

Pulmonary atresia: Sorting it all out

By Eliot May, PA-C, senior physician assistant, Herma Heart Center, Children's Hospital of Wisconsin

Pulmonary atresia is a term we often hear when discussing patients with congenital heart disease. Atresia of the pulmonary valve means that the valve is absent or imperforate. There are a few major distinctions between subtypes that can help us categorize these patients.

Pulmonary atresia with ventricular septal defect and fully developed native pulmonary arteries

These patients usually are born with a large patent ductus arteriosus that supplies all major segments of the lung bilaterally. This subgroup is handled similarly to a severe form of tetralogy of Fallot. Surgical repair is directed toward stabilizing pulmonary blood supply and placing a systemic-to-pulmonary artery shunt and PDA closure in anticipation of later complete repair at a later date. Complete repair involves closure of the ventricular septal defect, removal of the previously placed systemic-to-pulmonary artery shunt and construction of right ventricle-to-pulmonary artery continuity with a large patch or valved graft.

Pulmonary atresia with intact ventricular septum

This group of patients is born with atresia of the pulmonary valve and no VSD. This lesion often is associated with poor development of the right ventricle and/or tricuspid valve. Inadequate development of the right ventricle or tricuspid valve dictates a single-ventricle strategy. Since the pulmonary valve is imperforate, the normal flow of blood from systemic veins to right atrium, right ventricle and pulmonary artery isn't possible.

Pulmonary blood flow is dependent on a patent ductus arteriosus. Communication between the right atrium and left atrium assures decompression of the systemic veins. Systemic venous blood entering the systemic circulation results in cyanosis. In the absence of right ventricle dependent sinusoids, the surgical approach usually involves decompression of the right ventricle, with pulmonary valvotomy or right ventricular outflow tract reconstruction. A poorly compliant right ventricle often requires placement of a systemic-to-pulmonary artery shunt. The patent ductus arteriosus is closed at the time of shunt placement. Interatrial communication is left open. Complete repair is possible in select patients with adequate development of the right ventricle and tricuspid valve.

A staged single ventricle pathway is employed in all others and involves placement of a bidirectional Glenn shunt and eventual Fontan completion.

Pulmonary atresia with ventricular septal defect and major aorticopulmonary collateral arteries

In this challenging group of patients, a surgical strategy tailored to the individual needs of the patient is important. Patients born with pulmonary atresia with VSD and little or no contribution to pulmonary artery blood flow from a patent ductus arteriosus can have major aorticopulmonary

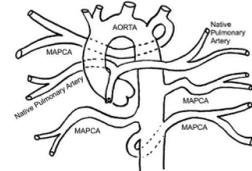
collateral arteries. MAPCAs are branches arising from the aorta or its major branches that supply blood to some or many of the pulmonary segments. There are approximately 10 segments in the right lung and eight to 10 segments in the left lung. Commonly, there is a combination of native pulmonary blood supply and MAPCA-supplied segments. Some segments have dual supply. Careful delineation of this complex anatomy is required to formulate a successful surgical plan. The ultimate goal is to create a single blood vessel that supplies all segments of both right and left lung and connect that to the right ventricle with a valved conduit and closure of the ventricular septal defect.

The terms "unifocalization" or "recruitment" refers to the process of connecting MAPCAs and native pulmonary artery vessels to form a single central focus. The MAPCAs are disconnected from their systemic origins and brought together centrally to form the new pulmonary artery. Unifocalization can be approached in stages or as a single stage. Many patients require more than one surgery. Initial unifocalization with placement of a systemic-to-pulmonary shunt will allow for small pulmonary arteries to grow and mature. Later, complete repair can be performed.

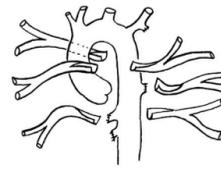
Single-stage repair is possible when most or all of the pulmonary segments are successfully unifocalized and thought to be of adequate caliber. Intraoperative flow studies can be performed to help the surgeon determine if VSD closure will be tolerated.

Unifocalization is difficult and exacting work. Surgical challenges are many and include the difficulty encountered working with blood vessels that are tiny (on the order of 2 mm or less in some cases), fragile, numerous and are located in the deepest recesses of the mediastinum. In addition, no two patients are alike. The anatomic variations are infinite and must carefully be mapped out. ■■

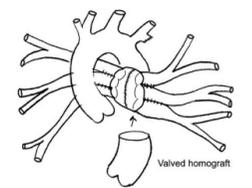
Pulmonary vascular anatomy in PA VSD with MAPCAs



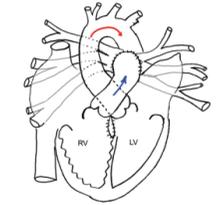
MAPCAs disconnected



Unifocalized MAPCAs and native PA



RV-to-PA continuity with valved homograft



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Calendar

Case Review: Cardiothoracic Surgery and Interventional Cardiology review clinically significant cases with an educational and quality improvement focus. Fourth Tuesday of the month, 7:30 a.m., Herma Heart Center conference room, first floor, Children's Hospital of Wisconsin.

Journal Club: CT Surgery, Cardiology, Critical Care and Anesthesia review a topic relevant to congenital or acquired heart disease. First Tuesday of the month, 4:30 p.m., Herma Heart Center conference room, seventh floor, Children's Hospital Clinics Building.

Research Focus: Herma Heart Center staff reviews existing or new research proposals, plans for abstract/manuscript preparation, invites guest speakers. Second Tuesday of the month, 7:30 a.m., cardiology conference room, first floor, Children's Hospital.

Cath Conference: Presentation of cases scheduled for cardiac surgery, interventional cath or group discussion. Every Thursday, 7 a.m., Briggs & Stratton Auditorium, second floor, Children's Hospital.

Heart Matters, a multidisciplinary approach to cardiac education, is produced quarterly. Past articles can be found at chw.org. Editor: Alexis Sullivan, RN. Co-editor: Edward Kirkpatrick, DO. Editorial staff: Stuart Berger, MD, and Maryanne Kessel, MBA, RN.

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Heart Matters

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Cardiovascular monitoring of children and adolescents receiving stimulant medications

By Stuart Berger, MD, medical director, Cardiology, co-director, Herma Heart Center, and Leigh Gabrielle Herma Chair in Cardiology, Children's Hospital of Wisconsin; professor, Pediatrics (Cardiology), The Medical College of Wisconsin

The recent American Heart Association statement, published in 2008, regarding the cardiovascular monitoring of children and adolescents receiving stimulant medications for attention-deficit hyperactivity disorder has been controversial. The issue came to attention in the last decade when sudden cardiac death had occurred in many patients who were taking Adderall XR®, a long-acting stimulant used for ADHD therapy. Upon further investigation, it was discovered that several patients had an underlying cardiovascular abnormality including cardiovascular abnormalities associated with sudden cardiac death such as hypertrophic cardiomyopathy, anomalous origin of a coronary artery from the opposite sinus of Valsalva, a family history of ventricular arrhythmias and more. What is not clear is whether the sudden cardiac death was associated with the underlying cardiovascular abnormality by itself or whether the stimulant medication caused the risk in a substrate with a baseline risk.

Because of the uncertainty of the association of stimulant medications with sudden cardiac death in patients with either diagnosed or undiagnosed heart disease, both the Food and Drug Administration and Health Canada (the Canadian equivalent of the FDA) took Adderall XR® off the market in 2005. The FDA also recommended the drug manufacturers alert patients of the possible cardiovascular risks of stimulant medications and that children and adolescents who are considered for ADHD therapy develop a treatment plan that includes a careful health history, family history and physical examination for cardiovascular and psychiatric issues.

Based on the available data, the American Academy of Pediatrics issued a statement in 2006 suggesting there is not compelling evidence for any medication-specific risks that should require changes in stimulant medication treatment for ADHD. In addition, the AAP recommended existing guidelines to identify children at increased risk continue to be used.

The AHA statement in 2008 created controversy by stating it may be useful to add an ECG to the screening regimen of

children and adolescents taking or about to take stimulant medications for ADHD. This will help identify children with conditions who are associated with sudden cardiac death such as hypertrophic cardiomyopathy, long QT syndrome or Wolf-Parkinson-White syndrome. These conditions have a high likelihood of being identified by ECG.

For many practitioners, the AHA statement implied that the consensus of the authors was that an ECG should be done, or is mandatory, in patients on or about to be started on stimulant medications for ADHD. There is no data in the literature to support a higher risk of SCD in patients taking stimulant medication in any circumstance, including children and adolescents with a normal heart or in those with known heart diseases with or without an association of SCD. Furthermore, it is unclear which forms of heart disease are at an increased risk in association with stimulant medications or whether ECG screening monitoring will alter the risk. Finally, it also is unclear as to what ECG findings would negate or even alter the use of stimulant medications in children and adolescents with either a normal heart or with known heart disease.

Therefore, subsequent to the AHA statement in April 2008, the AAP and the AHA have issued a follow-up statement that has suggested:

1. Continued careful assessment of all children and adolescents, including those on stimulants, using a targeted cardiac history, family history and physical examination.
2. With the current evidence, physicians should recommend therapy for ADHD without ECGs or subspecialty cardiology evaluation before starting ADHD medications.
3. Further research on risk factors and the role of ECG screening for all children and adolescents, including those with ADHD treated with stimulant medications. ■■

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Syndromes and Congenital Heart Disease 22Q11 Deletion

By Alexis Sullivan, RN, Children's Hospital of Wisconsin

The following article is a summary of a seminar presented by Katie Dodds, MSN, RN, CRNP, Children's Hospital of Philadelphia, at Cardiology 2010 in Orlando, Fla.

A large number of syndromes are associated with congenital heart disease. About 25 percent of infants with CHD have at least one extra cardiac malformation.

Often a spontaneous mutation, children affected with the 22Q11 deletion have a 50 percent chance of having a child with this defect. Development of the FISH test in 1990 noted this 22Q11 deletion in the majority of patients with DiGeorge syndrome. The FISH molecular genetic test is able to "light up" the missing chromosome piece using fluorescence in situ hybridization. Incidence is about 1 in every 4,000 live births and occurs with 1 of every 68 children with CHD.

Facial characteristics

Specific facial characteristics commonly are seen in patients with DiGeorge syndrome. These include wide-set eyes with hooded upper eyelids, protruding ears with preauricular pits and/or tags and narrow ear canals. A prominent nose with bulbous tip and small mouth with a thin upper lip also are associated with DiGeorge syndrome.

Palate problems

Palate problems are prevalent in this population. It is recommended that children with this known deletion be seen by a plastic surgeon specializing in cleft palate and velopharyngeal incompetence. Coordinating care with a speech pathologist for a potential speech, feeding or language difficulty is important in this group of patients because palate development plays a large role in speech development. The velopharyngeal located in the region of the pharynx that opens and closes during normal speech and swallowing is incompetent and unable to close completely, causing hyper-nasal speech. VPI can cause nasal regurgitation of formula and frequent ear infections.

Endocrine issues

Endocrine issues in this patient population include hypocalcaemia due to hypoplasia of the parathyroid glands. This often is seen only in infancy and is then outgrown. Hypocalcaemia may present as a seizure. Growth issues are present in about 40 percent of these patients with growth curves in less than the fifth percentile, secondary to low levels of growth factors IGF1 and IGFBP3. Growth hormone therapy can be helpful.

Immunology issues

Patients in this population are without a thymus or have hypoplasia of their thymus. They have impaired T-cell production and function. These patients also have humoral

B-cell defects. IgA deficiencies also contribute to immune system problems in nearly 75 percent of this population, but many outgrow this or see improvement within the first year of life.

Feeding issues

Although cardiac disease and palate problems account for some feeding issues, there still is a portion of patients with this deletion who do not have CHD or palate issues, but continue to have feeding problems. Some of the feeding disorders common to this group include nasal pharyngeal reflux, crico pharyngeal muscle hyperplasia (causing abnormal closure), dysmotility in the pharyngeal esophageal area and gastroesophageal reflux.

ENT issues

Chronic otitis media and chronic sinusitis is seen with patients having 22Q11 deletion as well as hearing loss related to infection or fluid.

Renal abnormalities

Renal ultrasound with Doppler can diagnose the many renal abnormalities associated with 22Q11 deletion including single kidney, echogenic kidney, multicystic or dysplastic kidney, calculi, bladder wall thickening, horseshoe kidney, renal tubular acidosis or duplicated collecting system. Patients may present with urinary tract infections, reflux or bed-wetting.

Neurodevelopment issues

Nearly half of toddlers are significantly delayed and 30 percent of preschoolers are diagnosed with mild retardation. Looking at motor development, nearly 80 percent of toddlers are significantly delayed and half have hypotonia. Nearly all children in this group have a late onset of speech and language delay. The delay in learning is associated with this deletion and not related to the associated issues. Twelve percent of school-aged children with this deletion have an average IQ, 25 percent are below average, 34 percent have borderline retardation and 27 percent have significant retardation. Verbal scores tend to be better than performance scores. Reading scores exceed math scores.

Other areas of concern

Hematologically, these children may have idiopathic thrombocytopenia. Rheumatologically, there is an increased risk for juvenile rheumatoid arthritis (150 times greater). Skeletal findings may include anterior lateral inflexibility neck. Since so many systems are involved, patients who genetically test positive for 22Q11 deletion should have a multidisciplinary approach to their evaluations to best support the impact it can have on these families. ■

Herma Heart Center research: Quality of Life in Children and Adolescents with Repaired Tetralogy of Fallot

By Elena N. Kwon, MD, Herma Heart Center, Children's Hospital of Wisconsin; fellow, Pediatric Cardiology, The Medical College of Wisconsin

Co-investigators: Margaret Samyn, MD; Cheryl Brosig, PhD; Kathy Mussatto, PhD, RN; Pippa Simpson, PhD; Melodee Nugent, MA

Tetralogy of Fallot is the most common cyanotic congenital heart defect. Also known as "blue baby syndrome," TOF consists of four entities: an aorta which overrides the ventricular septum, a malaligned ventricular septal defect, right ventricular outflow tract obstruction and right ventricular hypertrophy. With the steady decline in mortality rates after TOF repair, more attention has been directed to long-term follow-up of residual disease in these patients, and most recently, their health-related quality of life.

Most patients with repaired TOF have residual pulmonary regurgitation and RV dilatation, but often lack symptoms. Children with repaired TOF have been reported to have exercise capacity similar to healthy children, but this diminishes as an adult. Recent studies suggest that quality of life cannot be inferred uniquely from clinical and laboratory findings. Health-related quality of life has emerged as an essential measure of health outcome.

The primary aim of this study was to evaluate and compare self-reported and parent proxy-reported quality of life for pediatric patients with repaired TOF and determine the relationship with disease severity. It was hypothesized that both self and parent reports of QOL in children and adolescents with repaired TOF would be proportional to the severity of residual disease.

Methods

This is an IRB-approved study where patients were considered eligible when they were 8 to 18 years old, with repaired TOF spectrum, and at least mild residual PR. Quality of life questionnaires were administered to each patient and his or her parent.

The Pediatric Quality of Life Inventory (PedsQL™) Generic Core Scale Version 4.0 consists of 23 items, which assess physical functioning (eight items), emotional functioning (five items), social functioning (five items) and school functioning (five items).

Age-specific scales for children 8-12 and 13-18 were employed. Parents received the respective proxy report regarding their perception of their child's health-related quality of life, with higher scores meaning better quality of life. The PedsQL™ Cardiac Module Version 3.0 consists of five scales related to disease-specific symptoms (seven items), perceived physical

appearance (three items), treatment anxiety (four items), cognitive problems (five items) and communication (three items) for parent proxy-report and child self-report for ages 8-18 years(8).

The PedsQL™ Generic Core Scale scores were compared with normative data for peer groups considered healthy, chronically ill and with CHD. Cardiac module scores were compared with published data for self and parent proxy-report of children with CHD of all levels of severity. Clinical data obtained within three months of the quality of life survey included NYHA status, B-natriuretic peptide level, cardiac MRI, exercise stress test and transthoracic echocardiogram.

Results

Twenty child-parent pairs (eight males, 12 females) at a mean child age of 12.1 years completed quality of life questionnaires. Most of the children were healthy based on clinical assessment, laboratory and imaging studies. Quantification of residual disease severity on CMR showed that despite the moderate PR and moderate RV dilatation, the RV ejection fraction remained preserved.

Generic core comparisons showed self-reported quality of life to be similar to healthy subjects and, even better for school function. Compared to those with chronic illness, children with TOF overall reported better quality of life. Parental assessment of quality of life for children with TOF was significantly lower than parents of healthy children in all categories except emotional. For TOF children, parent proxy reported total quality of life mean scores were more comparable to parent proxy reports of chronically ill and significantly lower than healthy norms for the majority of the subscales including overall, physical, social and school functioning (Table 1).

Cardiac Module comparisons demonstrated no significant difference for all subsets between either the child or parent scores when TOF subjects were category matched to peers with CHD with residual disease. Child and parental scores for overall QOL and physical functioning positively correlated with the child's exercise capacity. Overall, there was poor agreement between the reported quality of life by the child and parent proxy for both the generic and cardiac module, with the child's scores usually higher. The child-parent pair agreement was somewhat better for the cardiac module, but still not

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Quality of Life in Children and Adolescents with Repaired Tetralogy of Fallot, continued

statistically significant. Self-reported quality of life for all subscales was higher in males than females for both modules (Overall QOL 93 vs. 80, p=0.025), although this was not found with parent reports.

There were no significant correlations with any of the subscales of self and parent-reported quality of life in both modules when considering all clinical and laboratory variables. However, when comparing exercise function for children with TOF to their general quality of life, the child's and parent's overall quality of life scores positively correlated with the child's exercise function, and was primarily driven by the physical subscale scores. Although the parents' scores were lower than the children's overall, in both cases the scores increased with improving exercise capacity.

Discussion

The results of this study suggest that quality of life in children and adolescents with repaired TOF is not proportional to the severity of their residual disease. Contrary to previous reports of children with all forms of CHD who report lower quality of life than healthy

children across all age groups, children with TOF in this sample reported health-related quality of life similar to healthy children.

Parent proxy-reported quality of life was lower than the child's for most subscales of the PedsQL™ generic core assessed, however, the parent proxy-reported quality of life was more predictive of their child's exercise functioning at lower levels of performance. Exercise testing results in this study are consistent with previous reports of exercise capacity for children with a ventricular septal defect or TOF as not differing from healthy children. Comparison of the results of exercise testing with self and parent proxy-reported QOL shows that there is a positive correlation between overall QOL and the exercise capacity of children with TOF.

Although children and adolescents with TOF report health-related quality of life similar to healthy peers, a comprehensive follow-up and early intervention is strongly encouraged, with cardiac rehabilitation and psychosocial evaluation to promote an active lifestyle. ■

Table 1

Scale descriptives for PedsQL™ 4.0 generic core scales TOF child self-report and parent proxy-report and comparisons with healthy and chronically ill children scores.

	GENERIC CORE											
	TOF			Normal			TOF vs. Normal	Chronic			TOF vs. Chronic	
CHILDREN	mean	SD	n	mean	SD	n	p value	mean	SD	n	p value	
Overall	85.3	13.1	20	83.0	14.8	401	0.441	77.2	15.5	367	0.007	
Physical	85.3	14.7	20	84.4	17.3	400	0.791	77.4	20.4	366	0.021	
Emotional	81.5	18.4	20	80.9	19.6	400	0.880	76.4	21.5	366	0.233	
Social	89.0	18.0	20	87.4	17.2	399	0.700	81.6	20.2	367	0.075	
School	85.5	11.8	20	78.6	20.5	386	0.015	73.4	19.6	362	0.000	
PARENT	mean	SD	n	mean	SD	n	p value	mean	SD	n	p value	
Overall	77.4	15.0	20	87.6	12.3	717	0.003	74.2	18.4	662	0.347	
Physical	78.0	19.3	20	89.3	16.4	717	0.009	73.3	27.0	653	0.288	
Emotional	76.0	17.6	20	82.6	17.5	718	0.096	73.1	23.3	661	0.465	
Social	73.0	22.4	20	91.6	14.2	716	< 0.001	79.8	21.9	657	0.184	
School	73.5	17.9	20	85.5	17.6	611	0.003	71.1	24.0	601	0.556	

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