BRIEF COMMUNICATIONS

SWITCH BACK: USING THE PULMONARY AUTOGRAFT TO REPLACE THE AORTIC VALVE AFTER ARTERIAL SWITCH OPERATION

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Aortic valve insufficiency has been described to occur after the arterial switch operation. Valve insufficiency is mild in most cases. In some patients valve repair or root reconstruction may solve the problem, but in others the valve will have to be replaced. Inasmuch as the number of patients surviving the arterial switch operation is growing, valve insufficiency may be seen more often. In infants the ideal way to replace the aortic valve is by using a pulmonary autograft. Our experience with aortic valve replacement using a pulmonary autograft (former aortic valve) in one infant with a history of arterial switch operation is described.

Clinical summary. A little girl, 3 years 4 months old, was referred to us from another institution. At the age of 2 days an arterial switch operation was performed for simple transposition of the great arteries. The coronary anatomy was normal (1LCx-2R, Leiden classification).¹ The aorta was anterior to the pulmonary artery. Both semilunar valves were tricuspid and normal. The coronary arteries were excised together with U-shaped aortic wall buttons and implanted in the pulmonary artery base by means of the trapdoor technique. The neopulmonary root was reconstructed with a pantaloony-shaped patch of autologous pericardium. A Lecompte maneuver was part of the procedure. The postoperative course was complicated by ischemia, frequent ventricular extrasystoles, and periods of ventricular fibrillation. Left hemidiaphragmatic paresis necessitated later diaphragmatic plication. After an extended period of intensive care, she gradually recovered and finally was discharged from the hospital. Progressive dilatation of the aortic root with valvular insufficiency was observed during follow-up. Insufficiency was considered to be significant (2/4) when she was 1 year old. The left ventricle was dilated. Her condition deteriorated gradually, leading to fatigue on slight exertion.

On physical examination at the age of 3 years 4 months, the girl weighed 12.5 kg. She had a murmur of aortic insufficiency at auscultation and a blood pressure of 105/45 mm Hg. The electrocardiogram demonstrated regular sinus rhythm with left ventricular hypertrophy and left precordial ST-segment inversions. The left ventricle had deteriorated according to the echocardiogram, with an end-diastolic dimension of 52 mm. The shortening fraction was calculated to be 25%. Aortic valve regurgitation was severe (4/4). The pulmonary valve was normal. Cardiac catheterization confirmed these findings. Pulmonary artery pressure was 25/10 mm Hg. Both coronary arteries were visualized angiographically and showed no evidence of stenoses. Angiography showed an aneurysm on the anterior aspect of the aortic root (Fig. 1. A and B). Left ventricular contractions were diminished with diffuse hypokinesia.

Procedure. At operation, the anatomy was as expected after an arterial switch procedure, with the pulmonary artery in front of the aorta. The proximal part of the ascending aorta was aneurysmal. Cannulation was done high in the ascending aorta and in the right auricle with a right-angled cannula. Cardiopulmonary bypass with moderate hypothermia was started. A left vent was inserted and the aorta was crossclamped. St. Thomas' Hospital cardioplegic solution was infused every 30 minutes combined with external myocardial cooling. The pulmonary artery was transected just proximal to the bifurcation, which facilitated exposure of the aortic root. The pulmonary valve was tricuspid without signs of degeneration. The pericardium used to reconstruct the neopulmonary trunk had fused with the rest of the pulmonary artery. The aorta was transected just distal to the aneurysmal root. The aortic valve was tricuspid, with fibrosis and retraction of all three leaflets. The coronary buttons had grown after the switch procedure without evidence of coronary stenosis. The aortic valve and root were resected, leaving generous coronary buttons. Next the pulmonary trunk was dissected from the right ventricle. The external diameter was 18 mm and the aortic annular diameter was 1 mm larger. The autograft was used to reconstruct the resected aortic root. In an effort to prevent distention, we inserted the autograft slightly deeper into the left ventricle than the original aortic valve. The coronary buttons were inserted as U's after equal U-shaped parts had been excised from the pulmonary autograft to avoid widening of the intercommissural distances. All suture lines were sewn with running 5 or 6-0 Prolene sutures (Ethicon GbmH, Nordstedt, Germany). After 100 minutes of

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Fig. 1. Angiograms showing the aneurysmal aortic root after the arterial switch procedure. **A**, Lateral angiogram: The aortic root has an aneurysmal anterior aspect and the left ventricle is dilated. **B**, Anteroposterior angiogram: Aneurysmal aortic root. *AR*, Aortic arch; *AN*, aneurysm; *LV*, left ventricle.

myocardial arrest, the pulmonary trunk was reconstructed with a 21 mm cryopreserved pulmonary homograft (Heart Valve Bank, Berlin, Germany) on the beating heart. Cardiopulmonary bypass was discontinued after rewarming. After modified ultrafiltration, the cannulas were removed and protamine was given. Epicardial echocardiography showed a well-functioning new aortic valve with no or minimal insufficiency. Hemodynamics were good with dopamine 5 $\mu\text{g}/\text{kg}$ per minute. She was extubated the next day and discharged from the intensive care unit on the second postoperative day. She was discharged from the hospital 9 days after the operation. Echocardiography showed a still dilated left ventricle and a well-functioning pulmonary autograft with a minimal central jet of insufficiency that was not considered to be of any hemodynamic importance.

Comment. Aortic valve insufficiency is seen more frequently in patients after pulmonary artery banding previous to the arterial switch operation. Dilatation of the pulmonary trunk is the mechanism of insufficiency of the neo-aortic valve after an arterial switch procedure. Even without previous pulmonary artery banding, aortic insufficiency seems to occur on occasion after the arterial switch procedure. The neo-aortic valve diameter has been reported to be higher than in the normal population, which may explain the mild valvular regurgitation that is

observed in some patients after the arterial switch procedure.² The exact pathogenesis of the increase in aortic annulus diameter in patients who have undergone the arterial switch is not fully understood.

Surgical technical aspects may play a role. An increased intercommissural distance should theoretically lead to a loss of central coaptation of the valve cusps. Yamaguchi and associates³ indicated that the use of coronary buttons may reduce the prevalence of insufficiency as compared with the use of trapdoor incisions and U-shaped coronary transfers.³

In the patient we described, the aortic root aneurysm was the main cause of aortic insufficiency, although the thickening and retraction of the leaflets remain unexplained. A too wide pericardial patch may have been used at the time of the arterial switch operation to adapt the wider neo-aortic root to the smaller distal ascending aorta (Fig. 1. *A* and *B*).

Aortic valve replacement by mechanical valve prostheses after the arterial switch procedure for transposition has been performed (personal communication J. M. Quaegebeur, 1996) and reported earlier.⁴ Aortic valve repair after the arterial switch procedure has also been described.⁵ In this infant we chose to replace the aortic valve with a pulmonary autograft for several reasons. Besides the known advantages of using a pulmonary

autograft rather than other valve prostheses in children, some specific reasons were present in this special situation. Resection of the aneurysmal aortic root was necessary and the relatively difficult access to the aortic root made the choice of a homograft less preferable in view of the inevitable reoperation.

The operation turned out to be straightforward. The anterior placement of the pulmonary trunk made its harvesting easy. Coronary artery problems were not encountered. Transposition may, however, be combined with coronary artery patterns that make harvesting of the pulmonary trunk more difficult, especially a right coronary artery crossing the right ventricular outflow tract. No important mismatch between the diameters of the pulmonary trunk and aortic anulus existed, which further encouraged us to choose the pulmonary autograft for aortic root replacement.

In conclusion, the Ross procedure is technically feasible after an arterial switch operation and may be a particularly attractive alternative for this special population. This may be even more true because it is the original aortic valve that is used to replace the insufficient neo-aortic valve.

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REVERSE FLAP OF DISTAL LATISSIMUS DORSI FOR DIAPHRAGM RECONSTRUCTION IN THE ADULT: SPECIFICATION OF THE TECHNICAL PROCEDURE AND REPORT ON SIX CASES

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The current repair procedures of diaphragmatic defects in the adult, although uncommon, involve the routine use of prosthetic materials,¹ whereas the use of autologous tissues and muscular flaps is preferred in pediatric subjects.² The recent clarification that the paraspinous dorsal perforating branches of the lower intercostal arteries and the lumbar vessels are reliable pedicles for the use of the whole latissimus dorsi (LD) muscle as a reverse flap³ prompted the use of this muscle in two experiences totaling eight children. Bianchi, Doig, and Cohen⁴ first used this flap for diaphragmatic hernia repair. More recently, Wallace and Roden² treated the congenital absence of the diaphragm by means of the reverse flap of the whole LD muscle and a Dexon patch (Davis & Geck,

Danbury, Conn.). We did not find any other publication on this topic in the literature. We describe the reconstruction of one hemidiaphragm in the adult by means of only the distal portion of the LD muscle, fashioned as a reverse flap.

The surgical procedure consists of an incision as for a posterolateral thoracotomy. The LD muscle is divided from the medial to the lateral margin at the projection points of the sixth and fifth ribs, respectively (Fig. 1), and its distal portion is then mobilized via extrafascial planes, down to just below the tenth rib. The serratus anterior muscle is mobilized as well to allow the primary thoracotomy, which is performed via the sixth or seventh intercostal space, or after subperiosteal resection of the sixth rib in case of an extrapleural pneumonectomy, without division of this muscle. The diaphragm is resected by means of an additional thoracotomy through the ninth or tenth intercostal space. The posterior tract of the rib overlying this second access is then resected over a distance of approximately 10 cm, starting from the margin of the spinalis muscle. The distal portion of the LD muscle is threaded through this orifice into the chest, and its apex is fixed to the most distant point of the diaphragmatic defect (Fig. 2). One to-and-fro continuous Maxon 1-0 mattress suture (Davis & Geck) is then applied to the medial margin of the defect, consisting of the lower pericardium or the remnant diaphragm, and the corresponding margin of the flap. A second similar suture is applied to

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