

Neonatal Cardiac Catheterization: A 10-Year Transition from Diagnosis to Therapy

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Abstract. To assess the changing role of cardiac catheterization in the care of the neonate, a retrospective review of all catheterizations between January 1984 to December 1985 (group I) and January 1994 to December 1995 (group II) at C.S. Mott Children's Hospital was performed. Neonatal cardiac catheterization was performed more frequently ($p = 0.02$) in group I, comprising 14% (110 of 772) of all catheterizations versus 11% (93 of 880) in group II. Access was performed by cut-down in 15 patients (13 venous and 2 arterial), all in group I. In group I, 20 of 110 patients (18%) had balloon atrial septostomies; no other catheter interventions were performed. Interventions were more frequent ($p = 0.003$) and varied in group II, including 15 septostomies, 17 balloon valvuloplasties (13 pulmonary and 4 aortic), 2 coil embolizations of collaterals, and 1 cardiac biopsy. Despite the higher prevalence and complexity of interventions in group II, fluoroscopy times (median; range: 16 min; 2–55 vs 16 min; 1–107) were similar in both groups ($p =$ not significant) as well as the prevalence of complications. Neonatal cardiac catheterizations are performed less frequently than they were a decade ago at our institution, and therapeutic interventions have become more common. Despite these changes, fluoroscopy time and the rate of complications have not increased.

Key words: Neonatal — Cardiac catheterization

Cardiac catheterization in the neonate has been an important diagnostic tool for several decades. However, since the advent of two-dimensional echocardiography and color-flow Doppler, cardiac catheterization is less frequently essential for anatomic and hemodynamic diagnosis. Concurrently, the introduction of lower profile catheters and intravascular devices brought transcatheter therapies to the neonate as diagnostic catheterization was

replaced by echocardiography. To evaluate these rapidly changing practices in pediatric cardiology, we review our experience with neonatal cardiac catheterizations during a period of 10 years at a single institution.

Methods

A retrospective review of all cardiac catheterizations performed from January 1984 through December 1985 (group I) and January 1994 through December 1995 (group II) at C.S. Mott Children's Hospital was performed. Inclusion criteria for the study included all neonates (≤ 28 days) who underwent cardiac catheterization and excluded those who entered the catheterization laboratory for other procedures. Catheterization reports were reviewed to determine age and weight at the time of the procedure. Cardiac catheterization quality assurance forms completed by the catheterization clinical nurse specialist were reviewed to assess complications. Method of vascular access, indication for catheterization, fluoroscopy times, and complications were also noted. All values are expressed as median with ranges. Categorical variables were compared by contingency analysis and continuous variables by analysis of variance.

Results

There were 772 cardiac catheterization procedures in 1984 and 1985, of which 110 neonatal procedures (14%) were performed in group I. This proportion was significantly ($p = 0.02$) higher than the 93 neonatal procedures in group II, which represented 11% of the 880 total catheterizations. Neonatal catheterization was performed at an earlier age ($p = 0.02$) in group I; however, weights were similar ($p =$ not significant [NS]) in both groups (Table 1). The diagnoses in each group are listed in Table 2.

Vascular access was achieved by cutdown in 15 patients in group I, with 11 patients who required cutdown for venous access, 2 patients for arterial access, and two patients who required cutdown for both venous and arterial access. In contrast, no patient in group II underwent cutdown for vascular access ($p < 0.001$), although

Table 1. Comparison of ages and weights of groups I and II

Parameter	Group I	Group II	<i>p</i>
Age (median; range)	3 days; 1–28 days	6 days; 1–28 days	0.02
Weight (median; range)	3.3 kg; 1.2–4.7 kg	3.2 kg; 1.6–4.6 kg	NS

NS, not significant.

Table 2. Cardiac diagnoses of groups I and II

Diagnosis	Group I	Group II
Aortic stenosis	2	5 (4) ^a
Anomalous left coronary artery	0	2
Anomalous pulmonary venous return	8	3 (1) ^a
Arteriovenous malformations	1	0
Cardiomyopathy	1	2 (1) ^a
Coarctation of the aorta	25	4
Discontinuous pulmonary arteries	0	1
Double-inlet left ventricle	2	4
Double-outlet right ventricle	4	3
Double-outlet left ventricle	0	1
Ebstein's anomaly	0	1
Endocardial cushion defect	4	5 (1) ^a
Hypoplastic left heart syndrome	7 (1) ^b	7 (1) ^{a,b}
Persistent fetal circulation	4	0
Pulmonary atresia/ventricular septal defect	2	9
Pulmonary atresia/intact ventricular septum	6 (2) ^b	4
Pulmonary stenosis	6	13 ^a
Supraventricular tachycardia	2	0
Tetralogy of Fallot	4	9 (1) ^{a,b}
D-transposition of the great arteries	17 (15) ^b	16 (12) ^{a,b}
L-transposition of the great arteries	5 (1) ^b	0
Tricuspid atresia	3 (1) ^b	1 (1) ^{a,b}
Truncus arteriosus	5	2
Ventricular septal defect	2	1
<i>Total</i>	110	93

^a Numbers in parentheses indicate the numbers of patients in which the therapeutic catheterization procedure was performed.

^b Numbers in parentheses indicate the numbers of patients in which balloon atrial septostomy was performed.

catheterization was aborted in 1 patient due to lack of access and 3 patients underwent catheterization via the transhepatic venous approach.

Cardiac catheterization was performed for primarily diagnostic purposes in all 110 neonates in group I. In contrast, 58 of 93 neonates (62%) in group II underwent diagnostic catheterization ($p < 0.001$). As indicated in Table 2, anomalous pulmonary venous return, coarctation of the aorta, and truncus arteriosus were common indications for diagnostic cardiac catheterization in 1984 and 1985, but these require catheterization less frequently in contemporary practice. Transcatheter therapy was more often the indication for cardiac catheterization in group II compared with group I. The proportion of

Table 3. Complications encountered during neonatal cardiac catheterizations from January 1984 to December 1985 (group I) and January 1994 to December 1995 (group II)

Complications	Group I	Group II
Cardiopulmonary resuscitation	4	3
Death	2	0
Dissection with tamponade	1	1
Embolization of guidewire fragment	0	1
Electrophysiologic events	37	13
Hypercyanotic spell	1	3
Hypotension	1	6
Hypothermia	2	0
Perforation of right ventricular outflow tract	0	4
Respiratory distress	3	1
Stain	1	1
Vascular complications	24	7
<i>Total</i>	76 (in 50% of patients)	41 (in 37% of patients)

neonatal cardiac interventions was significantly different between the two study periods ($p = 0.003$) with therapeutic catheterizations comprising 20 of 110 (18%) neonatal catheterizations in 1984 and 1985, consisting exclusively of balloon atrial septostomies; in all these neonates catheterization was also performed to obtain diagnostic data. However, in 1994 and 1995, therapeutic procedures were performed in 35 of 93 (38%) neonates, including balloon atrial septostomies ($n = 15$) as well as pulmonary balloon valvuloplasties ($n = 13$), aortic balloon valvuloplasties ($n = 4$), coil embolization of collaterals ($n = 2$), and endomyocardial biopsy ($n = 1$).

Despite the higher prevalence and complexity of interventions performed in group II, the rate of complications was similar to that of group I ($p = \text{NS}$; Table 3). Of note is the high incidence of vascular complications in group I, including absent or decreased femoral pulse ($n = 17$) and venostasis ($n = 5$), in comparison to group II, which had no reported instances of vascular complications. The incidence of blood transfusions was significantly higher in group I ($p < 0.001$) with 83 (75% of patients) transfusions performed, with only 3 associated with hypotension and 2 with excessive bleeding. In contrast, transfusions were performed in 23 patients (35%) in group II for hypotension ($n = 3$), perforation of the right ventricular outflow tract during pulmonary valvuloplasty ($n = 2$), dissection with tamponade ($n = 2$), and excessive blood loss ($n = 1$). Fluoroscopy times (16 min; 2–55 vs 16 min; 1–107) did not differ between the groups ($p = \text{NS}$).

Discussion

The data presented herein document the rapid changes that have occurred in the practice of neonatal cardiology

during the past decade. The indications for neonatal cardiac catheterization, associated with increased death and morbidity [1], have shifted from predominately diagnostic to a nearly equal mix of diagnostic and therapeutic procedures. Advances in echocardiography have largely eliminated the need for diagnostic catheterization studies in neonates with anomalous pulmonary venous return, coarctation of the aorta, and truncus arteriosus. The decreased need for diagnostic catheterization for coarctation of the aorta became more evident in 1987 as described by George et al. [2]. However, therapeutic catheterization procedures for the neonate with critical pulmonary or aortic stenosis, which were not available in 1984, are now commonplace. Thus, the care of neonatal heart disease has become substantially less invasive in the past decade, with a shift in diagnosis from the catheterization laboratory to the echocardiogram suite and a concomitant shift in some therapies from the operating room to the catheterization laboratory.

In addition to the changing indications for neonatal cardiac catheterization, our data also show that neonatal catheterizations currently comprise a smaller proportion of pediatric catheterizations than in the previous decade (14% vs 17%; $p = 0.02$). This comparison is likely to be confounded by changing indications for cardiac catheterizations beyond the neonatal period. When the number of pediatric open heart operations is used as a more consistent basis comparison, the decrease in neonatal cardiac catheterizations is even more dramatic, decreasing from one case per 2.50 pediatric open hearts in 1984 to one case per 10.04 open hearts in 1994 ($p < 0.0001$). Thus, although the raw number of neonatal catheterizations has remained essentially unchanged, they have become less common as the pediatric cardiology program at our center has grown when compared to total number of cardiac catheterizations and pediatric open heart surgeries.

Transfusions were more prevalent in group I compared to group II (75% vs 35%) which may reflect more judicious use of transfusions in the era of increased awareness of HIV. The use of blood transfusions has become more reserved for specific indications, especially those related to complications as a direct result of catheterization rather than for palliation of a cyanotic newborn with low hematocrit. Transfusions in response to complications comprise a greater proportion (8 of 23; 35%) of transfusions in group II compared to group I (5 of 83; 6%).

Other noteworthy patterns revealed by these data relate to catheterization complications and vascular access. Despite the increase in number of therapeutic cardiac catheterizations in recent years, the complication

rate has not increased (Table 3). This may reflect the current availability of smaller catheters, improved techniques (e.g., monitoring heparinization by activated clotting times [3]), and patient selection. The lower incidence of vascular complications, such as absent or decreased femoral pulse and venostasis in group II, supports these observations. Similar decreases in vascular complications were also described by Cassidy *et al.* [1]. Transient heart block remains the most common complication of neonatal cardiac catheterization.

Methods of obtaining vascular access have also evolved during the past decade. At our institution, cut-down has virtually disappeared as a means of obtaining vascular access in neonates. The availability of Doppler-tipped introducer needles [4] and the transhepatic approach [5] have essentially eliminated the need for cut-downs in the neonate. It seems likely that this trend will continue as fewer fellows have an opportunity to learn the cutdown approach.

Conclusions

Patterns of care for neonates with severe cardiac disease have changed substantially during the past decade. Diagnostic catheterizations are required much less often because essential data are usually obtained from echocardiography. Therapeutic catheterization procedures (e.g., balloon atrial septostomies and balloon dilation for critical pulmonary and aortic stenosis) are now commonplace in the neonate and have maintained the essential role of the cardiac catheterization laboratory in neonatal cardiology.

References

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