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Research Article

Anatomical Correction of Transposition of the Great Arteries at the Arterial Level with Dacron Patch Closure of Ventricular Septal Defect: A Video Presentation

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Abstract

We report here-in a 30 days-old male child diagnosed with D-transposition of the great arteries of the ventricular septal defect, Yacoub's type A coronary arterial pattern undergoing anatomical correction at the arterial level with Dacron patch closure of the ventricular septal defect under moderately hypothermic cardiopulmonary bypass and St. Thomas (II) based cold blood cardioplegia. Postoperative recovery was uneventful at 2 months follow-up, the child is asymptomatic, on nil medications and in Ross clinical score of 2.

Keywords: Left ventricular aneurysms; Myocardial ischemia; Subvalvular aortic aneurysm; Sudden death.

Introduction

Transposition of the great arteries is the congenital malformation, which results from the abnormal chamber connections of atrioventricular concordance and ventriculo-arterial discordance [SDD]. It is generally classified as a type of conotruncal abnormalities, a group of abnormalities that has a common theme of deranged development of the cardiac outflow tract. In D-transposition, the aorta is anterior and to the right of the pulmonary artery. This pattern results in the systemic and pulmonary circulations occurring in parallel rather than in series [1, 2].

These patients are subdivided into those with intact ventricular septum (50%), ventricular septal defect (25%), and ventricular septal defect with pulmonary stenosis (25%) [1, 2]. Other associated cardiac anomalies include persistent ductus arteriosus, coarctation of aorta and transposition of the great arteries [3, 4]. Transposition of the great arteries accounts for 9.9% of infants with congenital heart disease or 0.206 per 1000 live births [5].

Many classification systems have been used to describe the coronary anatomy in transposition of the great arteries [4, 5, and 6]. The Leiden classification is most commonly used [6, 7, 8]. The most common coronary pattern in D-transposition of the great arteries (68%) consists of the left main coronary artery arising from the leftward coronary sinus giving origin to left anterior interventricular and circumflex coronary arteries. The right coronary artery arises from the right posterior sinus. In 20% of cases, the circumflex coronary arteries arise from the right coronary artery and passes behind the pulmonary artery. In 4.5% of cases, a single right coronary artery arises from the right posterior sinus or a single left coronary artery from the leftward coronary sinus [9]. Intramural coronary arteries that proceed in the aortic wall for a distance before exiting to the epicardial surface, single coronary ostium or separate ostia have been described [10]. Inverted origin of the coronary arteries and inverted origin of the circumflex and right coronary arteries have been described in 3% and 7% of cases respectively [11].

Presently, the trend towards earlier corrective surgery and primary ventricular septal defect closure has limited the role of pulmonary artery banding to: a) late presenters with transposition of great arteries and intact ventricular septum requiring left ventricular training for rapid 2-stage arterial switch; b) patients with transposition of great arteries and right ventricular failure following atrial baffle for staged conversion to arterial switch [12]. In 1999, S. Conte and associates reported internal pulmonary arterial band placement to reduce the risk of pulmonary arterial distortion and coronary compression [13].

Although the atrial baffle procedures are associated with a low mortality rate (<5%), they are plagued by long-term complications namely, baffle leak, systemic venous pathway obstruction, supraventricular and ventricular dysrhythmias, triscuspid valve insufficiency and right ventricular failure [14, 15, 16]. The arterial switch operation has largely replaced atrial baffle procedures with excellent mid-term and long-term results [14, 15, and 16]. Presently, the indications of atrial baffle procedures are limited and are institutionally dependent [14, 15, and 16].

The anatomical correction at the arterial level is the procedure of choice. Improved techniques of coronary transfer, myocardial protection and neogreat vessel reconstruction have resulted in improved survival statistics that compare favourably with the atrial baffle procedures [17, 18, 19, and 20]. Anomalies of the coronary arterial origin and course in transposition of great arteries are common and various innovative techniques have been employed for coronary artery transfer during arterial switch operation [17, 18, 19, and 20].

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The arterial switch operation restores left ventricular to aortic continuity and has not been associated with atrial arrhythmias, tricuspid stenosis, baffle obstruction, right ventricular failure and sudden death, which occur following atrial baffle operation. The mid- and long-term results of patients undergoing arterial switch operation are encouraging [21, 22, 23, 24, 25, 26, and 27]. In the congenital heart surgeon study on 513 infants (transposition of great arteries with intact ventricular septum, n=385; transposition of great arteries with ventricular septal defect, n=129), the 1-month, 1-year and 5-year survival rates were 84%, 82% and 82% respectively [16, 28]. The largest series on 1095 patients from a single institution with long-term follow-up was reported in 2001. At a mean follow-up of 5 years, hospital mortality was 8.6%, survival was 89% at 1-year and 88% at 10 and 15-years [28].

Coronary insufficiency, supravalvular and subvalvular right ventricular outflow tract obstruction are the most common complications leading to early death and reoperation [29, 30, 31, 32, and 33]. Risk factors for death include origin of the left main coronary artery or only the left anterior descending or circumflex artery from the right posterior sinus, multiple ventricular septal defect, longer global myocardial ischemic time, longer circulatory arrest time and inexperienced institutions [32, 33, 34, 35, 36, and 37] A multicentre study reported a risk-adjusted base incidence of 0.5% per year of reintervention for right-sided outflow obstruction [37].

Surgical Techniques

The operation

Surgical planning and the position

Following median sternotomy, the thymus was sub totally excised taking care not to expose the brachiocephalic vein. The pericardium was incised about 5-6 mm in front of and parallel to the phrenic nerve, thus exposing the two great arteries, the right atrium and the superior vena cava. The pericardium was opened using scissors and not cautery to avoid inadvertent cautery-induced ventricular fibrillation. A rectangular segment of pericardium was harvested and fixed in 10% glutaraldehyde for 10 minutes for later use of right ventricular outflow tract reconstruction.

The position and size of the great arteries, as well as the site of origin and distribution of the coronary arteries was determined. All four chambers were inspected and pressures recorded. Note the anteroposterior disposition of the aorta and the main pulmonary artery with the left main coronary artery arising from the left posterior aortic sinus and the right coronary artery arising from the right posterior aortic sinus. The left main coronary artery giving origin to the left anterior interventricular coronary artery and circumflex coronary artery.

The operation was performed with moderately hypothermic cardiopulmonary bypass at 32°C. Angled venous cannulas were inserted into the superior and inferior caval veins and with distal aortic cannulation. Measures were taken to avoid excessive manipulation.

Dissection and division of the ductus arteriosus

The persistent ductus arteriosus was dissected on the superior surface of the pulmonary artery by McGoon's technique, transfixed at both aortic and pulmonary arterial ends using 6-0 polypropylene suture (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA) and was divided.

Mobilization of the aorta and the pulmonary arteries

The two great arteries were separated from each other by dividing the pericardial reflection and between them, starting from the level of the top of the commissures and pulmonary artery till the level of pulmonary arterial branching on either side. Low voltage cautery (10-15 mv) was used during dissection. The aorta, right pulmonary artery and left pulmonary artery were looped using elastomer vessel loops.

Placement of marking sutures at the proposed neoaortic location of coronary transfer

Two marking sutures were placed over the pulmonary artery at the proposed neoaortic location. Note the site of neoaortic coronary button, little above the sinuses to avoid waisting/kinking of the coronaries.

Cross clamping of the ascending aorta and administration of cardioplegia

The aorta was cross-clamped. Antegrade St. Thomas based (1:4) cold blood cardioplegia and topical cooling was used for myocardial preservation.

Venting of the left ventricle

Right atriotomy was done after snugging the inferior caval vein and left heart was vented through the atrial septal defect using a No.13 DLP suction vent (Medtronic Inc., Medtronic Parkway N.E., Minneapolis, MN, USA).

Dacron patch closure of the ventricular septal defect

The ventricular septal defect is closed using an appropriately sized Dacron polyester patch (Bard® Savage® filamentous knitted polyester fabric, Bard Peripheral Vascular Inc., Tempe, AZ, USA) and pledgeted 5-0 polypropylene sutures (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA). The tricuspid valve is being checked for competence injecting cold saline through the tricuspid valve into the right ventricle.

Administration of second dose of cardioplegia

Second dose of antegrade root cardioplegia was administered after closing the ventricular septal defect.

Dissection of the aorta and pulmonary trunk

The aorta was divided in between stay sutures at the level of pulmonary arterial bifurcation. Two stay sutures of 6-0 polypropylene were placed on the top of each coronary buttons for retraction and mobilization. The transected distal aortic end was retracted superiorly for optimal visualization and uncluttering of surgical field.

The pulmonary trunk was next divided about 1-2 mm below the level of pulmonary arterial bifurcation. The vessel loops on right and left pulmonary arteries were placed on traction for the LeCompte manoeuvre.

Inspection of the pulmonary valve

The pulmonary valve and sub pulmonary region were inspected through the transected end of the pulmonary artery.

Identification of the coronary artery

The position of the coronary ostia and their relation to the sinuses

of valsalva of the aortic and pulmonary valves were determined. Note the origin of both coronary arteries from the left and right posterior sinuses respectively. Additionally, the course and mode of branching of the proximal 5-6mm of each artery was inspected.

Mobilization of coronary buttons

The left and right coronary ostia were mobilized with a surrounding rim of aortic wall including almost the full thickness wall of the sinus of valsalva without causing injury to the valve leaflets. The process was started at the edge of the transected aortic wall for the left coronary ostium followed by the right coronary ostium. Low voltage cautery (5-6 mv) was used for hemostasis at the harvested site.

Creation of medial-based pulmonary arterial flaps for coronary artery translocation

A site on the pulmonary artery for the left and right coronary anastomoses were chosen. This neoaortic location was higher than the top of the sinus of valsalva, to avoid tension/kinking/waisting of the coronary arteries and to avoid distortion of the aortic valve. Two medially based pulmonary arterial flaps as described by Roger Mee were created accordingly. The sites chosen allowed for rotation of the mobilized coronary buttons through an angle not more than 30°. No portion of the pulmonary arterial wall was excised.

Coronary anastomoses

The coronary anastomoses were performed using 6-0 polypropylene suture, taking care not to injure the coronary ostia and distortion of the mobilized disc.

The LeCompte manoeuvre

The pulmonary arterial bifurcation, right and left pulmonary arteries were mobilized beyond the site of the divided ductus into the pulmonary hilum on the left side and behind the superior vena cava to the branching of the right pulmonary artery on the right side. The distal transected end of the aorta was then threaded behind the mobilized pulmonary arterial bifurcation by LeCompte manoeuvre and the second aortic controlling clamp was transferred onto the aorta at its new site behind the pulmonary artery bifurcation.

Reconstruction of the aorta

The small distal end of the aorta was matched to the larger proximal end for anastomosis using 6-0 polypropylene suture.

Repair of the defects in the aortic sinus

Two defects, which was produced in the facing sinuses of the pulmonary trunk, were repaired using a single patch of the autologous pericardium and 6-0 polypropylene suture. The size of the patch is approximately one and a half times the size of the defect, thus enlarging the diameter of the proximal aorta to match the size of the distal pulmonary artery. At this stage, we used topical thrombin (Tisseel, Baxter AG, Vienna, Austria) as an additional topical hemostatic agent.

Release of the aortic cross-clamp and restoration of myocardial perfusion

The aortic cross-clamp was released, thus restoring myocardial perfusion. Note the distended left and right coronary arteries perfusing the myocardium without any kinking or torsion.

Reconstruction of the pulmonary artery

The last stage of the LeCompte manoeuvre consists of direct anastomosis between the reconstructed proximal aorta and the distal pulmonary artery using a 6-0 polypropylene suture. Precautions were taken to anastomose the two ends without compressing the proximal parts of the coronary arteries, without causing narrowing of the right and left pulmonary ostia and without stretching the branches of both pulmonary arteries.

Closure of the right atriotomy

The atrial septal defect was directly closed using 5-0 polypropylene suture. The right atrium was closed in two layers using 5-0 polypropylene suture. The child was weaned-off cardiopulmonary bypass with stable hemodynamic on dobutamine and nitro-glycerine infusion.

Conclusions

We conclude that anatomical correction of transposition of the great arteries at the arterial level restores anatomical left ventricle to aortic continuity, thereby avoiding atrial arrhythmias, baffle obstruction and right ventricular failure, which occur following correction at the atrial level. Meticulous attention should be exercised at every step of the operation including coronary artery transfer to obtain a satisfactory outcome.

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