

Complications of pediatric cardiac catheterization: 18 - month study*

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Pediatric cardiac catheterization may be indicated under certain conditions, but is associated with some risk. The purpose of the study was to evaluate the complications associated with diagnostic and interventional catheterization procedures done over an 18-month period in our laboratory. Of the 230 cardiac catheterizations, 204 were solely diagnostic in nature. Eleven percent were interventional catheterizations including aortic and pulmonary valvuloplasties and balloon atrial septostomy. Six percent of the patients constituted grown-up congenital heart disease (GUCH). The median age was 34 months excluding the GUCH group. There was one death below one year of age (0.4% mortality) occurring six hours after the diagnostic catheterization; it was attributed to the underlying disease. There were eight complications (3.4%) that we would consider serious, including atrial flutter, ventricular tachycardia, severe hypercyanotic spell, seizure, transient complete heart block, peripheral vascular injury which resulted in pseudoaneurysm formation of the femoral artery requiring surgical intervention, and transient pulse loss. When catheterization is necessary, it should be carried out as efficiently as possible with awareness of conditions that probably increase the risk of a clinically important event. Although patients undergoing cardiac catheterization are now younger and have more complex cardiac abnormalities, the procedure seems to have become safer when compared to previous literature.

Key words: catheterization, interventional, pediatric, complications.

Despite advances in noninvasive evaluation, cardiac catheterization and angiocardiology continue to be essential for patients with congenital heart disease, but they are associated with some risk. The risks leading to complication may be reduced with appropriate patient selection and pericatheterization medical management^{1-6,10}. The incidence of major complications and death associated with pediatric cardiac catheterization is reported to have decreased markedly compared to the results a few decades ago². The majority of the complications are either successfully treated or are self limited. However, interventional catheterization has been reported to introduce a small number of new complications⁷⁻¹⁰, although technological advances seem to contribute significantly to the reduction of the risks. The aim of the present

study was to describe the complications and treatment and prevention techniques in a relatively new pediatric catheterization laboratory.

Material and Methods

We report the complication rate among 230 pediatric cardiac catheterizations and angiocardiology performed from December 1996 until July 1998. The files of these cases were reviewed retrospectively and analyzed. The diagnoses and complications are displayed in Tables I and II, respectively. Eleven percent of procedures were interventional, including pulmonary valvuloplasty, peripheral pulmonary angioplasty, aortic valvuloplasty and balloon atrial septostomy. Seven neonates aged five to 11 days underwent balloon atrial septostomy (Table III). Twelve patients with an age range

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of 2.5 to 15 years (mean 7.1 years) underwent pulmonary balloon valvuloplasty, one of whom had tetralogy of Fallot and left pulmonary artery cut-off following left-sided modified Blalock-Taussig shunt (Table IV). Seven patients, aged two months to eight years (mean: 4.5 years) underwent aortic balloon valvuloplasty (Table V). Two patients, aged 20 months and three years, underwent peripheral pulmonary angioplasty. Seven percent of the patients were in the grown-up congenital heart disease (GUCH) group. Totally, the age range was one day to 39 years (mean: 7.5 years). Excluding the GUCH group, the age range was one day to 17 years (mean: 34 months). Three-and-a-half percent of the patients were under one month. Twenty-two percent were between the ages of one month and two years. Twenty percent were between the ages of two and five years. Forty-seven-and-a-half percent were between five and 17 years. Pulmonary hypertension was present in 6.9 percent of the patients with left-to-right shunting lesions (age range: 26 months-11 years, mean: 6 years). Eisenmenger's syndrome was present in three patients (age range: 3-12 years), two of whom were Down's syndrome and atrioventricular septal defect. In the third, aorto-pulmonary window with a ventricular septal defect (VSD) was present. Persistent left superior vena cava was present in three patients with VSD, and in three patients with tetralogy of Fallot (TF), coronary sinus type atrial septal defect (ASD) and aortic coarctation. Interrupted inferior vena cava with azygos continuation accompanied tricuspid atresia, dextro-transposition of the great arteries, pulmonary stenosis (PS) and common atrium associated with polysplenia syndrome. Nine patients in the GUCH group had ASD, two PS, two TF, one VSD and PS, one patent ductus arteriosus, one aortic coarctation, and one corrected transposition of the great arteries and ASD.

Catherizations were performed by previously described techniques¹. Patients under one year of age were usually sedated by administration of oral chloral hydrate (50 mg/kg). A mixture of demoral, thorazine, phenergan (0.1 ml/kg, max: 2 mg) or 0.1 mg/kg subcutaneous morphine HCl was administered to older patients. Heparin (50-100 U/kg/dose) was given based on cardiologist's preference. Cineangiography was performed in nearly all patients. Nonionic, low osmolality contrast material was used at a maximum dose of 5-6 ml/kg/catheterization.

Table I. Frequency of Congenital Heart Lesions

Lesions	% of All lesions
Ventricular septal defect	26
Atrial septal defect	16
Tetralogy of Fallot	15
Pulmonary stenosis	9
Coarctation of aorta	7
Aortic valve stenosis	6
Patent ductus arteriosus	5
Post-operative	4
Double-outlet right ventricle	3.5
Dextrocardia	2
Atrioventricular septal defect	2
Dextro-transposition of the great arteries	1.7
Others*	2.8

* Tricuspid atresia, corrected transposition of the great arteries, total abnormal pulmonary venous return, subaortic stenosis, pulmonary atresia, cor triatriatum, Shone's complex, aorto-pulmonary window, double arcus aorta.

Table II. Complications of 230 Diagnostic and Interventional Pediatric Cardiac Catheterizations

Major	Number of patients	Minor	Number of patients
A) Death within 24h of catheterization	1	A) Arrhythmias	
B) Arrhythmias		a) Supraventricular tachycardia	7
a) Ventricular tachycardia	1	b) Atrial flutter	1
b) SVT	1	c) Sinus bradycardia	3
C) Catheter problems		d) 3° AV-block	1
a) Breakage or kinking	1	B) Arterial	4
D) Hypoxic spells	2	a) Weak or absent pulses after catheterization with good capillary refill	2
E) Hypothermia	1	b) Pseudoaneurysm formation surgical exploration and repair	2
F) CNS seizure	1	C) Myocardial staining with or without ST-T changes but without perforation	2
		D) Blood loss not requiring transfusion	3
Total	8 (3.4%)	25 (10.9%)	

(SVE: supraventricular tachycardia, CNS: central nervous system, AV: atrioventricular).

Table III. Immediate Results of Balloon Atrial Septostomy

	Before	After
Aortic oxygen saturation	17.5 ± 4.4%	74 ± 18%
Serum bicarbonate	5.5 ± 1.6	14 ± 2.2
Mean RA pressure (mmHg)	4.7 ± 1.1	5.7 ± 0.9
Mean LA pressure (mmHg)	10 ± 1.5	5.75 ± 1.2

(RA: right atrium, LA: left atrium).

Table IV. Immediate Results of Pulmonary Balloon Valvuloplasty

	Before	After
Systolic RV pressure (mmHg)	132 ± 58	59 ± 36
Systolic PA pressure (mmHg)	21 ± 9	32 ± 8
Gradient (RV-PA)	110 ± 46	37 ± 22

(RV: right ventricle, PA: pulmonary artery).

Table V. Immediate Results of Aortic Balloon Valvuloplasty

	Before	After
Systolic left ventricular pressure (mmHg)	173 ± 25	117 ± 37
Systolic aortic pressure (mmHg)	96 ± 14	80 ± 19
Left ventricular-aortic gradient (mmHg)	85 ± 10	34 ± 16

(RV: right ventricle, PA: pulmonary artery).

Balloon atrial septostomy was performed using Edwards-Miller catheter in seven neonates with the diagnosis of transposition of the great arteries. Arterial blood gases were obtained before and after the procedure. The indication for pulmonary balloon valvuloplasty was a peak Doppler echocardiographic gradient of 50 mmHg or more. Mean annulus to balloon ratio was 59 ± 16 percent. Aortic balloon valvuloplasty was performed in patients with peak instantaneous Doppler gradient of 50 mmHg or more and mild aortic regurgitation at most. The ratio of the annulus to balloon size was 1 ± 0.08 in our patients.

A life-threatening event requiring immediate treatment was considered a major complication. A transient event that had no long-term ill effect on the patients and was resolved with specific treatment was considered a minor complication.

Results

There were eight major (3.4%) and 25 minor (10.9%) complications in our study group (Table II). Eighty-seven-and-a-half percent of the major complications occurred in patients less than five years of age. The complication rate in the GUCH group was zero. Two of the major (0.86%) and five of the minor complications (2.1%) occurred in the interventional catheterization group.

Death: There was one death below one year of age (0.4% mortality) occurring six hours after the diagnostic catheterization which was attributed to the underlying disease. This patient, who was a six-month-old male with truncus arteriosus, developed high fever and febrile

seizures within six hours of the procedure. During a seizure he developed cardiopulmonary arrest which did not respond to resuscitation.

Arrhythmias: A serious episode of ventricular tachycardia occurred in a five-month-old patient with tricuspid atresia, hypoplastic right ventricle and systemic venous return abnormality during contrast material injection into the presumed hypoplastic ventricle. Following intravenous lidocaine bolus, ventricular tachycardia (VT) subsided immediately and continued in the form of 2:1 ventricular ectopic beats within several minutes of lidocaine infusion.

2:1 atrial flutter followed by VT occurred and resolved spontaneously in an eight-month-old patient with single ventricle physiology and heterotaxy syndrome.

Spontaneously resolving supraventricular tachycardia was noted in seven patients (3%). Intravenous administration of verapamil was necessary in only one patient. Sinus bradycardia accompanied pulmonary balloon valvuloplasty in three cases. Spontaneously resolving transient complete heart block occurred in an eight-year-old patient with Down's syndrome, atrioventricular septal defect, Eisenmenger's syndrome and alternating 2:1 and 3:1 block.

Arterial Complications: Four arterial complications were noted (1.7%). Two patients, aged 35 days and 2.5 months, had decreased pulses in the limb; an arterial catheter had been placed beyond two hours in both. Decreased pulses returned to normal following intravenous heparinization at a dose of 1 ml/kg bolus followed by 20 U/kg/hr for a mean period of 36 hours⁴. None required thrombolytic therapy or surgical thrombectomy^{5,6}. In two cases, pseudoaneurysm of the femoral artery developed and was surgically repaired approximately two weeks after the catheterization.

Catheter Problems: Kinking of the balloon catheter occurred during the pulmonary balloon valvuloplasty, but it was successfully drawn through the introducer sheath.

Hypercyanotic Spells: Hypoxic spells occurred in two patients, aged six months and 18 months. The latter patient was a tetralogy of Fallot who had undergone left modified Blalock-Taussig shunt. He manifested with the symptoms approximately 12 hours after the procedure. Both patients responded well to medical treatment.

Seizure : A 12-year-old boy with pulmonary stenosis and suprasystemic right ventricular pressure developed seizure during the first episode of balloon inflation and deflation.

Bleeding : Prolonged bleeding from the entry site at the groin occurred in three infants who were severely cyanotic and manifested elevated hematocrit levels.

Discussion

Current risk of pediatric catheterization is reported to have decreased significantly when compared to previous results within the same institution¹. The incidence of major complications was 3.4 percent and of minor complications 10.9 percent in all age groups in our study population. Cassidy et al.² reported an incidence of 1.4 percent for major and 6.8 percent for minor complications, lower compared to our results. Yet, our results may be assumed reasonable considering the reported data reflects our initial experience in a new unit. In this study, the majority of complications occurred in patients less than two years of age. Seventy-one percent of the major and 47 percent of the minor complications were seen in the infant group (Table II).

The risk of perforation is also greater in newborns and infants. Therefore, infants should be considered a high risk group regarding all aspects of catheterization procedures. Arterial problems are reported to be as high as 15 percent in the neonatal group, as was the case in our study group⁴⁻⁶. However, prophylactic use of heparin in prolonged procedures should decrease the incidence of such complications. Cyanotic patients constitute another group of major complications. Arrhythmias, bleeding at the entry site, hypoxic spells and major events such as death have been shown to occur more commonly in the cyanotic infant group. Hypoxic spells may be prevented with administration of intravenous fluids to avoid dehydration in the pre-catheterization period, use of low osmolality, nonionic contrast material and with careful manipulation at the right ventricular outflow tract. Mean hematocrit and arterial oxygen saturation of the cyanotic patients who manifested minor complications were 55 ± 9 and 77 ± 10 percent, respectively.

In this study, only two major complications occurred during interventional catheterizations. Arterial problems were seen in none of the patients undergoing aortic balloon valvuloplasty^{5,6}.

It may be stated that interventional catheterizations introduced a small number of new complications when compared to previous literature^{1-3,7,8,11}.

In conclusion, the majority of the catheterization complications were successfully treated or were self limited. Careful planning and keeping the duration of the procedure short as far as possible, supervision of relatively inexperienced personnel and recognition of high risk procedures should certainly result in decreased possibility of complications.

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