Percutaneous treatment of native aortic coarctation performed in infants and children up to ten years old: a single-center experience

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Introduction

Percutaneous procedures performed in infants and children with native coarctation have become a safe and minimally invasive alternative to cardiac surgery [1]. Timely diagnosis of coarctation is crucial for adequate treatment, and hence a lower risk of mortality. Even after successful intervention, patients with native coarctation require long-term follow-up [2].

The aim of this study is to evaluate the effectiveness and safety of percutaneous intervention of native coarctation in patients in two age groups. Clinical outcome data were collected immediately after the procedure and at 1-year follow-up.

Methods

Study population

The study was performed as retrospective review of patient records. It included 42 patients aged up to 10 years with a native aortic coarctation, treated in our center between 2011 and 2021. The cohort was divided into two groups according to the age range. Group A included patients who underwent the procedure in the first year of life. Group B included patients whose procedure was performed between 1 and 10 years of age. Patients with other intracardiac lesions were excluded. All eligible patients provided written informed consent before enrollment.

Study design, data collection, and definition

Clinical, echocardiographic and procedural details were recorded before and after the procedure. The following were also recorded: age at the time of percutaneous treatment, clinical condition before and after the procedure, and echocardiographic details, including coarctation peak gradient, diameter of the isthmus and left ventricular function. Percutaneous intervention was performed if the upper-to-lower limb systolic pressure gradient was > 20 mm Hg, the peak systolic echocardiographic gradient was > 40 mm Hg and if coarctation was seen with left ventricle dysfunction, ignoring the measured gradient [2]. Details such as balloon size, postdilatation ascending and descending aortic peak gradient, types of stents and indications for stent implantation were noted.

Follow-up

Echocardiographic details were recorded following the procedure, before discharge, at subsequent follow-ups after three and twelve months, and at the most recent follow-up. Details of any reintervention and early complications were reported. This is a single-center study, so the treatment strategy is uniform. No long-term outcome analysis was possible due to the short observational period.

Statistical analysis

Categorical variables were summarized using percentages and counts. All data were analyzed using R studio program 2021.09.1. The Pearson χ^2 test was used. The level of statistical significance was set at $p < 0.05$.

Results and discussion

Therapeutic success, immediately after the procedure, was obtained in all 42 patients (Table I). Of these,

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Table I. IQR range of terapeutic success

Parameter		Group A (n = 23)	Group B (n = 19)
Patient characteristics:			
Age at the time of intervention [year] (mean ± SD)		0.15 ±0.23	3.39 ±2.03
Gender	Male	14 (61%)	14 (74%)
	Female	9 (39%)	5 (26%)
Percutaneous procedures:			
Balloon angioplasty		19 (82%)	12 (63%)
Stent implantation		4 (17%)	7(37%)
Balloon re-dilatation		1 (4%)	0 (0%)
Re-stenting		2 (9%)	0 (0%)
Stent re-dilatation		4 (17%)	2 (10%)
Crawford's surgery after angioplasty		13 (56%)	0 (0%)
Baseline:			
ECHO	Minimal lumen [mm] median ± IQR	2.55 ±1.18	4.20 ±1.05
	Peak systolic gradient [mm Hg] median ± IQR	69.00 ±14.50	52.00 ±13.50
	Left ventricular function, median ± IQR	65.00 ±18.75	74.00 ±10.50
CoA	Diameter after intervention, median ± IQR	2.30 ±1.38	N/D
	Peak systolic gradient after procedure, median ± IQR	41.50 ±23.00	38.00 ±18.00
After intervention:			
ECHO	Minimal lumen [mm] median ± IQR	4.20 ±0.70	5.50 ±1.80
	Peak systolic gradient [mm Hg] median ± IQR	20.50 ±8.50	26.00 ±10.00
	Left ventricular function, median ± IQR	70.00 ±8.25	77.00 ±4.00
CoA	Diameter after intervention, median ± IQR	4.45 ±1.65	N/D
	Peak systolic gradient after procedure, median ± IQR	10.00 ±5.75	4.00 ±4.50
3 month follow-up:			
ECHO	Peak systolic gradient [mm Hg] median ± IQR	13.50 ±9.75	15.00 ±6.25
	Left ventricular function, median ± IQR	70.00 ±5.50	75.00 ±6.00
12–24 month follow up:			
ECHO	Peak systolic gradient [mm Hg], median ± IQR	42.00 ±36.00	18.00 ±6.75
	Left ventricular function, median ± IQR	72.00 ±6.75	72.00 ±6.75

23 (54.7%) patients were treated at less than 1 year of age (Group A), and 19 (45.2%) between 1 and 10 years of life (Group B). In addition, 31 (73.8%) patients were treated with balloon expansion (19 patients in Group A and 12 patients in Group B), and 11 (26.2%) required stent implantation (4 in Group A; 7 in Group B). Nine of all patients (21.4%) required reintervention within 1 year of the percutaneous treatment. One patient in Group A required balloon re-dilatation, 2 patients from both groups were treated with re-stenting and 6 patients underwent stent re-dilatation (4 patients in Group A and 2 patients in Group B). Thirteen (56%) patients from Group A required surgical coarctation repair later. All of these patients underwent balloon angioplasty earlier (p = 0.003; statistically significant). It should be noted that surgical reintervention was needed only in patients in Group A. The surgical procedure was postponed for at least 1 year after the interventional procedure. Patients were selected for surgery on the basis of echocardiographic examination, in which the peak pressure gradient was 42 ±36 mm Hg in 12–24 month follow-up. Direct measurements showed the peak systolic gradient across the coarctation to change from 42 mm Hg to 13 mm Hg (in Group A) and from 39.6 mm Hg to 4.1 mm Hg (in Group B). The minimal lumen diameter increased from 2.9 mm to 5.7 mm in Group A. In echocardiographic measurements, the peak systolic gradient changed from 69 mm Hg to 20.5 mm Hg (Group A) and from 52 mm Hg to 26 mm Hg (Group B), while the minimal lumen diameter changed from 2.5 mm to 4.2 mm (in Group A) and from 4.2 mm to 5.5 mm (in Group B). The diameter of the isthmus was not measured in Group B. Left ventricular function did not change significantly in either group after the procedure or in a short-term follow-up. After the procedure, there were two occlusions of the femoral artery, which were confirmed by Doppler ultrasound of the lower limbs. In both cases rich collateral circulation was developed. Extravasation in the puncture site was observed in 3 patients immediately after the procedure. No deaths occurred because of this procedure. All patients from both groups were studied three and 12 months after the procedure. Tables I and II show how the echocardiographic measurements (peak systolic gradient, minimal lumen diameter) changed during the first year after the intervention.

Table II. Results of the χ^2 test for the procedures performed by study group

Procedure	χ^2	*df*	*P*-value
Balloon dilatation	1.15	1	0.283
Stent implantation	1.15	1	0.283
Recoarctation: balloon dilatation	0.00	1	1.000
Recoarctation: stent implantation	0.00	1	1.000
Recoarctation: stent redilatation	0.04	1	0.849
Crawford's surgery after balloon angioplasty	8.58	1	0.003*

*χ^2 – chi-square test, df – degrees of freedom, *statistically significant.*

A complete 12-month follow-up study was performed in all patients. Seven patients had elevated blood pressure values in manometric measurements during 3 months after the procedure and required drugs (3 patients in Group A and 4 patients in Group B); all these patients were treated with an angiotensin-converting enzyme inhibitor. One patient developed nutcracker syndrome. Four patients with severe left ventricle dysfunction (Group A) immediately before the procedure demonstrated complete recovery to normal function on follow-up.

In infants and children, while balloon angioplasty is widely accepted for postoperative recoarctation, it remains controversial in native coarctation [3]. Balloon angioplasty and stent placement is preferred as a first-line therapy for most adolescent and adult patients. Percutaneous interventions are now a viable option in younger patients. The advent of bioresorbable stents may provide further expansion of treatment options to include very small patients [4]. In our center we used coronary stents in Group A (Avangarda 4 × 16 mm; balloon Tyshak II 6–8 × 20 mm) and stents with the possibility of further tightening to the target size (Valeo, Formula, CP) in Group B. Due to the surrounding surgical scar tissue, a safer approach is percutaneous treatment of recoarctation after surgery, and this can reduce risk of aortic rupture and major vascular complications [5]. Studies on balloon angioplasty in recent years have shown good immediate procedural success in infants and children with native coarctation [6], and this is confirmed by our present findings. However, although percutaneous treatment is a safe and minimally invasive procedure, early recurrence rates are undoubtedly high in infants and young children. This is particularly true in younger infants (Group A), most of whom required surgery after percutaneous treatment [7, 8]. Based on the cited literature it was concluded that surgery should be considered the preferred method in infants and infants [8, 9]. The records indicate that the treatment was successful in older children (Group B), who did not require any surgical intervention either after angioplasty or after stent implantation. Each patient, especially from Group A, was discussed in detail at a meeting together with cardiac surgeons. It is important to emphasize, therefore, that no single therapeutic plan can satisfy all cases, and each patient requires individual management decisions [9]. Both our present findings and those of a previous review [10] confirm that not all young patients develop hypertension, and in this case, only seven developed hypertension, all of whom underwent balloon angioplasty.

The study has a couple of limitations. The 1-year follow-up evaluation included routine echocardiography, but no computed tomography. In addition, due to the short length of the study, no long-term outcome analysis was possible. However, as it was a single-center study, the same treatment strategy was used in all cases.

Conflict of interest

The authors declare no conflict of interest.

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