

The Management and Follow-up of Cardiac Disease in People with Down Syndrome

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Down syndrome is commonly associated with congenital heart disease. The incidence of congenital heart disease in people with DS has been estimated to be 40 to 50 percent.^{1,2} Most congenital cardiac lesions are amenable to surgical or non-surgical repair. While some have advocated in the past that the cardiac defects in people with DS should not be repaired, reports have shown outcome comparable to individuals without DS.³ The improvement in life expectancy and quality of life afforded by repairing heart defects demands an aggressive approach to the early surgical management in individuals with DS. After repair or palliation of congenital heart defects, long-term follow-up and management is imperative.

The most common congenital cardiac defect in people with DS is the atrioventricular (AV) canal defect (also known as an AV septal defect or endocardial cushion defect). Next most common are ventricular septal defects. Other defects encountered in people with DS include atrial septal defects and tetralogy of Fallot.⁴ The anatomy of the normal heart and of these defects will be explored further.

The normal human heart consists of four chambers. The upper chambers are thin-walled and receive blood from other parts of the body. The right atrium receives blood returning through veins from the body. The left atrium receives blood through veins returning from the lungs. The two lower chambers of the heart, the ventricles, are muscular and pump blood to other parts of the body. The right ventricle pumps blood to the lungs. Blood flowing through the lungs picks up and carries oxygen, and then returns back to the heart. The left ventricle pumps blood to the body, delivering oxygen and nutrients to all parts of the body. The wall separating the two ventricles is the ventricular septum. The wall separating the two atria is the atrial septum. There are two valves between the atria and ventricles. The tricuspid valve is between the right atrium and the right ventricle. The mitral valve lies between the left atrium and the left ventricle. The valves normally allow the forward flow of blood while preventing backward flow. The pulmonic valve, located between the right ventricle and the main pulmonary artery, allows blood to flow forward into the lungs and prevents back flow into the right ventricle. The aortic valve allows forward flow of blood out of the left ventricle into the aorta, which carries the blood out to the body.

An AV canal defect is a frequently encountered congenital heart defect, both in patients with and without DS. AV canal defects involve abnormalities in the atrial septum close to the atrioventricular (mitral and tricuspid) valves. The atrioventricular (AV) valves are abnormal to varying degrees ranging from a cleft or gap in the mitral valve to severe malformation of the valves in which there is a single common valve entering both

ventricles. There may also be a defect in the ventricular septum. There may be any combination of these features; for instance, there can be a primum defect with a cleft mitral valve and no VSD, or there may be a large primum defect with a large VSD and a common AV valve. The pattern of the defects dictates the type of surgical repair and the timing of that repair. The presence of a large ventricular septal defect as part of the overall cardiac malformation requires early surgery within the first few months of life to prevent permanent damage to the pulmonary arteries. This damaging process caused by excessive blood flow into the lungs is known as pulmonary vascular disease. On the other hand, when there is only a primum atrial septal defect without the ventricular septal defect component, surgery can be safely performed later.

Ventricular septal defects may also occur apart from AV canal defects. The defect is described based on its location; membranous VSDs are high in the ventricular septum close to the aortic valve, and muscular VSDs are in the area of the ventricular septum that is highly muscular. There are also other varieties of VSD. Large VSDs, just as in individuals with an AV canal defect, can cause pulmonary vascular disease, and typically require surgical closure. Small VSDs often don't cause problems and can be followed. Small VSDs frequently become smaller over time and may undergo spontaneous closure.

Tetralogy of Fallot consists of a VSD, pulmonic stenosis (obstruction to blood flow into the lungs), aortic override (the aorta is deviated to the right and hangs over the right ventricle) and right ventricular hypertrophy (abnormally increased thickness of the muscle of the right ventricle). Tetralogy of Fallot requires surgical repair. Isolated ASDs may require closure, but can be followed if they are small. ASDs can be closed non-surgically; there are several devices used to close ASDs via delivery through a catheter entering through a small puncture in a vein. The Amplatzer septal occluder is currently the only device approved by the FDA for ASD closure. A PDA is a connection between the aorta and the pulmonary artery. This connection is normal prior to birth and typically closes shortly after birth. If it does not close, it may cause some of the problems seen with other types of defects like the VSD. PDAs can be surgically closed or can be closed with a catheter procedure non-surgically.

After repair of a congenital heart defect, patients generally do very well. Surgical outcomes in children with DS appear comparable to children without DS.³ Surgical repair does not imply the heart has been made completely normal. There may be residual abnormalities not fully corrected, or problems can develop after surgery or as a consequence of surgery. Especially important in the discussion of AV canal defects is mitral regurgitation. Mitral regurgitation (or mitral insufficiency) refers to the leakage of the mitral valve, allowing blood to leak back into the left atrium when the ventricles contract. There may be mitral regurgitation if the mitral valve is deficient in its structure. Mitral regurgitation may also develop after surgical repairs. Mitral regurgitation can lead to overwork of the left ventricle, enlargement of the left atrium, heart rhythm abnormalities, and heart failure. It is therefore

necessary to evaluate the heart on a regular basis to make sure mitral regurgitation is not developing, or existing regurgitation is not worsening. Mitral regurgitation can be treated with medications. In some cases, surgical re-repair of the valve may be necessary. Valves other than the mitral valve can become regurgitant as well.

Obstruction to blood flow out of the left ventricle can develop related to the unique anatomy of the ventricles in an AV canal defect. This is known as subaortic stenosis. Subaortic stenosis can also develop in individuals with a VSD (unrepaired or post repair) or it can occur associated with other types of disease involving the left ventricle and left sided heart structures. Subaortic stenosis may also be an isolated defect. It can be followed if it is mild, but may require operation if it becomes significant. Subaortic stenosis can lead to excessive pressure work on the left ventricle, abnormal thickening and stiffness of the left ventricle, distortion and dysfunction of the aortic valve, and ultimately to failure of the left ventricle. The treatment for subaortic stenosis is surgical, and usually very effective.

Stenosis can occur in other areas as well. There can be blood vessel stenosis or valve stenosis. Excellent therapies exist for these problems. Blood vessel stenosis is frequently addressed by dilation with a balloon catheter (balloon angioplasty). In other situations, surgical reconstruction is necessary. Valve stenosis likewise can be treated with balloon catheter dilation; surgical repair or replacement of heart valves is now common, effective and safe.

The heart muscle may become weak. Myocardial (heart muscle) dysfunction can be positively impacted by addressing the problem that predisposed its development in the first place (such as fixing a stenotic or regurgitant valve, fixing arterial stenosis, or closing a septal defect). Medications may also improve myocardial dysfunction.

Cardiac arrhythmias (abnormal heart rhythms) may occur for a variety of reasons. Some individuals are born with abnormal electrical circuits within the heart that can lead to arrhythmias. Chambers of the heart can become stretched or enlarged predisposing the cardiac tissue to have abnormal electric responses. Repair of the heart can result in internal scarring of the heart that creates abnormal electrical circuits. Addressing underlying abnormalities that predisposed the arrhythmia development in the first place helps to control arrhythmias. Medication may also suppress arrhythmias. Catheter procedures can treat and cure arrhythmias. Sophisticated technologies are available to assist in other types of arrhythmia. Implanted pacemaker devices can overcome inadequate electrical conduction in the heart. An implanted cardiac defibrillator (ICD) is designed to sense abnormal fast heart rates and deliver a shock to the heart to interrupt life-threatening arrhythmias.

Individuals with DS are also at risk for the development of cardiac abnormality even if the heart is normal at birth. Mitral valve prolapse (MVP) may develop.⁵ MVP is an abnormal bowing of the mitral valve into the left atrium when the valve closes. This can lead to mitral

regurgitation. In addition, aortic valve regurgitation is seen in individuals with DS.⁵ Both of these abnormalities should be recognized early so appropriate measures can be taken to minimize any negative effects on the heart. Screening for MVP and aortic regurgitation has been advocated to be part of the routine medical care of adults with DS.⁶

Follow-up needs to be obtained at a center that can provide a wide range of congenital cardiac services, including diagnostic imaging, congenital cardiac catheterization and catheter intervention, arrhythmia management, and congenital cardiac surgery. Adult congenital heart centers are becoming a reality to address this very unique need in adult individuals with DS, and in individuals with all types of congenital heart disease.

To summarize, DS is highly associated with cardiac defects with 40 to 50 percent of children born with DS having a congenital heart defect. Some cardiac defects don't cause any problems or resolve by themselves. Other types of defects require surgical repair. The timing of the repair depends on the defect and the effects it is having on the heart. Surgical repair is effective and usually carries a low risk. Despite having had a repair, the heart is rarely without some residual problem or propensity to go on to develop new problems. Therefore, individuals require appropriate cardiac follow-up. Good therapies for problems and complications exist and are tailored for the individual's needs. Follow up needs to extend into adulthood. Follow-up of congenital defects should be done by a cardiologist and center with special expertise in the management of congenital heart problems and individuals with DS.

References

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