

Interventional cardiac catheterization in infants weighing less than 2500 g

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Received: 1 July 2014, Accepted: 8 September 2014

SUMMARY: Karagöz T, Akın A, Aykan HH, Çeliker A, Alehan D, Özer S, Özkutlu S. Interventional cardiac catheterization in infants weighing less than 2500 g. Turk J Pediatr 2015; 57: 136-140.

The aim of our study was to share our clinical experience regarding cases of interventional cardiac catheterization in low-weight infants. We retrospectively reviewed all interventional catheterizations performed in infants weighing 2500 g or less between March 2001 and October 2012. Twenty patients were included in the study. The procedures included balloon atrial septostomy in 8 patients, balloon pulmonary valvuloplasty in 7 patients, balloon aortic valvuloplasty in 3 patients and balloon angioplasty for coarctation in 2 patients. The mean age at catheterization was 11.9 ± 9.6 days (range, 1 to 31 days) and the mean weight, 2038 ± 480 g (range, 1100 to 2500 g). The mean procedure time was 80.3 ± 32 minutes, and the mean fluoroscopy time was 17.5 ± 12 minutes. Only two patients had no benefit from the intervention. One patient died at day 4 after catheterization, due to sepsis. Complications occurred in 3 patients: one patient developed atrial flutter and respiratory arrest, one patient developed apnea episodes, and one patient developed anemia that required transfusion. In conclusion, although studies investigating complications related to invasive cardiac catheterization in infants weighing less than 2500 g have reported increased complication rates, such complications were less likely to result in permanent sequelae. We did not observe significant complications related to the procedure; therefore, we would like to suggest that invasive cardiac catheterization can appropriately be performed in low-weight infants.

Key words: low birth weight infants, invasive cardiac catheterization, complication.

The increased survival of low-weight infants entails the possibility that some of these infants might be candidates for cardiac catheterization. Advances in cardiac catheterization techniques and equipment have facilitated catheterization in low-weight infants¹. This study investigated the outcomes of cardiac catheterization performed in infants weighing 2500 g or less in a single center over a 10-year period.

Material and Methods

We retrospectively reviewed all interventional catheterizations performed on infants weighing 2500 g or less in our Pediatric Cardiology cardiac catheterization laboratory between March 2001 and October 2012. A total of

twenty patients were included in the study. Demographic characteristics, diagnosis, type of interventional procedure, procedural success, complications, procedure/fluoroscopy duration and equipment used during the intervention were recorded retrospectively.

Results

The mean age was 11.9 ± 9.6 days (range, 1 to 31 days), and the mean body weight, 2038 ± 480 g (range, 1100 to 2500 g). Mean procedure time was 80.3 ± 32 minutes (range, 45 to 150 minutes), and mean fluoroscopy time, 17.5 ± 12 minutes (range, 1.8 to 53 minutes). Eight patients underwent balloon atrial septostomy (BAS), 7 patients underwent

pulmonary balloon valvuloplasty (PBV), 3 patients underwent aortic balloon valvuloplasty (ABV) and 2 patients underwent balloon aortic angioplasty for aortic coarctation (BAA). A 3-4 Fr introducer sheath was used in patients undergoing artery cannulation, and a 4-6 Fr introducer sheath used in vein cannulation. Complications occurred in 3 patients. One patient (2000 g) who underwent BAS developed atrial flutter and respiratory arrest, which were corrected with intervention. Another patient (2500 g) who underwent BAS developed anemia that required transfusion, and a patient who underwent PBV (1270 g) developed short-term apnea episodes. A patient who underwent BAA died due to sepsis at day 4 after the procedure. The remaining patients did not experience any problems in the short-term follow-up period. No procedure-related mortality was observed. Table I shows the characteristics of infants undergoing interventional cardiac catheterization.

In patients undergoing BAS, mean oxygen saturation before and after the procedure was found to be 54% (range, 51%-57%) and 81% (range, 74%- 85%), respectively. Mean diameter of the atrial septal defect was measured as 3.7 mm before the procedure and 6.1 mm after it.

The mean pulmonary gradient in patients who underwent PBV was 82 mmHg (range, 55 to 107 mmHg) before the procedure and 23 mmHg (range, 7 to 47 mmHg) after it. Mean size of the pulmonary valve annulus was 5.7 mmHg (range, 5.5 to 6.2 mmHg) before the procedure. Tyshak® 4-8 mm balloons were used in the procedure. In one patient, PBV was repeated 1.5 months after the initial procedure (at 2 months of age) because of increased pulmonary artery gradient (52 mmHg); pulmonary valve gradient was measured at 12 mmHg after the second valvuloplasty. The lowest-weight patient to undergo PBV was 17 days old and 1270 g. In this patient, the pulmonary valve was accessed by a hydrophilic catheter passed through a 4 Fr sheath placed in the femoral vein, with the help of a 0.014-inch Roadrunner® guidewire. The valvuloplasty was performed using a 5 mm x 2 cm Tyshak II® balloon.

Of the two patients who underwent BAA, the procedure was successful in one patient, but failed in the other, who was 3 days old, weighed 2500 g and was diagnosed as hypoplastic left

heart syndrome, since the stenotic site had elastic properties. This patient died due to sepsis after 4 days (at the age of 7 days). The other patient was 17 days old and had the lower weight (1200 g) of the two. In this patient, a 3 Fr sheath was placed in the femoral vein. An attempt was made to pass through the descending aorta using a 2.5 Fr microcatheter and a 0.014-inch coronary guidewire. Although Cobra and other hydrophilic catheters were used, the coarcted segment could not be passed anterogradely. We then tried placing a 3 Fr sheath in the femoral artery; because of the unsuccessful attempts, contrast fluid was manually injected into the distal part of the coarcted segment through the dilator of the sheath. A 0.014-inch guidewire was then advanced through the dilator to the thoracic aorta and the coarctation point was passed using a 2 Fr microcatheter. A 4 mm x 2 cm coronary balloon was then placed over the guidewire, and BAA was successfully performed. The diameter of the coarcted region measured 4.4 mm after the procedure.

The ABV procedure was successful in 2 (1100 and 2400 g) of the 3 patients who underwent it; however, the procedure failed due to a dysplastic valve in the other patient, who had been diagnosed with critical aortic stenosis. The 1100 g patient, the lowest-weight infant in the study, was a premature (gestational age 31 weeks) 6-day-old newborn. He was diagnosed as patent ductus arteriosus and critical aortic stenosis by means of echocardiography. At diagnosis, the ejection fraction was 34%, the bicuspid aortic annulus was 4 mm, and the aortic flow was passing through an area of only one mm². A 4 Fr sheath was placed in the femoral vein, and a 0.014-inch (182 cm) coronary guidewire (Boston Scientific, CholCE™ floppy) was delivered to the aortic arch by passing through the atrial septal defect, left atrium and left ventricle. Valvuloplasty was performed three times using a 4 mm x 2 cm coronary balloon (Boston Scientific, Monorail™ Maverick™ PTA dilatation catheter). Aortic gradient at the level of the valve after ABV was 18 mmHg.

Discussion

The rate of mortality after invasive cardiac catheterization in infants weighing less than 2500 g has been found to range between 0%

Table I. Characteristics of Infants Undergoing Interventional Cardiac Catheterization

Patients	Weight (grams)	Age (days)	Disease	Procedure	Success	Complications	Procedure time (minutes)	Fluoroscopy time (minutes)
1	1100	6	AS, PDA, ASD	AV	Yes	No	50	4
2	1200	17	COA, ASD, MY	AA	Yes	No	120	53
3	2500	3	HLHS, COA, PDA, MS, ASD	AA	No	No	150	3
4	1800	1	AS, PDA, ASD	AV	No	No	55	11
5	2400	6	AS, PFO	AV	Yes	No	60	12
6	1270	17	PS, PFO	PV	Yes	Apnea	60	10
7	1600	29	PS, PDA	PV	Yes	No	50	10
8	1900	31	PS	PV	Yes	No	90	8.6
9	2200	16	PS	PV	Yes	No	105	24.7
10	2300	6	PS, PFO	PV	Yes	No	60	13.2
11	2400	1	PS, PDA	PV	Yes	No.	60	13
12	2500	29	PS, VSD, PFO, PDA	PV	Yes	No	60	8.4
13	1500	2	d-TGA, PDA, ASD, pulmonary artery hypoplasia	BAS	Yes	No	65	18
14	2000	6	TGA, PS, VSD, ASD, tortuous aorta	BAS	Yes	Bradycardia, atrial flutter, respiratory arrest	120	36
15	2000	12	d-TGA, VSD, PDA, PH	BAS	Yes	No	90	24
16	2100	18	d-TGA, PDA, PFO	BAS	Yes	No	45	9.4
17	2500	10	TA, VSD, ASD, HRV, pulmonary artery hypoplasia	BAS	Yes	No	65	21
18	2500	19	TGA, small VSD, PDA, PH	BAS	Yes	No	90	24
19	2500	7	d-TGA, ASD	BAS	Yes	No	45	1.8
20	2500	2	d-TGA, VSD, ASD, PDA	BAS	Yes	Anemia requiring transfusion	60	24

AA: aortic angioplasty, AS: aortic stenosis, ASD: atrial septal defect, AV: aortic valvuloplasty, BAS: balloon atrial septostomy, COA: coarctation of the aorta, HLHS: hypoplastic left heart syndrome, HRV: hypoplastic right ventricle, MS: mitral stenosis, MY: mitral valve insufficiency, PDA: patent ductus arteriosus, PFO: patent foramen ovale, PH: pulmonary hypertension, PS: pulmonary stenosis, PV: pulmonary valvuloplasty, TA: tricuspid atresia, TGA: transposition of the great arteries, VSD: ventricular septal defect.

and 39%; however, mortalities were reported to have been the result of causes not directly related to catheterization¹⁻³. In studies of similar patient groups, the rate of complications related to the procedure has been reported to be 21%-56%^{2,3}. The most common complications were arrhythmias, deterioration of respiration, bleeding and a decrease in arterial perfusion¹⁻⁴. We did not observe any procedure-related mortalities in our study; however, one patient with the diagnosis of hypoplastic left heart syndrome died due to sepsis 4 days after balloon angioplasty for aortic coarctation. Our procedure-related complication rate was found to be 15%.

Simpson et al.¹ performed BAS in 16 patients weighing less than 2500 g and noted minor complications in 3 patients and major complication in 2 patients (deterioration of respiration in 1 patient and femoral vein ligation after femoral vein cutdown in the other patient). One patient developed atrial flutter related to catheter manipulation; sinus rhythm was achieved after intervention. Anemia requiring transfusion developed in 1 patient after the procedure.

Sutton et al.³ performed ABV in 4 patients weighing less than 1500 g; 2 patients died due to reasons not related to the catheterization. In our study, no complications occurred in the 3 patients who underwent ABV. It was reported that transapical ABV using a hybrid method was successfully carried out in a newborn weighing 890 g⁵. In addition, Koestenberger et al.⁶ reported a successful transcarotid ABV in a 1100 g newborn. To the best of our knowledge, the 1100 g newborn in our study is the lowest-weight case in the literature to have undergone transvenous-antegrade ABV⁷. Therefore, although transarterial, transapical and transcarotid ABV can be used in low birth weight newborns, transvenous-antegrade ABV, which is less invasive than other methods, may be preferred.

In the literature, the number of cases less than 2500 g undergoing balloon angioplasty of aortic coarctation is limited. The procedure has been successful in an infant weighing 460 g, who underwent transumbilical angioplasty for aortic coarctation; no procedure-related complication was observed⁸. In our study, the procedure was successful in one patient who weighed 1200 g,

with no complications occurring; however, the procedure failed in the other patient due to elastic recoiling properties of the stenotic site.

The rate of mortality after PBV has been reported to be 3-6% in infants undergoing the procedure. Simpson et al.¹ performed 9 pulmonary valvuloplasty procedures in 8 patients weighing less than 2500 g, and no procedure-related mortalities occurred; however, complications were seen in 4 patients (atrial flutter, femoral vein injury, hypoxic spell, metabolic acidosis). Sutton et al.³ performed transcatheter pulmonary valve dilatations in 3 patients weighing less than 1500 g; systolic valve gradient before and after the procedure was reported to be 40-70 mmHg and 5-15 mmHg, respectively. In our study, mean systolic valve gradient before and after the procedure was 82 mmHg and 23 mmHg, respectively. Of the 7 patients who underwent PBV, one developed episodes of short-term apnea, from which recovery was spontaneous; no complications occurred in the other patients.

Simpson et al.¹ performed BAS in 16 patients, PBV in 10 patients, pulmonary artery angioplasty in 1 patient, myocardial biopsy in 1 patient and collateral vein coil occlusion in 3 patients. In these 31 patients weighing less than 2500 g, only one mortality was reported, in the patient who underwent myocardial biopsy. The reported complication rate was 42%. The most common complications were arrhythmia (3 patients, 10%) and deterioration of respiration (3 patients, 10%). Chen et al.² performed cardiac catheterization in 14 infants weighing less than 2500 g and noted complications in 3 patients (supraventricular tachycardia, bleeding, linear dissection of the coarctation).

Sutton et al.³ compared 18 patients weighing less than 1500 g with 54 patients weighing between 2-3 kilograms who underwent catheterization in the first 6 months of life, and found no difference between the groups in terms of the total complication rate (57% vs. 56%). They reported mortality in 7 patients (39%); however, they did not report any mortality that was directly catheter related³.

Items used in interventional procedures in low-weight infants—such as intraducers, wires, needles and catheters—should be selected carefully to minimize complications related to catheterization. We thus chose 21 Ga x 2.5 cm

(0.021 inch) needles, and small-size sheaths (3 or 4 Fr) and guidewires (0.014 inch) for arterial interventions in our patients. The stenotic area should be passed with the possible smallest sheath in newborns with critical aortic stenosis and aortic coarctation. Hence, we generally used 2.5 Fr microcatheters in these patients. If possible, the antegrade approach seems more reliable in patients with aortic stenosis, according to our experience. Coronary balloons or guidewires may be preferred for use in small vessels where Tyshak® balloons are not suitable.

In invasive procedures, the complication rate is expected to increase with decreasing body weight. However, although studies investigating complications related to invasive cardiac catheterization in infants weighing less than 2500 g did report an increased complication rate in this group of infants, such complications were less likely to result in permanent sequelae. Therefore, we would like to suggest that invasive cardiac catheterization may be appropriately performed in low-weight infants.

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