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Endovascular stenting for coarctation of the aorta in Infants and young children in southeast Iran: A retrospective study

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Abstract

BACKGROUND: Coarctation of the aorta (CoA) in infants and young children is typically treated with high-risk open-heart surgery. Endovascular stenting provides a less invasive alternative; however, its safety and efficacy remain underexplored. This study aimed to evaluate procedural success, complications, and four-year outcomes of stenting for CoA.

METHODS: A retrospective review included 30 infants and young children (28 days to 3 years of age, weight >2.5 kg) with CoA who underwent endovascular stenting in Kerman and Sistan-Baluchestan, Iran, from 2024 to 2025. Patients with complex heart defects requiring immediate surgery or weighing <2.5 kg were excluded. Diagnostics utilized echocardiography, femoral angiography (for gradient assessment), and CT angiography. Outcomes included reduction in gradient, *minor complications* (*hematoma, transient arrhythmia*, localized bleeding, and bruising), major complications (stent thrombosis, vascular rupture, stent migration, vascular injury, sepsis, and mortality), and stent patency.

RESULTS: Procedural success was achieved in 27 out of 30 patients (90%, 95% CI: 73.5–97.9%). The mean gradient was reduced by 89% (from 45 ± 10 mmHg to 5 ± 3 mmHg, p<0.001). Minor complications occurred in 3 of 30 patients (10%; 95% CI: 2.1–26.5%), including 2 hematomas and 1 transient arrhythmia; no major complications or mortality were reported. Four-year stent patency was 90% (95% CI: 73.5–97.9%); 3 out of 30 patients (10%) required re-dilation at 2.5 years due to growth. Cox regression analysis found no predictors for re-intervention (p>0.05).

CONCLUSION: Endovascular stenting seems to be a safe and effective alternative for CoA in infants and young children. Larger prospective studies are necessary.

Keywords: Coarctation of the Aorta, Endovascular Stenting, Infants, Children, Congenital Heart Disease, Vascular Intervention, Long-Term Outcomes

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Introduction

Coarctation of the aorta (CoA), a congenital narrowing of the descending aorta, has a global birth prevalence of 0.3–0.4 per 1,000 live births[1], with higher rates in Iran (approximately 0.2–0.5 per 1,000, representing 5–16% of congenital heart defects)[2,3]. It poses significant risks, particularly in infants, often presenting with acute heart failure, shock, or ventilator dependence, requiring urgent intervention, while untreated cases lead to resistant hypertension, premature mortality, or systemic complications in childhood[4–6]. Standard treatment involves open surgical repair, typically via end-to-end anastomosis or subclavian flap aortoplasty, which is effective but carries risks of prolonged hospitalization, spinal cord injury, and significant morbidity[6,7].

Endovascular stenting offers a less invasive alternative, with success rates of 85–90% in children over 7 years[4,7]. A systematic review reported an 88% success rate and 10–15% complication rate for CoA stenting, but data in infants and young children remain limited due to technical challenges (such as small vessel diameter), concerns about vascular growth, and insufficient long-term outcomes[8]. A case series in infants and small children demonstrated an 85% success rate in 10 patients with no major complications, yet follow-up was short-term[9]. These gaps highlight the need for studies evaluating stenting safety and efficacy in younger populations.

In southeastern Iran, the absence of specialized congenital cardiac surgeons and critical patient conditions, often requiring mechanical ventilation, limits surgical options[2,3]. Endovascular stenting is thus a vital alternative despite its complexities. This study aimed to evaluate the safety, feasibility, and three-year outcomes of endovascular stenting for CoA in 30 infants and young children in Kerman and Sistan-Baluchestan, addressing a critical need in resource-limited settings.

Methods

Patient Selection

This retrospective study included 30 infants and young children (28 days to 3 years of age, weight greater than 2.5 kg) diagnosed with CoA, who were treated in the Neonatal Intensive Care Units (NICU) or Pediatric Intensive Care Units (PICU) in the Kerman and Sistan-Baluchestan provinces from 2024 to 2025. Inclusion criteria were anatomical suitability for stenting (vessel diameter >2 mm, assessed by CT angiography) and clinical stability for catheterization. Exclusion criteria included complex congenital heart defects requiring immediate surgical correction (severe hypoplastic left heart syndrome) or a weight of less than 2.5 kg. The sample size of 30 patients was determined based on the availability of eligible cases during the study period. Since the endovascular management of CoA in infants is restricted to a few clinical situations and is not performed on a routine basis, the available sample size was considered sufficient for this retrospective study.

Pre-Procedure Evaluation

The diagnosis was confirmed using transthoracic echocardiography (to assess pressure gradients, mean 45 ± 10 mmHg, range 30–60 mmHg), femoral artery angiography (4F Pigtail catheter, contrast dose 0.5–1 mL/kg), and CT angiography (64-slice scanner, Siemens, Germany) to evaluate the type of CoA (discrete, n=24; diffuse, n=6) and arch hypoplasia. Blood pressure gradients were measured across the coarctation site, and aortic arch dimensions were quantified.

Intervention Protocol

Procedures were performed under general anesthesia with intubation. Vascular access was achieved via femoral (n=25) or axillary (n=5) arteries, selected based on vessel size and accessibility. Initial balloon dilation (3–5 mm balloons, Cordis, USA) was performed for coexisting aortic stenosis (n=8). Formula (n=18) or Blue Palmaz (n=12) bare-metal stents (4–6 mm diameter, 12–18 mm length, Cordis, USA) were deployed using balloon-expandable techniques. Heparin (50–100 IU/kg) was administered to maintain activated clotting time at 150–200 seconds. Contrast dose was minimized (0.5–1 mL/kg) to reduce nephrotoxicity. Stent size

was determined based on the aortic diameter proximal to the left subclavian artery or, in hypoplastic cases, approximately twice the coarctation diameter. Formula or Blue Palmaz stents were chosen for their capacity for redilatation to accommodate future vessel growth. In 9 cases, prostaglandin E1 infusion was used pre-procedure to maintain ductal patency in severely hypoplastic arches. Detailed procedural techniques, including sheath coating with diluted trinitroglycerin (TNG), anesthetic choices (atropine administration, avoidance of ketamine), and sheath, dilator, and guidewire specifications, are provided in Supplementary Appendix S1. The procedural steps, including vascular access and stent deployment, were visually documented in representative cases, as illustrated in Figs. 1 and 2.

Data Collection

Outcomes included gradient reduction, minor complications, major complications, and stent patency. Data were collected from medical records, clinical examinations, and imaging studies during hospitalization and follow-up visits at 1, 6, 12, 24, and 48 months. Gradient reduction was assessed via echocardiography. Blood pressure gradients were measured across the coarctation site, and aortic arch dimensions were quantified. Stent patency was evaluated using echocardiography and CT angiography to confirm vessel flow and stent integrity.

Complications were classified as minor (hematoma, arrhythmia, localized bleeding, bruising) or major (stent thrombosis, vascular rupture, stent migration, vascular injury, sepsis, mortality). Minor and major complications

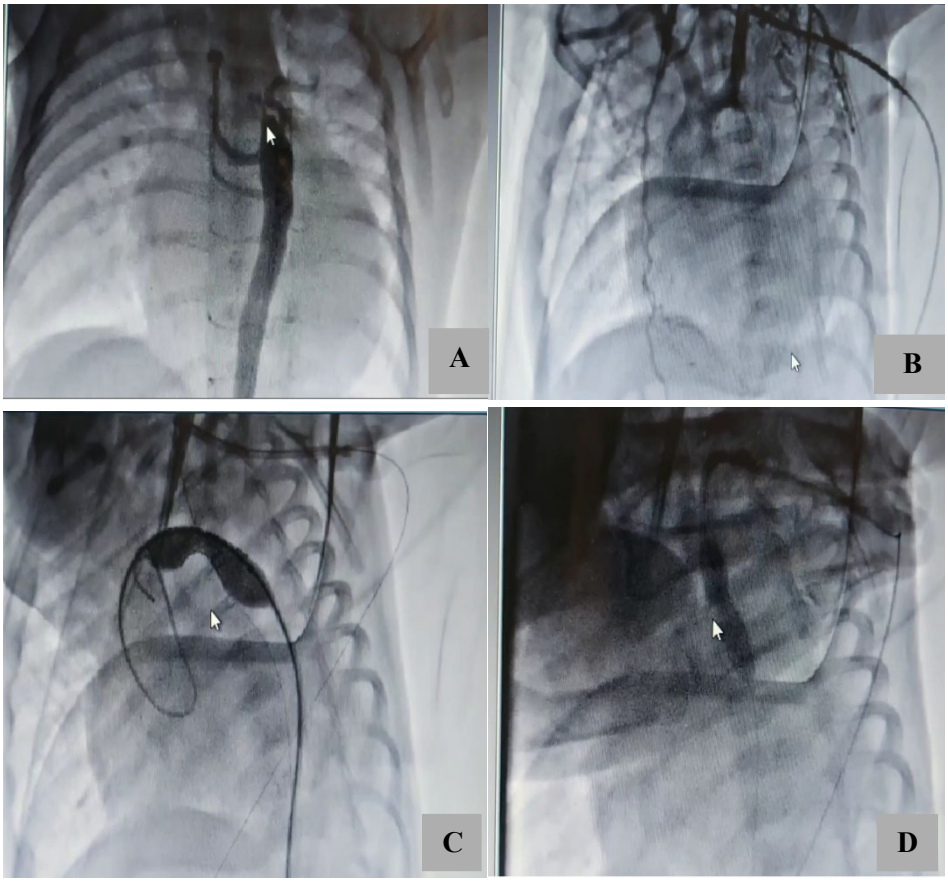


Fig. 1. Procedural images of a 2-month-old infant with coarctation of the aorta (CoA) and a hypoplastic aortic arch. **(A)** Pre-procedural CT angiography demonstrating discrete CoA with a hypoplastic arch (arrow). **(B)** Intra-procedural fluoroscopy showing balloon angioplasty via axillary access for concurrent aortic narrowing, followed by **(C)** deployment of a 4 mm Blue Palmaz stent (Cordis, USA) using a balloon-expandable technique. **(D)** Post-procedural angiography confirmed stent patency and a residual gradient of 4 mmHg. This case demonstrates the feasibility of axillary access and staged intervention in infants with complex coarctation of the aorta (CoA) anatomy

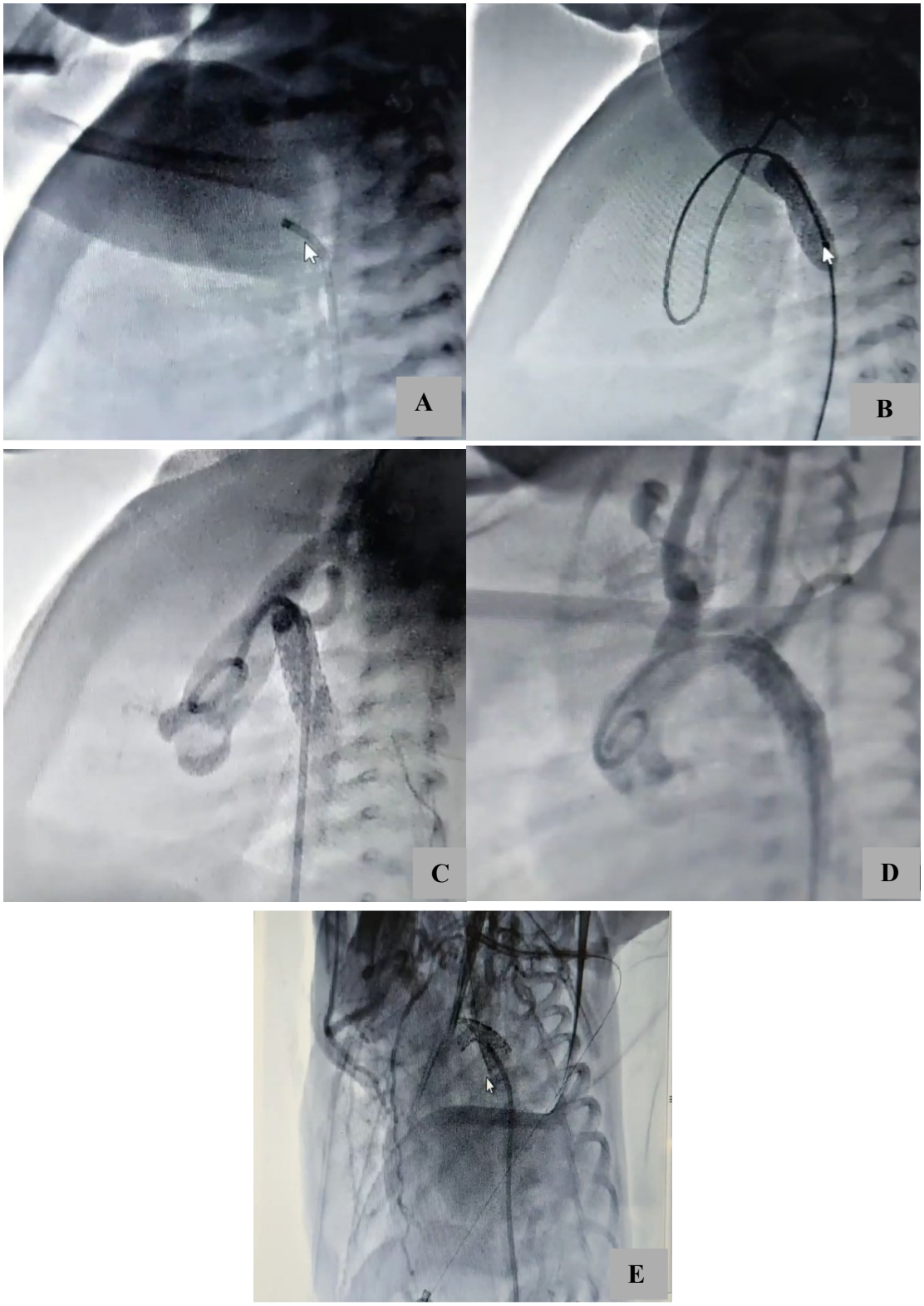


Fig. 2. Procedural images of a 28-day-old infant with coarctation of the aorta (CoA) and severe heart failure. **(A)** Pre-procedural echocardiography showed a discrete CoA with a pressure gradient of 50 mmHg and impaired left ventricular function. **(B)** Intra-procedural fluoroscopy demonstrated vascular access and balloon preparation. **(C)** Deployment of a stent using a balloon-expandable technique. **(D)**&**(E)** Post-procedural angiography (stent patency with residual gradient < 10mmHg). This case highlights the efficacy of stenting in managing severe CoA with heart failure in an infant

were identified through clinical assessments, laboratory tests (for infection), and imaging (for hematoma or vascular injury). Data on complications were collected during follow-up visits at 1, 6, 12, 24, and 48 months. Re-interventions, primarily stent redilatation due to somatic growth, were documented via catheterization records. Two independent reviewers verified all data to ensure accuracy.

Statistical Analysis

Continuous variables (pressure gradients, aortic diameter) were reported as mean ± standard deviation or median (range). Normality was assessed using the Shapiro-Wilk test. Paired t-tests were conducted for pre- and post-procedure gradient comparisons, while Wilcoxon signed-rank tests served as a non-parametric alternative when normality was not met. Changes in mean pressure gradients over multiple follow-up time points were assessed using repeated-measures analysis of variance (ANOVA). Categorical variables (success rate, complications) were presented as frequencies and percentages, with 95% confidence intervals (CI) calculated using the Wilson score method. Between-group comparisons for categorical outcomes in exploratory subgroups were performed using Fisher's exact test, and for continuous outcomes using the Mann-Whitney U test. Kaplan-Meier analysis estimated re-intervention-free survival, with 95% confidence intervals (CI) determined using the Greenwood formula. Log-rank tests were employed to assess differences in survival curves when applicable. Cox proportional hazards regression was used to evaluate risk factors (age, weight, stent type, and access route) for re-intervention. Missing data were minimal (<5%) and handled through listwise deletion. Analyses were performed using SPSS version 25 (IBM, USA).

Ethics approval and consent to participate

Informed consent was obtained from the parents or legal guardians of all neonates and infants prior to endovascular stenting, with clear explanations of the procedure, risks, benefits, and research use of anonymized data. The data were de-identified and securely stored to ensure confidentiality, in compliance with Iranian data protection regulations. No identifiable information was included in the manuscript or supplementary materials, and the retrospective design ensured that no additional procedures were performed for research purposes.

Results

Patient Characteristics: The cohort consisted of 30 patients (18 males, 12 females), with a median age of 6 months (range: 28 days to 3 years of age) and a median weight of 5.5 kg (range: 2.5–12 kg) (Table 1). Coarctation of the aorta (CoA) was discrete in 24/30 patients (80%) and diffuse in 6/30 patients (20%), as confirmed by pre-procedural CT angiography and echocardiography. All patients presented with hypoplastic, long-segment, and tortuous aortic arch, associated with left ventricular dysfunction and pulmonary hypertension. Several patients (n=13) had concurrent anomalies, including VSD, PDA, and ASD. Most patients were not eligible for referral due to ventilator dependence or unstable status.

Associated anomalies included ventricular septal defect (VSD) in 6/30 patients (20%), patent ductus arteriosus (PDA) in 9/30 patients (30%), and atrial septal defect (ASD) in 4/30 patients (13.3%). Of the 30 patients, 13 had

Table 1. Patient Demographics and Clinical Characteristics

Parameter	Value
Number of Patients	30
Age (median, range)	6 months (1 day–3 years)
Weight (median, range)	5.5 kg (2.5–12 kg)
Male/Female	18/12 (60%/40%)
CoA Type	
- Discrete	24/30 (80%)
- Diffuse	6/30 (20%)
Associated Anomalies	
- Ventricular Septal Defect (VSD)	6/30 (20%)
- Patent Ductus Arteriosus (PDA)	9/30 (30%)
- Atrial Septal Defect (ASD)	4/30 (13.3%)

at least one associated anomaly (VSD, PDA, or ASD), with some patients (n=6) having multiple anomalies due to coincidence (VSD and PDA). The remaining 17 patients (56.7%) had isolated coarctation of the aorta with no other congenital heart defects reported in clinical records.

Pre-procedural echocardiography revealed a mean pressure gradient across the CoA of 45 ± 10 mmHg (range: 30–60 mmHg), with normality confirmed via the Shapiro-Wilk test (p=0.12).

Procedural Outcomes: Procedural success, defined as a residual gradient <10 mmHg, was achieved in 27/30 patients (90%, 95% CI: 73.5–97.9%, calculated using the Wilson score method) (Table 2). The mean ± SD post-procedural gradient was 5 ± 3 mmHg, representing an 89% reduction from baseline (p<0.001, paired t-test; Shapiro-Wilk post-procedure: p=0.15, confirming normality). Stents used were Formula (Cook Medical, 18/30, 60%) and Blue Palmaz (Cordis, 12/30, 40%), with diameters ranging from 4–6 mm and lengths from 12–20 mm. Vascular access was achieved via the femoral route in 27/30 cases (90%) and the axillary route in 3/30 cases (10%) (Figs. 1 and 2).

Table 2. Procedural and Follow-Up Outcomes

Parameter	Value
Procedural Success Rate	27/30 (90%)
Pre-Procedure Gradient (mmHg)	45 ± 10
Post-Procedure Gradient (mmHg)	5 ± 3
Sheath Size (French)	
- 4F	20/30 (66.7%)
- 5F	10/30 (33.3%)
Vascular access - Femoral -Axillary	25/30 (83.3%) 5/30 (16.6%)
Stent Type	
- Formula (Cook Medical)	18/30 (60%)
- Blue Palmaz (Cordis)	12/30 (40%)
Stent Size (mm)	4–6
Stent Length (mm)	12–20
Complications	
- Sepsis	0/30 (0%)
- Minor Vascular Access Issues (Hematoma)	2/30 (6.7%)
- Transient Arrhythmia	1/30 (3.3%)
- Mortality	0/30 (0%)
Hospital Stay (days)	3 ± 1
4-Year Follow-Up Outcomes	
- Stent Patency	27/30 (90%)
- Redilation Required	3/30 (10%)
- Mean Gradient (mmHg)	6 ± 4

Note: Data are presented as mean ± SD or n/N (%)

To evaluate the stability of our stenting procedure over time, we examined the mean pressure gradient across the stented segment at multiple follow-up points over 48 months. The gradient remained stable at 5 ± 3 mmHg during the first year (1, 6, and 12 months), with a slight increase to 5 ± 4 mmHg at 24, 30, and 32 months, and further rose to 6 ± 4 mmHg at 48 months, reflecting potential changes in vessel dynamics or stent performance. Due to the small sample size (n=30, reducing to n=27 by 48 months due to re-interventions), a formal statistical comparison (ANOVA) was not conducted to assess significance.

Post-Procedure Care: Patients received heparin (50–100 IU/kg) for 24–48 hours, with activated clotting time (ACT) monitored at 150–200 seconds, prothrombin time (PT) at 11–13 seconds, and partial thromboplastin time (PTT) at 30–40 seconds, measured every 6 hours. Broad-spectrum antibiotics (ceftriaxone, 50 mg/kg/day) were administered prophylactically. Patients were monitored in the Neonatal and Pediatric Intensive Care Units (NICU/PICU) for 48–72 hours and discharged if stable, with normal blood pressure and intense femoral pulses. Mean hospital stay was 3 ± 1 days (range: 2–5 days), significantly shorter than reported surgical stays (7–10 days, Torok et al.[3]. All patients received aspirin at a dose of 3–5 mg/kg/day for at least one month post-discharge.

Complications: Minor complications occurred in 3/30 patients (10%, 95% CI: 2.1–26.5%), including hematomas at the access site (2/30, 6.7%, 95% CI: 0.8–22.1%; one femoral, one axillary, both resolved within 48 hours with compression) and a transient supraventricular arrhythmia (1/30, 3.3%, 95% CI: 0.1–17.2%; resolved spontaneously within 1 hour). No major complications (stent migration, vascular injury, sepsis) or mortality were reported.

Follow-up assessments were conducted at

1, 6, 12, 24, and 48 months, including clinical evaluations (blood pressure, femoral pulse, and growth metrics) and echocardiography. Selective CT angiography was performed in 10/30 patients (33%) when restenosis was suspected (gradient >20 mmHg) (Fig. 3). Table 3 summarizes longitudinal outcomes. Mean pressure gradients were 5 ± 3 mmHg at 1, 6, and 12 months, 5 ± 4 mmHg at 24 months, and 6 ± 4 mmHg at 48 months (repeated-measures ANOVA, p=0.89, indicating no significant change post-procedure; Shapiro-Wilk at 48 months: p=0.18) (Table 3). Stent patency was maintained in 27/30 patients (90%, 95% CI: 73.5–97.9%) at 48 months. CT angiography in the 10 patients revealed a mean increase in vessel diameter of 2.1 ± 0.5 mm over 4 years, with no evidence of stent malposition or kinking.

Redilation was required in 3/30 patients (10%, 95% CI: 2.1–26.5%) at approximately 28, 30, and 32 months due to somatic growth. Kaplan-Meier analysis estimated 90% re-intervention-free survival at 48 months (95% CI: 73.5–97.9%, Greenwood formula; Fig. 4). Due to imprecise event timing in clinical records, a sensitivity analysis assuming re-dilation times within ±3 months confirmed consistent survival estimates (89–91% at 48 months).

Cox proportional hazards regression was used to evaluate potential risk factors (age, weight,

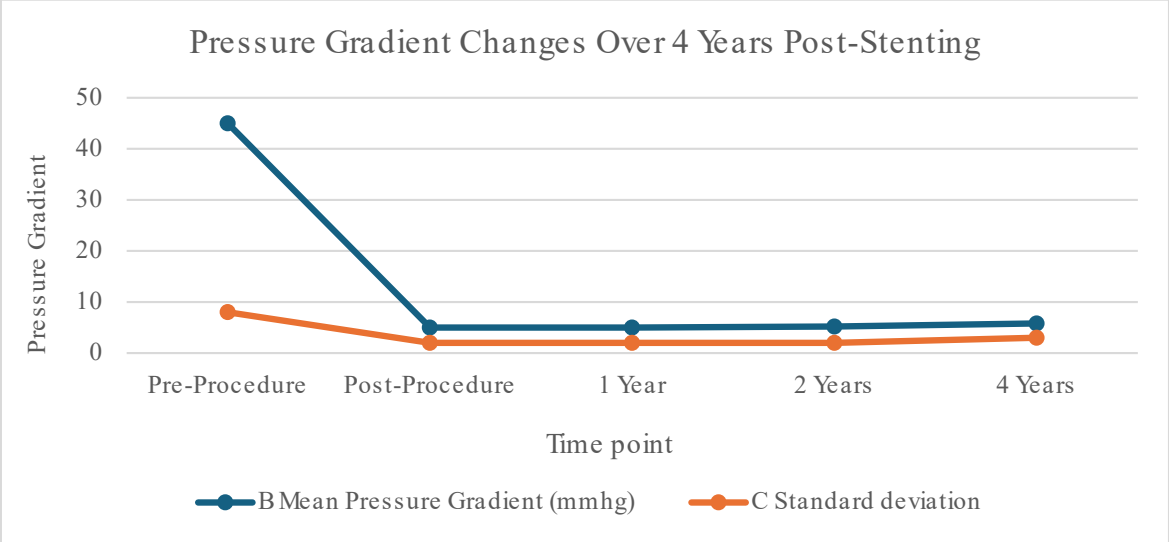


Fig. 3. A line chart illustrating pressure gradient changes over time (pre-procedure: 45 ± 10 mmHg; post-procedure: 5 ± 3 mmHg; 1-year: 5 ± 3 mmHg; 2-year: 5 ± 4 mmHg; 4-year: 6 ± 4 mmHg) demonstrates sustained efficacy

Table 3. Longitudinal Follow-Up Outcomes with Clinical Characteristics for three patients with re-intervention at 48 months

Follow-up Time (months)	Mean Gradient (mmHg)*	Patency, n/N (%)**	Cumulative Re-intervention, n/N (%)	Re-intervention Details (Age [months], Weight [kg], Stent Diameter [mm], Stent Length [mm], Access Route, Post-Re-intervention Gradient [mmHg])
1, 6, 12	5 ± 3	30/30 (100%)	0/30 (0%)	–
24	5 ± 4	29/30 (96.7%)	1/30 (3.3%)	6, 5.5, 4, 12, Femoral, 4
30	5 ± 4	28/30 (93.3%)	2/30 (6.7%)	6, 4.8, 5, 15, Femoral, 4
32	5 ± 4	27/30 (90%)	3/30 (10%)	6, 5.2, 6, 18, Axillary, 5
48	6 ± 4	27/30 (90%)	3/30 (10%)	6 ± 0, 5.2 ± 0.4, 5 ± 1, 15 ± 3, 2 Femoral/1 Axillary, 4 ± 1*

Note: Data are presented as mean ± SD* or n/N(%)**. Re-intervention details are provided individually **for each of the three patients** who required redilation (at 24, 30, and 32 months). No additional re-interventions occurred by 48 months; the cumulative rate reflects these same patients. No stent occlusions were observed.

stent type, and access route) for re-intervention. No significant predictors were identified (age: HR=1.02, 95% CI 0.85–1.22, p=0.78; weight: HR=0.95, 95% CI 0.78–1.15, p=0.62; stent type: HR=1.12, 95% CI 0.80–1.57, p=0.54; access route: HR=0.89, 95% CI 0.62–1.28, p=0.71).

Subgroup Analysis

Exploratory subgroup analysis by CoA type showed procedural success in 22/24 patients (91.7%) with discrete CoA and 5/6 patients (83.3%) with diffuse CoA (Fisher's exact test, p=0.47) (Table 4).

Exploratory subgroup analysis by CoA type showed procedural success in 22/24 patients (91.7%) with discrete CoA and 5/6 patients (83.3%) with diffuse CoA (Fisher's exact test, p=0.47) (Table 4).

Mean post-procedural gradients were 4.8 ± 2.9 mmHg for discrete CoA and 5.6 ± 3.2 mmHg for diffuse CoA (Mann-Whitney U test, p=0.62) (Table 4).

By stent type, success rates were 16/18 (88.9%, 95% CI: 65.3–98.6%) for Formula and 11/12 (91.7%, 95% CI: 61.5–99.8%) for Blue Palmaz stents (Fisher's exact test, p=0.99). Patients with associated anomalies (VSD, PDA, or ASD; n=13) had a success rate of 11/13 (84.6%, 95% CI: 54.6–98.1%) compared to 16/17 (94.1%, 95% CI: 71.3–99.9%) without anomalies (Fisher's exact test, p=0.57). Seventeen patients without VSD, PDA, or ASD had isolated coarctation of the aorta (CoA) with no other congenital heart defects reported in clinical records. Due to potential overlap in anomalies (patients with both VSD and PDA), the total number of

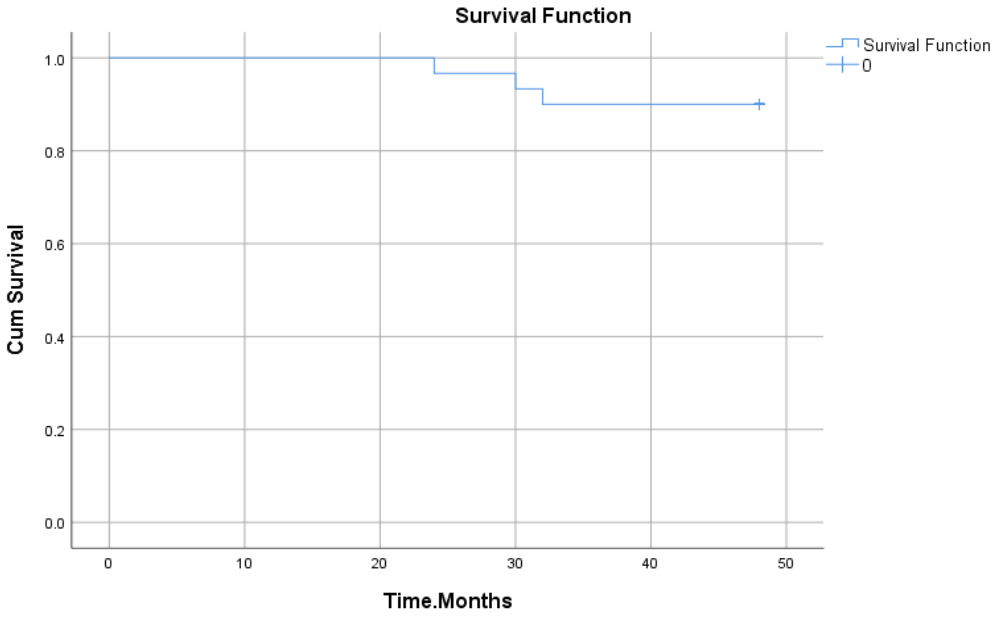


Fig. 4. Kaplan-Meier curve showing re-intervention-free survival, with a drop from 1.0 to 0.9 between 24–32 months and 90% survival at 48 months (95% CI: 73.5–97.9%)

Table 4. Subgroup Analysis of Procedural Outcomes by Coarctation Type (Discrete vs. Diffuse)

Subgroup	Number of Patients	Success, n/N (%)	Failure, n/N (%)	Post-Procedural Gradient in Success Cases (mmHg, mean ± SD)	P-value for Success Rate*	P-value for Gradient**
Discrete CoA	24	22/24 (91.7%)	2/24 (8.3%)	4.8 ± 2.9	0.47*	0.62**
Diffuse CoA	6	5/6 (83.3%)	1/6 (16.7%)	5.6 ± 3.2		

Note: Data are presented as n/N (%) or mean ± SD. Fisher's exact test (two-sided) for success rates.
** Mann-Whitney U test for post-procedural gradients. Post-procedural gradients are reported only for successful cases (residual gradient). No significant differences were observed between subgroups. Significance level set at 0.05.

patients with anomalies was estimated at 13 based on clinical records. These analyses were underpowered due to the small sample size.

Discussion

This study highlights a promising approach to treating coarctation of the aorta (CoA) in infants and young children through endovascular stenting, particularly in a region like southeastern Iran, where access to traditional open-heart surgery is limited. The use of stenting in this young age group, with follow-up extending over several years, offers new insights into a treatment option previously less explored in such patients.

The procedure successfully reduces the pressure difference across the narrowed aorta, maintaining benefits over time, which sets it apart from earlier studies focused on older children[10,11]. In southeastern Iran, where specialized congenital heart surgeons are scarce and many infants depend on ventilators due to critical conditions, this less invasive technique provides a vital alternative. Compared to surgical approaches, like those described by Torok et al.[6], which reported higher rates of complications such as infections and vascular injuries, our stenting method shows a more favorable outcome with fewer and less severe issues. Similarly, while Dijkema et al.[4] noted effective results in older children, our study extends these benefits to a younger population, demonstrating that stenting can effectively lower pressure differences from high levels to very low levels right after the procedure, with lasting effects over the years.

Also, our 90% success rate and low complication rate align with a case series from Isfahan, Iran, which reported 100% gradient reduction and no severe complications in 5 infants undergoing CoA stenting[9]. These results are also comparable to Kang et al.[12], who noted similar efficacy in children under 30 kg from other regions, supporting the potential of endovascular stenting as a reliable alternative in diverse Iranian settings.

Compared to Torok et al. (2015), who reported a mean gradient of 8 ± 5 mmHg at 12 months post-stenting in a cohort of older children (1–5 years), our study observed a lower gradient of 5 ± 3 mmHg at the same interval, potentially indicating better stent performance in our younger cohort (28 days to 3 years)[6]. This difference may be attributed to age-related vascular responses or procedural techniques.

The re-intervention rate of 10% (3/30 patients, 95% CI: 2.1–26.5%) at a mean of 2.5 years, driven by somatic growth, is comparable to balloon angioplasty studies, such as Rao[7], which reported re-intervention rates of 8–12% in infants. The observed mean vessel diameter increase of 2 mm over four years supports the hypothesis that re-dilation is primarily necessitated by growth-related vessel narrowing rather than stent failure. The use of 4–6 mm stents, tailored to vessel size (>2 mm), likely contributed to sustained patency, as evidenced by the mean gradient of 6 ± 4 mmHg at four years.

A notable finding is that some patients required a repeat procedure after a couple of years, primarily due to their natural growth, with the blood vessels showing signs of expansion over time. This indicates that stents can adapt to growth to some extent, though ongoing monitoring remains essential. The low need for repeat interventions underscores the reliability of this method, especially in areas where regular follow-up care can be challenging.

Limitations of this study include its retrospective design, which introduces potential selection bias. Patients were selected based on specific inclusion criteria, such as a vessel diameter greater than 2 mm and clinical stability for catheterization, which may have favored cases with less severe anatomical or clinical profiles. This selection process could limit the generalizability of our findings to patients with more complex CoA or those requiring immediate surgical intervention, such as those with severe arch hypoplasia or critical instability. The small sample size (n=30) restricts statistical power. The absence of a concurrent surgical control group precludes a direct comparison with the standard

of care; however, our outcomes are consistent with those reported in older children[4].

While no instances of stent fracture or aneurysm formation were observed in this study's cases, these are potential long-term risks associated with endovascular stenting, as reported in studies of older children and adults[4,7]. Stent fracture may occur due to mechanical stress from vessel growth or pulsatile flow, potentially leading to restenosis. In contrast, aneurysm formation at the stent site could increase the risk of rupture or require surgical correction. These risks underscore the need for extended follow-up beyond four years to monitor stent integrity and changes in the vessel wall, particularly in growing children. Additionally, the statistical power of Cox proportional hazards regression was limited by the low event rate (three re-interventions among 30 patients), rendering the results non-significant; this highlights the need for larger sample sizes in future studies to enhance generalizability and confidence in risk factor analyses.

To address these limitations, a prospective, multicenter study is recommended to validate our findings in a larger and more diverse cohort. Such a study could employ a randomized controlled design to directly compare endovascular stenting with surgical repair, incorporating patients with varying degrees of CoA severity and associated anomalies. This approach would minimize selection bias, enhance statistical power, and provide more robust evidence to guide clinical practice in infants and young children.

Conclusion

Endovascular stenting appears to be a safe and effective alternative to surgical repair for coarctation of the aorta (CoA) in infants and young children, with a high procedural success rate and sustained stent patency of 90%. Complications were minimal, with no cases of sepsis or mortality and only 10% minor events in appropriately selected patients. Regular follow-up using echocardiography and selective CT angiography ensured optimal stent performance, and only 10% required re-dilation due to growth. These findings support the wider use of stenting in this age group; however, larger prospective multicenter studies are needed to confirm these results, compare stenting with surgery, and identify predictors of re-intervention.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

Study Conception or Design: RD
Data Acquisition: RD
Data Analysis or Interpretation: FD-M
Manuscript Drafting: RD; FD-M
Critical Manuscript Revision: RD; FD-M
All authors have approved the final manuscript and are responsible for all aspects of the work.

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Supplementary Appendix S1

Detailed Procedural Techniques for Endovascular Stenting:
All procedures were performed using Cordis or Merit sheaths and dilators. Vascular access was achieved with **4F–5F (**French**) Entrack sheaths** for femoral access (n=25) and **4F sheaths** for axillary access (n=5). Gradual dilation was performed using **3F, 3.5F, 4F, and 5F dilators**, all coated with **diluted trinitroglycerin (TNG)** to minimize arterial trauma. In three cases, stent deployment was accomplished **without a sheath.** Guidewires used included **0.014 and 0.035**.

Stents were deployed using balloon-expandable techniques with an **inflation pressure of 6–8 atm (**atmospheres**)**. For coexisting aortic stenosis (n=8), **balloon valvuloplasty** was performed using a **balloon sized 80% of the annular diameter** before coarctation repair. **Pre-procedure atropine** was administered to increase heart rate and prevent stent migration. **Ketamine was avoided** due to its pulmonary hypertensive effects.