Surgical Repair for Corrected Transposition of the Great Arteries with Severe Pulmonary Stenosis

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Horiuchi, T., Abe, T., Ishitoya, T., Tanaka, S., Kuribayashi, R., Okada, Y. and Ishizawa, E. Surgical Repair for Corrected Transposition of the Great Arteries with Severe Pulmonary Stenosis. Tohoku J. Exp. Med., 1971, 104 (2), 143-149 — The corrected transposition of the great arteries with pulmonary stenosis was completely repaired in a 5 1/2-year-old boy. To relieve the stenosis of the pulmonary valve ring which was located posterior to the aorta and heart chambers, the valve-bearing tube-graft made of the pericardium was implanted as a bypass graft between the right-sided ventricle and the pulmonary trunk. Postoperative hemodynamics and cineangiographic findings were satisfactory. The use of the viable autologous tissue such as the pericardium is definitely more advantageous than that of the other homografts, since the former requires neither sterilization nor long-term preservation. —— corrected transposition; valve-bearing tube-graft; autologous pericardial tube-graft

Although the corrected transposition of the great arteries is hemodynamically normal, it is usually associated with one or more intracardiac malformations. When both pulmonary stenosis and ventricular septal defect are associated, clinical manifestations and hemodynamics are similar to those of tetralogy of Fallot. Total correction is, however, not so easy as in the Fallot's tetrad chiefly because of anatomical characteristics of corrected transposition. One of the most difficult problems is to relieve pulmonary stenosis, since the outflow tract and pulmonary trunk are located posterior to the aorta and the cardiac chambers. Pulmonary stenosis may not be relieved completely in some cases unless a bypass graft between the functional right ventricle and the pulmonary trunk is established. There have been a number of experimental and clinical studies on the bypass technique between the right ventricle and the pulmonary trunk. Our current choice for this purpose is the use of a valve-bearing tube-graft made of the autologous pericardium (Horiuchi et al. 1969).

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A 5½-year-old boy was first seen at the Tohoku University Hospital on January 6, 1970, because of slight cyanosis noted at the age of 2 years and decreased exercise tolerance. A cardiac murmur had been noted shortly after birth. Physical examination revealed a normally developed boy weighing 19 kg. The patient had a slight cyanosis but no clubbing of fingers and toes. Blood pressure was 106/65 mm Hg and heart rate was 86 beats per minute. Red blood cell count was $603 \times 10^4$ per mm³, hemoglobin value 16.8 gm per 100 ml and hematocrit 53 per cent. A grade 3/6 systolic ejection murmur was heard best at the second to the third intercostal space of the left sternal border and the second heart sound at the same area was loud and single (Fig. 1a). Electrocardiogram demonstrated a right axis deviation in the frontal plane (a QRS axis of $+175$ degrees), a negative P wave in I, II, III, aVF, and the left precordial leads ($V_4$ to $V_6$), and an RS pattern in the right precordial leads except qR wave in $V_{6R}$ (Fig. 2). On the chest roentgenogram, the heart was located in the middle of the thorax (mesocardia) and the left upper border of the cardiac configuration was convex owing to the ascending aorta, and the right hilar vascularity was “water fall” sign, suggesting l-transposition of the great arteries. The liver and stomach bubble were located normally in the upper abdomen (situs solitus). There was no evidence of cardiomegaly. In addition, the pulmonary vascularity appeared decreased. Cardiac catheterization study was performed (Table 1). Peak systolic pressure in the venous ventricle was equal to the peak systolic systemic pressure. The shunt rate from left to right

![Fig. 1. Preoperative (a) and postoperative (b) electrophonogram. A2: aortic sound. P2: pulmonic sound.](image-url)
and right to left were 35 and 26 per cent, respectively. Selective cineangiogram confirmed the diagnosis of \( l \)-transposition of the great arteries with ventricular septal defect and pulmonary stenosis (Fig. 3a). Open heart operation was performed on February 3, 1970.

Median sternotomy was carried out and a large square sheet of the pericardium was excised (about 6 by 7 cm in size). As shown in Fig. 4, the valve-bearing tube-graft was made of the excised pericardium and preserved in a heparin and penicillin-added saline solution. Examination of the heart and great vessels revealed that the ascending aorta with a diameter of 2.0 cm was located anterior and left to the pulmonary trunk (\( l \)-transposition), producing the convexity in the left upper mediastinal border in the chest roentgenogram. Both ventricles were inverted, that is, the anatomical left ventricle was right-sided, whereas the anatomical right ventricle left-sided. Total cardiopulmonary bypass was instituted in the usual manner and the right-sided left ventricle was opened obliquely in the space between the large branches of the left coronary artery. Ventricular septal defect (1.4 cm in diameter) was located just behind the posteriorly positioned septal leaflet of the mitral valve and was closed with a Teflon patch. Then the pulmonary

### Table 1. Data of cardiac catheterization

<table>
<thead>
<tr>
<th></th>
<th>Systemic artery (mm Hg)</th>
<th>Venous ventricle (mm Hg)</th>
<th>Pulmonary artery (mm Hg)</th>
<th>Shunt ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before operation</td>
<td>110/80</td>
<td>106/7</td>
<td>?</td>
<td>Lt-Rt 35</td>
</tr>
<tr>
<td>Immediately after</td>
<td>95/</td>
<td>45/</td>
<td>?</td>
<td>Rt-Lt 26</td>
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<tr>
<td>operation</td>
<td></td>
<td></td>
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<tr>
<td>Two months after</td>
<td>100/70</td>
<td>75/16</td>
<td>53/15</td>
<td>0</td>
</tr>
<tr>
<td>operation</td>
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Fig. 3. Preoperative (a) and postoperative (b) cineangiogram in antero-posterior view. (a) shows the injection of contrast medium into the arterial ventricle. (b) shows the contrast medium injected into the venous ventricle.

Fig. 4. Valve-bearing tube-graft made of the autologous pericardium. PG: pericardial graft. TG: teflon graft.
trunk (about 1.5 cm in diameter) was opened transversely and the examination disclosed valvular stenosis with a narrow pulmonary ring about 0.7 cm in diameter. Although direct pulmonary valvotomy was performed, pulmonary stenosis could not be relieved because of the presence of the extremely narrow ring. Owing to the posterior localization of the pulmonary trunk, outflow patch plasty seemed difficult. Bypass operation between the right-sided left ventricle and the pulmonary trunk was carried out by using the pericardial tube-graft which had been already prepared. The prosthetic portion of the graft was fashioned as a gusset for the anastomosis between the graft and the right-sided ventricle (Fig. 5). Total cardiopulmonary bypass time was 150 minutes. Resuscitation of the heart was easy and immediate postoperative hemodynamics were satisfactory as shown in Table 1. Systolic pressure in the right ventricle became elevated from 45 to 95 mmHg by cross clamping of the implanted graft. Thus, it became apparent that the newly reconstructed pathway was effective. Postoperative course was uneventful except mild right heart failure which was well controlled with digitalis and diuretics.

Cardiac catheterization study was performed 2 months after the operation, which revealed slight pressure gradient between the right-sided left ventricle and the pulmonary artery (Table 1). Selective cineangiogram demonstrated that the contrast medium mostly passed through the implanted tube-graft and only contrast medium mostly minimal amount through the original outflow tract (Fig. 2b). Postoperative phonocardiogram showed a widely splitting second heart sound.

Fig. 5. Diagram (a) and photograph (b): completion of operation.
which had been single preoperatively (Fig. 1b). In addition, no diastolic murmur was recorded, suggesting a competent pericardial valve. The patient was discharged from the hospital 3 months after operation with full recovery.

**COMMENT**

Clinical manifestations and hemodynamics of corrected transposition of the great arteries with ventricular septal defect and pulmonary stenosis are similar to those of tetralogy of Fallot. Total correction of the former is, however, much more difficult than the latter because of anatomical characteristics of pulmonary stenosis of corrected transposition. In corrected transposition of the great arteries, both great arteries are generally l-transposed; that is, the aorta is located anterior and left to the pulmonary trunk. There is no infundibular muscle beneath the pulmonary valve (pulmonary-mitral fibrous continuity), since the type of cono-truncus is subaortic. Pulmonary stenosis in this cardiac anomaly is, therefore, characterized by valvular and/or annular type. Surgical relief of pulmonary stenosis is generally very easy when it is of valvular type alone. It may be, however, very difficult when the pulmonary valve ring is stenotic. The right coronary artery traverses just anterior to the valve ring and, therefore, an outflow patch plasty is not feasible as in Fallot’s tetrad. Kiser and his associates (1968) described a method to relieve such a stenotic valve ring of l-loop double outlet right ventricle in which similar anatomical difficulty was encountered. They relieved stenosis by incising pulmonary valve ring posteriorly and extending this incision 1 cm distally into the pulmonary trunk and 1 cm proximally into the subjacent ventricle. This longitudinal incision was then resutured transversely. This seems an excellent method for relieving such a particular stenosis, but has a definite limitation for the indication. Recently, Rastelli et al. (1969) reported a new operative technique for bypassing pulmonary stenosis using a valve-retaining aortic homograft in the patient with transposition of the great arteries with pulmonary stenosis. By using this, Arai et al. (1970) reported a successful total correction in the patient with transposition of the great arteries. For the same purpose, we devised a new method for complete reconstruction of the pulmonary trunk using a valve-bearing tube-graft made of the autologous pericardium in 1968. Up to the present, 7 patients (2 of truncus arteriosus, 2 of pseudotruncus, 2 of l-loop double outlet right ventricle and 1 of corrected transposition of the great arteries reported herein) were operated upon and 4 of them survived (Abe et al. 1970). The cause of death in the remaining cases was severe pulmonary obstructive disease in 2 cases of truncus arteriosus and low cardiac output failure in 1 case of l-loop double outlet right ventricle. It is an advantage of our method over the valve-retaining homograft that the graft utilized is a viable autologous tissue, which does not require sterilization and preservation and of which the size and length can be freely selected at the time of operation, although the fate of the graft needs a careful long-term follow-up.
References


