was planned during follow-up. After device implantation, ivabradine therapy was initiated, and the patient subsequently showed marked rhythm improvement, achieving near-normal sinus rhythm.

Procedural characteristics

The median procedure duration was 40 minutes (IQR: 35–65), and fluoroscopy time was 11.90 minutes (IQR: 8.60–19.45). The median radiation dose was 1.37 Gy·cm² (IQR: 0.83–2.19). Transesophageal echocardiography was used in 6 patients (Table II).

All procedures were performed using Amplatzer Septal Occluder devices (Abbott, Plymouth, MN, USA), and the overall procedural success rate was 100%. Pulmonary artery pressure was ≥20 mmHg in 17 patients, and the mean pulmonary artery pressure across the cohort was 19.50± 5.01 mmHg. The median pulmonary-to-systemic flow ratio was 2.16 (IQR: 1.75–2.84), the median pulmonary vascular resistance (PVR) was 0.97 Wood units (IQR: 0.44–1.20).

The median balloon-sized ASD diameter was 14.30 mm (IQR: 12–17), and the mean device size was 15.16±4.11 mm,

Table II: Procedural and follow-up characteristics of the patients

Variables	Values
Balloon-sized ASD diameter, mm*	14.30 (12-17)
PA pressure, mmHg†	19.50±5.01
Patients with PH‡	17 (50)
Qp/Qs*	2.16 (1.75–2.84)
PVR, WU*	0.97 (0.44-1.20)
TEE used‡	6 (17.64)
Amplatzer occluder size, mm†	15.16±4.11
Fluoroscopy time, min*	11.90 (8.60–19.45)
Procedure time, min*	40 (35–65)
Radiation dose, Gy·cm²*	1.37 (0.83-2.19)
Concomitant procedure‡	
Balloon pulmonary valvuloplasty	3 (8.82)
Complications‡	
Transient SVT	1 (2.94)
Postprocedure follow-up	
Residual shunt closure time, days§	1 (1-30)
RV diameter normalization time*	1 (1-30)

:** *median (IQR),* **†:** *mean±SD,* **‡:** *n(%),* **§:** *median (range),* ***ASD: *atrial septal defect,* ***PA:*** *pulmonary artery,* ***PH:*** *pulmonary hypertension,* ***Qp/Qs:*** *Pulmonary-to-systemic flow ratio,* ***PVR:*** *pulmonary vascular resistance,* ***WU:*** *Wood units,* ***TEE:*** *transesophageal echocardiography,* ***SVT:*** *supraventricular tachycardia,* ***RV:*** *right ventricle*

with a mean ASD diameter-to-device ratio of 1.02±0.26 and a device-to-weight ratio of 1.05±0.27.

Among patients with multiple ASDs, one hemodynamically insignificant 5-mm defect was left open, while two smaller defects were closed simultaneously by the main occluder device. Balloon valvuloplasty was performed in all three cases of pulmonary stenosis.

In two patients, the device was delivered via the right superior pulmonary vein, and in one 3-year-old patient with a 3-mm ASD and prior TIA, device closure with a 4-mm occluder was performed after neurology consultation.

Post-procedural outcomes

The median time to residual shunt closure was 1 day (IQR: 1–1; range: 0–30 days). The median time for normalization of right ventricular dimensions was also 1 day (IQR: 1–30). In most patients, remodeling occurred within the first few days; however, in two cases the process was delayed, with one patient showing improvement at 1 month and another not achieving full normalization even at 6 months.

A brief episode of supraventricular tachycardia (four beats) was detected on Holter monitoring in one patient during the early post-procedural period. No antiarrhythmic therapy was required, and subsequent Holter recordings at one week and one month were normal. In patients with normal baseline ECG, no new conduction abnormalities developed after device closure. In those with right axis deviation, axis normalization occurred in most during early follow-up. One patient persisted with right axis deviation at 1 month, another until 4–5 months, and one still showed deviation at 6 months. Additionally, one patient with JET achieved near-normal sinus rhythm under ivabradine therapy.

Discussion

Traditionally, transcatheter closure of atrial septal defects has been recommended for children older than 4 years and weighing more than 15 kilograms, as higher complication rates in smaller patients have led to the suggested deferral of the procedure in this group (2,5). This recommendation primarily stems from concerns regarding the relative size of the occluder device to cardiac structures, vascular access challenges, the higher risk of procedural complications in smaller patients, and the spontaneous closure potential of atrial septal defects smaller than 8 mm (6,7). However, in symptomatic patients with significant left-to-right shunting, recurrent respiratory infections, or growth failure, earlier closure may be considered. In such cases, surgical repair is often contemplated as the preferred approach. Nevertheless, data on transcatheter ASD closure in symptomatic children weighing less than 15 kg remain limited, and current guidelines generally discourage this approach due to the increased risk of technical and procedural complications (2). In our cohort, all patients were symptomatic, with the primary indications for intervention being failure to thrive in 15 patients, recurrent respiratory tract infections in 5 patients, and a history of transient ischemic attack in 1 patient. These proportions were higher than those reported in previous studies, likely because most published series have included patients in whom right ventricular enlargement alone was considered an indication for closure (8). In contrast, in our study, right ventricular enlargement was accepted as an indication only in patients aged over 4 years and weighing around 15 kg, which may explain the higher rate of symptomatic presentation in our cohort.

In our study, the mean ASD diameter measured by transthoracic echocardiography was 10.41±2.96 mm, and the median diameter determined by balloon sizing was 14.30 mm (IQR: 12–17), indicating that these defects were unlikely to close spontaneously without intervention (9).

The procedural success rate in our study was 100%, consistent with previously published series that generally report success rates above 90%. This high success rate may be attributed to meticulous pre-procedural assessment of defect morphology and surrounding rims, as well as the routine use of balloon sizing prior to device selection, which facilitates accurate device sizing and stable implantation (10, 11). Another factor contributing to the high procedural success in our cohort may be the careful selection of patients, in line with the widely accepted recommendation to avoid transcatheter closure when the defect-to-weight ratio exceeds two. In our study, the mean ASD diameter-

to-device ratio was 1.02±0.26, and none of the patients had values above this threshold (12).

In small children, suboptimal device positioning may occur due to the relatively small size of the left atrium, which can prevent the device from opening symmetrically and may necessitate the use of technical modifications (13). In our cohort, the mean device-to-weight ratio was 1.05±0.27, indicating that device size was not disproportionately large for patient body size. Consequently, transcatheter closure was successfully performed through the left upper pulmonary vein in all but one patient, in whom the device was delivered via the right upper pulmonary vein. None of the patients required balloon-assisted device implantation.

Beyond the conventional 15 kg threshold, accumulating evidence from recent studies indicates that transcatheter ASD closure can also be safely and effectively performed in carefully selected children weighing under 10 kg, with high procedural success rates (14,15). In a comparative study including 96 symptomatic children under 10 kg, device closure was shown to be both feasible and safe, with significant post-procedural improvement in symptoms and growth parameters. The authors reported a 99% procedural success rate, with only one case of device embolization requiring surgical retrieval (14). Similarly, another series involving 28 infants weighing ≤10 kg reported a 93% procedural success rate, with only minor transient complications such as self-limited arrhythmias and post-procedural fever, and no long-term conduction abnormalities during follow-up (15). In our study, the lowest patient weight was 12 kg, and the smaller device-to-defect and device-to-weight ratios compared with those reported in studies involving <10 kg children may have contributed to the absence of such serious complications, including embolization.

Residual shunt findings were consistent with previous reports, as no residual flow was observed in 29 of the 33 patients on the first postoperative day (8). At the 1-month follow-up, residual shunt persisted in only one patient; however, the exact timing of spontaneous closure could not be determined because the patient did not attend subsequent follow-up visits.

Right ventricular dimensions returned to normal in 27 of the 33 patients, mostly within the first postoperative day and by 1 month in all of these cases. In five patients, normalization occurred within 6 months, whereas in one patient, mild right ventricular dilation persisted at the 6-month follow-up.

Only one patient (2.94%) experienced a procedural complication, which is consistent with the reported 3–4% complication rates in both <15 kg and ≥15 kg cohorts (8,16,17). This event consisted of a brief, self-limiting episode of supraventricular tachycardia (four beats) occurring immediately after device deployment. No medical intervention was required, and follow-up Holter monitoring at 1 week and 1 month demonstrated complete resolution.

In our cohort, one patient—a 2.7-year-old girl—underwent ASD closure following a confirmed ischemic attack on magnetic resonance imaging of the brain. During the etiological evaluation, a small atrial septal defect was identified, and, upon consultation with the pediatric neurology team, transcatheter closure was recommended and performed using a 4-mm Amplatzer occluder device. Previous studies have demonstrated that percutaneous closure of interatrial communications is superior to medical therapy in preventing recurrent ischemic events, particularly in patients with paradoxical embolism (18, 19). However, the number of reports describing device closure in very young and low-weight children remains limited, as most published studies have focused on adolescent or adult populations (20). In this regard, our case is noteworthy, given that it is characterised by a significant age and a substantial weight of 15 kilograms.

Limitations

This study has several limitations. First, it was a retrospective, single-center study with a relatively small sample size, which may limit the generalizability of the findings. Second, although all patients were followed clinically and echocardiographically, long-term follow-up data beyond six months were not available for every patient. Finally, subtle hemodynamic or electrical changes that may occur in the long term could not be fully assessed due to the limited observation period.

Conclusion

This study demonstrates that in carefully selected children weighing less than 15 kg—particularly those with favorable echocardiographic anatomy and without excessive defect-to-body or device-to-body ratios—transcatheter ASD closure can be performed safely with high procedural success and complication rates comparable to those in heavier patients. Appropriate case selection, accurate device sizing, and operator experience appear to be key factors for procedural success. Further studies with larger cohorts and long-term follow-up are warranted to validate these findings.

Ethics committee approval

This study was conducted in accordance with the Helsinki Declaration Principles. The study was approved by Ankara Bilkent City Hospital Ethics Committee (date: 08.10.2025, number: TABED 1-25-1752).

Contribution of the authors

UP conceived and designed the study, collected the data, and drafted the initial manuscript; HAG. coordinated and supervised data collection, contributed to study design, and critically reviewed and revised the manuscript; EA. contributed to study design and provided critical revisions to the manuscript; YÖŞ. provided critical revisions to the manuscript; İİÇ critically reviewed the manuscript for important intellectual content. All authors read and approved the final version of the manuscript

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Conflict of interest

The authors declare that there is no conflict of interest.

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