JSHD
Journal of Structural Heart Disease

Original Research Article

Journal of Structural Heart Disease, August 2016,
Volume 2, Issue 4:91-97
DOI: http://dx.doi.org/10.12945/j.jshd.2016.005.15

Received: June 30, 2015
Accepted: July 28, 2015
Published online: August 2016

Percutaneous Balloon Angioplasty for Aortic Coarctation in Newborns and Infants: Is It Still an Option?

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Abstract

Background: **Coarctation of aorta may present as severe heart failure in infants and may lead to myocardial dysfunction. Current evidence supports surgical management of neonatal coarctation; however, it can be precarious in sick infants. Thus, percutaneous balloon angioplasty may be a beneficial alternative palliation before possible surgical treatment.**

Methods: **To investigate the safety, efficacy, immediate, and mid-term outcome of percutaneous balloon angioplasty for aortic coarctation in infants who present late and have additional risk factors for surgical treatment, a retrospective case series was examined, reviewing the charts of all patients under six months of age who underwent balloon angioplasty for aortic coarctation.**

Results: **Between January 2008 and April 2014, 14 infants with coarctation were included. Their mean weight was 3.5 kg (1.9–5 kg) and they had a mean age of 69 days (4–142 days). All patients were sick, needed admission in an intensive care unit for inotropic and/or ventilator support, and had different additional risk factors for surgery. All underwent successful percutaneous balloon angioplasty with minor complications. Following which their clinical condition and left ventricular function improved leading to weaning from inotrope and ventilator support. On further follow up, seven underwent elective surgical repair, two needed re-dilation, and three continued without any further intervention.**

Conclusions: **Surgical repair for native neonatal and infantile coarctation is a preferred choice of treatment, but it can be challenging in sick patients with additional risk factors. However, percutaneous balloon angioplasty remains a safe and effective temporary palliation. Despite a high incidence of restenosis, some patients do not need mid-term further intervention.**

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Key Words

Neonates • Infants • Balloon dilation • Aortic coarctation • Percutaneous balloon angioplasty

Introduction

Coarctation of aorta (CoA) accounts for 5–7% of all congenital heart diseases [1, 2]. Native CoA in infancy may present with symptoms of congestive heart failure, low cardiac output, and/or shock. Since introduction, four decades ago, the role of percutaneous balloon angioplasty in this age group remains controversial [3-5].

It is accepted that surgical repair is the preferred treatment for neonatal and infancy CoA. One of the most important arguments being that percutaneous balloon angioplasty in the first months of life has an extremely high re-stenosis rate [6, 7].

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© 2016 Journal of Structural Heart Disease
Published by Science International Corp.
ISSN 2326-4004

Accessible online at:
http://structuralheartdisease.org/

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In certain circumstances, such as low body weight, critical patient condition with severe myocardial dysfunction and/or other organ failure, surgical repair is not preferable [8-10]. Additional risk factors like late presentation or other systemic disease may influence treatment option decisions. Under these conditions, whilst acknowledging that percutaneous balloon angioplasty is associated with high re-stenosis rate and possible aneurysm formation [5, 11, 12], it is argued that it can provide short to midterm solutions for stabilization of patients allowing surgical repair to be performed later with less risks.

The aim of this study was to present our experience with balloon angioplasty in neonates and infants with aortic coarctation who were referred late to us and/or had confounding risk factors precluding surgical treatment. Additionally, we were evaluating the immediate and mid-term outcome of this procedure in our patient population.

Methods

A retrospective cohort study was performed between January 2008 and April 2014 Fourteen neonates and infants (age less than 6 months) who underwent balloon angioplasty for aortic coarctation were identified and included in the study. All patients were admitted in an intensive care unit either due to need of respiratory support or poor cardiac output state. Additionally, they had different confounding factors which might have increased their risk of surgical treatment. Ethical clearance and permission to publish the related clinical information was obtained from the hospitals institutional review board (IRB).

Inclusion Criteria

All patients less than 6 months of age who presented with hemodynamic instability (low cardiac output) and/or any additional risk factors which may have increased their risk of surgery were included. The additional risk factors which were considered were: Late referral combined with no improvement to medical therapy, low body weight, long ventilator support, chronic lung disease, and serious systemic disease.

Exclusion Criteria

Patients less than 6 months of age, who showed stable hemodynamics with good cardiac output and no additional risk factors for surgical treatment. These patients were sent electively to surgery.

Patients underwent clinical and complete echocardiography evaluation before and after the percutaneous balloon angioplasty and at follow up. The following echocardiographic factors were evaluated: Doppler gradient across the segment of coarctation, existence of diastolic run off, patency of arterial duct, right and left ventricular cardiac function and diameters, any associated cardiac lesion, aortic arch dimensions (proximal arch, transverse arch between first branch and left common carotid artery, and distal arch between left common carotid and subclavian arteries, narrowest segment), associated mitral valve involvement, and any left ventricular outflow obstruction.

Procedure Details

Percutaneous balloon angioplasty was performed in all patients. During procedure patients received heparin boluses to keep activated clotting time (ACT) more than 200 seconds. After establishing an arterial access with a 4-Fr sheath in the majority of patients (more recently a 3-Fr sheath had been utilized in two patients), a pigtail catheter (Medtronic, Minneapolis, Minnesota, USA) was advanced into the descending and ascending aorta. The pressures across the isthmus were measured. The aortogram in lateral and antero-posterior projection was performed. The transverse arch, the isthmus distal to the left subclavian artery and narrowest diameter were measured. Percutaneous transluminal coronary angioplasty (PTCA) balloon of different sizes and lengths were used for intervention in most cases (Medtronic, Minneapolis, Minnesota, USA). Balloon size was chosen according to aortic size immediately above the stenosis and was one mm smaller than this diameter. The balloon was usually inflated three-four times across the narrowest region. Pressures after the procedure were obtained, making sure not to cross the dilated region a second time with the wire. Repeat aortogram was performed to document the angiographic results of the intervention. To avoid aortic wall injury, the pigtail catheter used for angiogram was advanced and withdrawn over a wire through the dilated segment.

Results

In 14 patients (3 female, 11 male), their mean weight was 3.5 kg (1.9–5 kg) and their mean age was 69 days (4–142 days) (Table 1).

Risk Factors for Surgical Treatment

Risk factors for surgical treatment for each patient are presented in Table 2. Many patients showed no improvement despite medical therapy including inotropes and prostaglandin E_1 (PGE_1). Another risk factor was low body weight especially for those born premature where we had to delay the intervention whilst awaiting their growth. Additionally some patients were referred late, some were on ventilation

Table 1: Demographic and clinical data of patients.

Age (days)	Gender	Weight (kg)	Urine output (ml/kg/hr)		PGE_1 before	Ventilator mode	Duration of respiratory support before PBA	Inotropes support
			before	after				
62	M	3.5	1.2	4.8	N	MV	58	N
20	M	4	1.7	3.4	Y	None	N	N
132	F	3.4	1.5	3.1	N	MV	91	N
12	F	2.4	0.6	2.3	N	MV	12	Y
4	F	1.9	2.1	3.1	Y	CPAP	2	N
124	M	4.3	1.1	1.4	N	MV	5	Y
142	M	5	1.3	2.9	N	MV	62	N
64	M	4	0.9	2.8	N	Oxygen via NC	3	Y
24	M	3.7	2.7	3.6	Y	None	N	N
65	M	4.5	0.8	2.5	N	MV	22	Y
94	M	3.1	1.3	3.2	N	MV	53	N
103	M	4.5	2.1	2.7	N	Oxygen via NC	6	N
46	M	2.1	2.7	4.3	Y	Oxygen via NC	4	N
82	M	2.7	2.1	3.3	Y	Oxygen via NC	3	N

PGE_1 = prostaglandin E_1; M = male; F = female; N = none; Y = yes; MV = mechanical ventilation; CPAP = continuous positive airway pressure; NC = nasal cannula; PBA = percutaneous balloon angioplasty.

for a long time and some had chronic or systemic disease.

Associated Cardiac Lesions

Associated cardiac lesions and echocardiographic findings at presentation for each patient are presented in Table 2. Two thirds of the patients had moderate to severe right ventricular dilatation. Half of the patients had patent arterial duct, and few had hypoplasia of arch. One third of patients had large significant ventricular septal defects. Other associated cardiac lesions were double orifice mitral valve in one patient and severe aortic valve stenosis in another

Immediate Outcome after Balloon Dilation

Mean fluoroscopy time was 15.3 minutes (range 2–62 min), and procedure time (skin-to-skin) was 72 minutes (range 34–174 min). Two patients needed transfusion due to blood loss during procedure. Four patients had cold leg with absent pulses and were treated with heparin infusion for 48 hours which resulted in an improvement (these were not the infants who were cannulated with a 3-Fr sheath). The mean gradient across the coarctation dropped from 37 (range 6–90 mm Hg) to 14 mm Hg (range 0–40 mm Hg). The drop was of clinical relevance and statistically significant ($p < 0.0024$, 95% confidence interval 9.02–37.41). Detailed catheterization data are presented in Table 3.

Hospital Course until Discharge

All patients were weaned off ventilation or oxygen supplement within 72 hours after intervention, except two who continued to need support for six days. Before the procedure, four patients required inotrope support and five patients were on prostaglandin. Prostaglandin was stopped in all five patients within 48 hours of intervention. Two patients needed inotropes for a longer period of time (more than 48 hours) and ventilator support due to sepsis (*Pseudomonas aeruginosa* and *Staphylococcus* in blood culture).

Table 2: indication criteria for ballooning and echocardiography finding of all patients at presentation.

Associated cardiac lesions	Risk factors for surgical treatment	Presence of PDA	RV dilatation (function)	Aorta dimensions			
				AA	TA	DA	Isthmus
Discrete coarctation	Prolonged ventilation	Moderate	Severe (good)	7.2	6.6	4.6	2.9
Discrete coarctation, moderate ASD, large apical VSD	No response to medical therapy, large apical VSD	None	Mild (good)	7.5	7.1	3.1	2.7
Discrete coarctation, double orifice MV, subaortic membrane	Late referral, SCD, prolonged ventilation (130 days), CLD	Large	Normal, RVH (good)	10	6.6	4.3	2.0
Long segment coarctation, large unrestrictive inlet membranous VSD, mitral stenosis	Post-surgical arch reconstruction, poor myocardial function	Tiny	Mild, RVH (good)	6.4	2.5	2.4	2.1
Discrete coarctation, ASD secundum, large VSD	Low body weight associated with arch hypoplasia	Large	Mild (good)	5.7	3.1	2.3	1.4
Discrete coarctation	RSV infection, poor myocardial function, no improvement with medical therapy	None	Normal (good)	10	5	3.2	1.2
Discrete coarctation, moderate ASD	Late referral, CLD, dysmorphism, severe pharyngeal dysphagia.	Small	Moderate (good)	7	6	4.8	2.6
Discrete coarctation	Low cardiac output despite medical therapy	None	Mild (good)	7.8	5.6	6	1.8
Discrete coarctation	Poor myocardial function, no response to medical therapy	None	Mild, RVH (good)	10	3.7	4.3	2.2
Tight coarctation, bicuspid **AoV with stenosis, ASD secundum**	Prolonged ventilation, severe AoV stenosis, poor myocardial function despite prolong inotropes, (underwent dilatation for AoV, CoA)	None	Normal (good)	7.3	3.3	3.0	1.7
Long segment coarctation, large VSD	Extreme preterm, low birth weight (1.4 kg), Down's syndrome	Large	Normal (good)	5.8	3.2	2.3	1.7
Discrete coarctation	Late referral, pulmonary hypertension	Large	Severe (good)	5.1	3.6	3.5	1.8
Discrete coarctation, mild arch hypoplasia, ASD, bicuspid aortic valve	Premature, low body weight 1.7 kg. No response to PGE_1	None	Normal (good)	6.5	2.9	2.5	1.8
Discrete coarctation	No response to medical therapy	None	Normal (good)	7.4	4.8	3.2	1.2

ASD = atrial septal defect; VSD = ventricular septal defect; PDA = patent ductus arteriosus; RV = right ventricle; RVH = right ventricular hypertrophy; AoV = aortic valve; AA = ascending aorta; TA = transverse arch; D = descending aorta; SCD = sickle cell disease; CLD = chronic lung disease; RSV = respiratory syncytial virus; PGE_1 = prostaglandin E_1.

The clinical status improved in all patients. Echocardiographic assessment showed improvement in cardiac function. Mean urine output before intervention of all patients was 1.6 ml/kg/hour (0.6–2.7) which improved to 3.1 ml/kg/hour (1.4–4.8 ml/kg/hour) after dilatation. This improvement was statistically significant ($p < 0.0001$, 95% confidence interval -2.1 to -0.93). Detailed results are presented in Table 1.

Table 3: Catheterization data with outcome.

PGB	PGA	Gradient drop	Transfusion	Heparin	Follow up
65	22	43	None	None	Surgical repair
10	10	No change in gradient	None	None	Surgical repair
47	28	19	None	None	Surgical repair
40	40	No change in gradient	None	Needed for 48 hrs.	Surgical repair
28	13	15	None	None	Surgical repair
55	15	40	None	Needed for 24 hrs.	Redilation
40	12	28	Needed	Needed for 48 hrs.	Lost
22	0	22	None	None	Redilation
48	20	28	None	None	Surgical repair
10	6	4	None	None	No recoarctaion
30	0	30	Needed	None	Surgical repair
6	0	6	None	None	Lost
30	10	20	None	Needed for 48 hrs.	No recoarctaion
90	20	70	None	None	No recoarctaion

PGB = pressure gradient before the percutaneous balloon angioplasty; PGA = pressure gradient after the percutaneous balloon angioplasty.

Follow Up and Further Management

The mean follow up time was 25 months (range 15–58 months). One month survival was 100%, two year survival was 86% (two deaths, both not related to intervention). One patient died after 6 weeks of intervention due to *P. aeruginosa* and staphylococcal sepsis. The other died 13 months after intervention due to sickle cell crisis. Seven patients needed surgical repair due to recoarctation within a mean time of 12 weeks of intervention. Two patients needed redilation within 12 months of intervention. Three patients did not require any further intervention (follow up time: 15–31 months).

Discussion

The current paper presents the effectiveness of percutaneous balloon angioplasty in 14 patients with infantile aortic coarctation. All patients were considered for balloon angioplasty due to their multiple risk factors (Table 2) although surgical repair is the gold standard for this age group [13]. After percutaneous balloon angioplasty all infants showed significant clinical and hemodynamic improvement. No mortality was recorded in relation to the procedure. However, as reported in other studies, the restenosis rate was high. These results confirm previous reports that demonstrate that percutaneous balloon angioplasty is effective for stabilizing patients and, in some cases, improving survival [8, 14].

Successful percutaneous balloon angioplasty for neonatal aortic coarctation was reported in the early eighties [3]. It was initially described to be effective in neonates with discrete coarctation and good clinical condition [15, 16]. In the successive years, different authors have concluded that there is a prohibitive high incidence of recoarctation, especially in neonates [6, 7, 17]. Therefore, the role of angioplasty in this age group remained controversial [17]. Surgery remains the preferred choice for neonates and young infants, due to lower restenosis and aneurysmal rate as compared to percutaneous balloon angioplasty [18]. However morbidity as well as mortality has been reported to be higher in infants with poor preoperative clinical status, low cardiac output, associated cardiac lesions including long segment arch hypoplasia, additional systemic disease, and low body weight [19-22].

The dilemma arises when confronted with sick infants and those with associated general risk fac-

tor, as found in our series. In these cases, probably percutaneous balloon angioplasty is an effective and temporary alternative to surgery in order to minimize the operative risk and prepare them for safer final management [8, 14]. Other authors have proven the efficacy and safety of this treatment option in this category of infants [8, 14, 23]. Interestingly 35% of our patients did not require further surgical management.

At the time of intervention, our patients were relatively old (mean age 69 days). The main contributory reasons for this were prematurity (two patients), low birth weight (three patients), and late referral (seven patients). The patients with low birth weight needed time to achieve an acceptable weight in order to perform balloon angioplasty. Late referrals were those born in small rural hospitals where, unfortunately, there were fewer facilities and less experienced primary health care providers.

PGE_1 infusion is the primary medical management for stabilizing sick neonates with aortic coarctation [24-26]. This treatment option was not suitable for our patients as some referred late and some did not respond favorably to PGE_1.

Limitations of the Study

The authors acknowledge that the major limitations of this study are its retrospective nature as well as the relatively small number of patients. On the other hand, this category of patients is rare and hence a prospective study will take considerable time. It would have been interesting to compare our population to a control group of infants with similar clinical presentation undergoing surgical repair. Our treatment option and the previous similar reports confirm safety and efficacy of this management. Thus, such a prospective study would be unethical.

Conclusions

Percutaneous balloon angioplasty of aortic coarctation is safe and effective for neonates and infants with low body weight and hemodynamic instability. The procedure is not only helpful for stabilization of the extremely ill patients but also provides a bridging for them until future surgical repair. It should be considered as an emergent palliative procedure in this particular group of patients where other treatment alternatives are more risky.

Acknowledgements

We acknowledge Ms. Penelope Swift BSN, RM, RGN, RSCN, nurse manager, Comprehensive Cancer Centre, King Fahad Medical City. Ms. Swift is a native English speaker who assisted us with language editing and correction.

Conflict of Interest

The authors have no conflicts of interest relevant to this publication.

Comment on this Article or Ask a Question

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Cite this article as: Jadoon S, Segaier, ME, Galal, MO. Percutaneous Balloon Angioplasty for Aortic Coarctation in Newborns and Infants. Structural Heart Disease. 2016;2(4):91-97. DOI: http://dx.doi.org/10.12945/j.jshd.2016.005.15