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Arterial Switch and Modified Konno Procedure With Detachment of the Aortic Root for Transposition of the Great Arteries and Left Ventricular Outflow Tract Obstruction

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The arterial switch operation for the transposition of the great arteries accompanied by a ventricular septal defect and posterior malalignment of the outlet septum is a surgical challenge. We describe a new surgical technique in 2 patients having this pathology. The surgical technique consists of the arterial switch operation and a modified Konno procedure through partial detachment of the semilunar valve of the right ventricle as in the Ross procedure.

Approximately 20% of infants with transposition of the great arteries (TGA) also has left ventricular outflow tract obstruction (LVOTO). The LVOTO is more common and severe with ventricular septal defect (VSD), and the anatomy of the obstruction may vary considerably [1]. The optimal procedure for TGA and LVOTO is still debated. We report two cases of TGA associated with a VSD and LVOTO caused by posterior malalignment of the infundibular septum. In both cases, the arterial switch operation (ASO) and the modified Konno procedure were performed. A novel technique of partial aortic detachment was used to have a better view of the left ventricular outflow tract in the Konno procedure.

Technique

Cardiopulmonary bypass was begun after a median sternotomy, standard aortic cannulation, and venous cannulation through both the superior and inferior vena cavae. The temperature was lowered to 24°C. Ductus arteriosus was divided, and the branch pulmonary arteries were mobilized up to the hilar branches. The aorta was cross clamped and blood cardioplegic arrest was induced. Cardioplegia was given every 20 to 30 minutes directly into the coronary arteries during the aortic cross clamp. Atrial septal defects were closed so that a 2-mm residual defect was left to allow shunting in the early postoperative period. The ascending aorta was divided 5 mm distal to the sinotubular junction. The left coronary artery was excised with an O-shaped aortic cuff in an effort to maintain the sinotubular junction of the ascending aorta intact. The left half of the aortic root, including the aortic valve, was excised from the right ventricular outflow tract in a manner analogous to that applied for the Ross pulmonary autograft operation. The main pulmonary artery was then transected just proximal to its bifurcation. The Lecompte maneuver was performed. To protect the pulmonary valve from injury during VSD augmentation, a marking suture of 5-0 polypropylene was placed transseptally, just beneath the commissure (Fig 1). This suture determined the superior margin of the septal incision. A large enough dilator was passed across the pulmonary valve to lift up the left ventricular outflow tract and the outlet septum for a better vision during incision. In both cases the septal incision was extended from the small VSD to the previously placed marking suture, just below the pulmonary valve. In the first case, a patch of autologous pericardium treated with glutaraldehyde was sutured in a running fashion with 5-0 polypropylene to the right ventricular aspect of the septal incision and the VSD. In the other case, a Dacron patch was used instead. The right coronary ostium was excised with a generous U-shaped aortic cuff. The left half of the aortic root was reimplanted to the right ventricular infundibulum using a double row of continuous 6-0 polypropylene suture. The coronary artery buttons were reimplanted after the neoaortic reconstruction. With the aortic clamp off, the neopulmonary sinus defects were repaired using two pieces of autologous pericardium and the neopulmonary anastomosis was completed (Fig 2). Ultra filtration on bypass and modified ultra filtration after bypass was used. Left atrial and pulmonary artery pressure monitoring lines and a peritoneal dialysis catheter were inserted.

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Patient 1
The first case was a 6-month-old girl with TGA, VSD, LVOTO, and patent ductus arteriosus. A balloon atrial septostomy was done in the neonatal period. In the echocardiographic examination, the VSD was 2 mm in diameter and was located in the muscular outlet region. The LVOTO was due to the posterior malalignment of the outlet septum. The pulmonary annulus and the valve were normal. Doppler echocardiography revealed 58 mm Hg systolic gradient in the left ventricular outflow tract. An ASO with a modified Konno procedure was performed. The cardiopulmonary bypass time and cross-clamp time were 232 minutes and 145 minutes, respectively. The sternum was closed primarily. The patient received epinephrine, dopamine, and milrinone in the early postoperative period and was easily weaned. She stayed in the intensive care unit for 5 days and was discharged on postoperative day 10. The echocardiography at discharge revealed no residual VSD or LVOTO. The left ventricular outflow tract diameter and the neo-aortic annulus were 9.2 mm and 9.7 mm, respectively. Mild regurgitation of the neo-aortic valve was noted with no gradient in the valve. The left ventricle was functioning normally.

Patient 2
The second case was a 3 month-old girl of a diabetic mother. She had TGA, VSD, foramen ovale, and LVOTO. The 2.5-mm VSD was located in the trabecular outlet region, and the LVOTO was caused by the posterior malalignment of the outlet septum. She also had a bicuspid pulmonary valve that was not stenotic. There was a 65 mm Hg Doppler gradient across the left ventricular outflow tract. The cardiopulmonary bypass time of the operation was 186 minutes and the cross-clamp time was 90 minutes. She had a primary closure of the sternum. Epinephrine, dopamine, and milrinone infusions were used in the early postoperative period. The postoperative course was uneventful in the intensive care unit. She stayed in the intensive care unit for 3 days and was discharged on postoperative day 10. The postoperative echocardiography revealed no residual VSD or LVOTO. The maximum systolic gradient was 14 mm Hg in the LVOT. The neo-aortic valve was bicuspid, but it was not stenotic. Trivial aortic regurgitation was observed. The left ventricular function was normal.

Comment
Surgical management of TGA with VSD and LVOTO continues to present a surgical challenge because of the wide variety in anatomy and unsatisfactory outcome of the current approaches. In the past, the basic requirements for ASO used to include competent and unobstructed ventriculo-arterial connections; however, reports are accumulating that document the good outcome of ASO in the presence of left ventricular outflow tract (LVOT) abnormalities [1–3]. In most cases, the subpulmonary obstructive tissue may be resected or the valvular pulmonary stenosis may be treated so that an ASO can still be performed [4]. However, when the LVOT is fixed and severe, surgical options other than ASO are considered. The Rastelli operation is the widely known and applied procedure in these patients [5]. The disad-
Vantages of Rastelli operation, however, consist of reoperations for LVOTO and RVOTO [5]. In the reparation, a letage ventriculaire (REV) procedure proposed by Lecompte and colleagues [6], a prosthetic conduit is not used and the intracardiac tunnel is shorter and more direct. This leads to less reinterventions compared with the Rastelli operation; however, free pulmonary regurgitation created by the RVOT reconstruction had been a concern. Recently, small series have reported that aortic translocation with resection of the outlet septum, originally proposed by Nikaidoh, is a successful operation in patients with TGA and pulmonary valve hypoplasia or atresia [7].

When the pulmonary valve is normal, the complex stenosis of the left ventricular outflow tract may also be effectively reduced with the modified Konno procedure, while function of the neoaortic valve is maintained. The classical incision of the RVOT and septum in the modified Konno procedure may be hazardous due to the close proximity of the aortic and pulmonary valves, especially in newborns and infants [8]. We believe the novel technique that we applied to our patients allows a better view of the left ventricular outflow tract during the Konno procedure. Partial translocation of the semilunar valve of the right ventricle, as in the Ross procedure ensures easy and safe application of the modified Konno operation; thus effective and sustained elimination of the LVOTO may be achieved. Moreover, patients with TGA, LVOTO, and normal pulmonary valve may be operated on at an earlier age by using this technique. Using less prosthetic material reduces the likelihood of reoperation for outflow tract obstructions, and clearly no conduit replacement is anticipated. Unlike the aortic translocation or the Nikaidoh procedure, this technique preserves both semilunar valves so that better competence is expected in the long term.

References
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