

Short- and Mid-term Results of Balloon Angioplasty for Coarctation of the Aorta in Neonates

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Introduction

Coarctation of the aorta consists of a narrowing of the aorta, generally at a point distal to the branching of the left subclavian artery. Possible treatments are the surgical resection of the stenosis and end-to-end anastomosis or subclavian flap angioplasty, interventional catheterization with balloon angioplasty or stent placement. We aimed to examine our clinical data on balloon angioplasty in neonates with aortic coarctation, and its short- and mid-term results.

Methods

The data from 51 newborn patients (mean age 13±9 days) who underwent balloon angioplasty for aortic coarctation from December 2004 to March 2010 were retrospectively studied. The patients had either been diagnosed at our center, after having consulted for symptoms such as failing to suckle, cyanosis, tachypnea, failure to gain weight, skin discoloration or direct symptoms of congestive heart failure, or their suspected diagnosis of coarctation of the aorta had been confirmed at our center.

All patients had clinical evidence of aortic coarctation including weak femoral pulse, systolic hypertension of the upper limbs and systolic murmur. All had been subjected to electrocardiography, telecardiography and echocardiography. The location, size and hemodynamic severity of the stenosis was determined by two-dimensional echocardiography along the suprasternal long axis, color flow Doppler and continuous wave Doppler investigations.

Balloon angioplasty of the coarctation was performed in all our patients at the time of referral to our center, as they all were symptomatic. We didn't perform coarctation balloon angioplasty to patients whose clinical conditions were suitable for elective surgery.

The balloon angioplasty procedure was performed by cardiac catheterization following sedation by midazolam and ketamine. Retrograde catheterization was applied from the femoral artery access. Heparin, 100 U/kg was given after placement of a pediatric 4 F (French) sheath to the femoral artery. A 4 F National Institutes of Health (NIH, Cordis Company) or right coronary artery catheter was advanced into the ascending aorta and the peak systolic pressure values downstream and upstream from the stenosis were measured. Injections anterior, posterior and lateral to the aorta were given. The diameter of the balloon chosen for angioplasty was equal to, or up to one millimeter smaller than, that of the nearest and smallest aortic segment. The disappearance or near-disappearance of the indentation on the balloon was ascertained. The pressures were measured again following the post-procedure angiographic control for the shape of the stenosis and the possible acute formation of an aneurysm.

If no important concomitant intracardiac lesion is present except for patent ductus arteriosus (PDA), the coarctation was defined as "simple", and termed "complex" in the presence of any such significant concomitant intracardiac lesion. Isthmic hypoplasia was defined as a diameter of the isthmus area inferior to 40% to that of the aorta. As for the patients who presented a patent ductus arteriosus, this was small and of porous appearance, not of a size that could have caused pulmonary hypertension. Aneurysms with a larger diameter up to 0.5 mm were designated as microaneurysms and larger ones as macroaneurysms.

The observed patients were followed up at 1, 6 and months from the intervention and yearly thereafter by physical examination, blood pressure measurement in both the upper and the lower limbs by sphygmomanometry, two-dimensional echocardiography and Doppler echocardiography for a possible recurrence of aortic stenosis. A pressure difference of 20 mm Hg or more as measured by transthoracic echocardiography between the ascending and the descending aorta, a flow pattern continuous with the diastole on continuous-wave Doppler echocardiography, a difference of 20 mm Hg or more between the blood pressure in the upper and lower extremities was accepted as showing re-stenosis (recoarctation). The mean follow-up duration was 8.7±9.6 (range 1-46, median 6) months.

Results

Balloon angioplasty was performed in 51 neonatal patients. Of the patients aged 1-28 days (mean 13±9), 41 (80.4%) were male and 10 (19.6%) female. A systolic ejection murmur was found in 44 (86.3%). Clinical characteristics, procedures and follow-up results are summarized in Table 1.

Table 1: Clinical characteristics, procedures and results.

	n	%	Before angioplasty	After angioplasty	p
Total patients	51				
Sex	Male: 41 Female: 10	80.4 19.6			
Mean age, days	13±9				
Left ventricle dysfunction	18	35.3			
Isthmic hypoplasia	17	33.3			
Pulmonary hypertension	29	56.9			
Mean systolic gradient, mm Hg			36±20	8.6±7.0	<0.001
Follow-up duration, months	8.7 ±9.6				
Recoarctation following balloon angioplasty	20	39.2			
Recoarctation following surgical procedure	0	0			
Time from angioplasty to recoarctation, months	3.2±3.1				
Deaths	7	13.7			

The coarctation was characterized as isolated in 13 (25.5%) of patients and complex in 38 (74.5%). It was in pre-ductal position in one patient, while in all 50 others it was post-ductal. A patent ductus

was found to be present in 29 patients (56.9%) and isthmus hypoplasia in 17 (33.3%); isthmus diameter was 3.4±1.2 mm. The most frequent associated abnormality was a VSD in 49% and in all cases the VSD was small in hemodynamical terms (Table 2).

Table 2. Cardiac abnormalities accompanying aortic coarctation (n=38)

Abnormalities	n	%
Ventricular septal defect	25	49
Patent ductus arteriosus	29	56.9
Atrial septal defect	19	3.3
Bicuspid aortic valve	10	19.6
Mitral valve abnormality	4	7
Pulmonary stenosis	2	3.9
Atrioventricular septal defect	2	3.9
Coronary artery abnormality	2	3.9
Aortic valve stenosis	1	2
Subaortic stenosis	1	2
Transposition of the great arteries	1	2
Double-inlet left ventricle	1	2
Double-outlet right ventricle	1	2
Coronary arteriovenous fistula	1	2
Double-inlet right ventricle	1	2
Hypoplastic left heart syndrome	1	2

A bicuspid aortic valve (BAV) was present in 10 patients (19.6%). No correlation was found between recoarctation and the presence of any of the following: BAV, isthmus hypoplasia, PDA, VSD or left ventricular dysfunction (p>0.05).

Pulmonary hypertension was found in 29 patients (56.9%), while 18 (35.2%) had left ventricular dysfunction. One patient had congenital hypothyroidism, another one renal malformation and a third patient presented with an abnormality of the urinary tract and also a cleft palate. One of the patients, born with right ventricular hypoplasia and transposition of the great arteries, underwent balloon atrial septostomy at the same time as coarctation angioplasty. The systolic pressure gradient across the coarctation area fell from 36±20 mm Hg (range 0-93) pre-operatively to 8.6±7.0 mm Hg following the intervention; the reduction satisfied the requirements in all patients. The balloon angioplasty procedure was successful in all the patients, in whom the anatomical stenosis area was widened.

One patient developed thrombosis of the femoral artery. The follow-up duration ranged from 1 to 46 months, with a median of 6 and a mean of 8.7±9.6 months; during this period 20 patients (39.2%) developed recoarctation 3.2±3.1 months after the procedure. Recoarctation occurred in 4 of the 17 patients with isthmus hypoplasia and 11 of the 18 with left ventricular dysfunction (p>0.05). Repeat angioplasty was performed in 9 (45%) of these patients, while 11 (55%) of them underwent open surgery. The pressure gradient fell satisfactorily following repeat balloon angioplasty in all patients and repeated recoarctation was not observed after it. Similarly, there was no recurrent recoarctation following open surgery (p<0.001). Seven patients (13.7%) died 1-7 months after the intervention. Of these, three had a complex cardiac abnormality (double-inlet left ventricle, double-inlet right ventricle and hypoplastic left heart syndrome) and six had pulmonary hypertension (Table 3).

Table 3. Characteristics of the seven deceased patients

Case	Age, Days	Sex	Follow-up, months	Concomitant cardiac defects	Before angioplasty, mm Hg	After angioplasty, mm Hg	Recoarctation	LVD	Cause of deaths
1	3	M	2	DILV, PDA, PH	43	12	none	present	MODS
2	3	M	7	VSD, PDA	53	1	none	none	HF
3	11	M	3	ASD, PDA, PH	20	11	none	none	HF
4	12	F	1	DIRV, PH, PDA	40	1	none	none	HF
5	12	F	3	HLHS, VSD, PH, PDA	33	3	none	none	MODS
6	24	F	1	PDA, PH	95	14	none	none	HF
7	7	F	1	PDA, PH	34	11	yes	none	HF

ASD: Atrial septal defect, DILV: double-inlet left ventricle, DIRV: double-inlet right ventricle, PDA: Patent ductus arteriosus, HF:Heart failure, HLHS: hypoplastic left heart syndrome, LVD: Left ventricular dysfunction, MODS: Multiple organ dysfunction syndrome, PH: pulmonary hypertension, VSD: ventricular septal defect.

Conclusion: Considering both short-term and mid-term results, balloon angioplasty has a higher recoarctation rate than the surgical procedure. This is why balloon angioplasty should be reserved to cases with complex heart disease and poor general condition to ensure the patients' survival until full repair surgery can be applied.