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## Correction of D-Loop, D-Transposition of the Great Arteries and Sub-Pulmonary Stenosis with a Dacron Conduit and Stented Porcine Xenograft Valve

Lorenzo Gonzalez-Lavin, MD\* and Gordon M. Folger, MD\*\*

*Total correction of transposition of the great arteries and left ventricular outflow tract obstruction has become feasible in recent years. Certain modifications are needed, however, to improve the long term function of the valved conduit required in the procedure. A stented porcine xenograft valve, sutured into a woven Dacron tubular graft, was used successfully in the total correction of such a malfunction. The patient described is the first so treated at the Henry Ford Hospital.*

*The main advantage of this technique is its practicality. Both Dacron tubular grafts and stented porcine xenograft valves are commercially available. This approach is applicable also in the repair of congenital cardiac malformations which have discontinuity between the right ventricle and the pulmonary artery.*

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**T**RANSPOSITION of the great arteries (TGA) is a condition in which the atria and ventricles are in concordant relation and the ventricles and great arteries in discordant relation. Therefore both arteries are transposed relative to the ventricular septum, the aorta is in relation to the anatomic right ventricle and the pulmonary artery to the anatomic left ventricle.

The usual effect is that 80% of those patients who have poor mixing between the systemic and pulmonary circulation are dead before the age of 6 months.<sup>1</sup> When additional communications are present, the prognosis is somewhat improved.<sup>2,3</sup> The best outlook for longevity without treatment is for those patients who have TGA with a ventricular septal defect and left ventricular outflow tract obstruction (LVOTO).<sup>4</sup> Although palliative procedures have been provided for many years,<sup>5-7</sup> it is only recently that total correction of TGA and LVOTO has become feasible.<sup>8-11</sup> However, certain modifications are needed to improve the long term function of the valved conduit required.

We report here the first patient at Henry Ford Hospital having successful repair of this malformation using a Dacron conduit with a porcine xenograft valve.

TABLE I. CARDIAC CATHETERIZATION DATA

	10/13/59				03/08/63					03/27/73		
	Pressures cmH <sub>2</sub> O	mmHg	O <sub>2</sub> Content Vol. %	O <sub>2</sub> Sat. %	Pressures cmH <sub>2</sub> O	mmHg	S/D	O <sub>2</sub> Content Vol. %	O <sub>2</sub> Sat. %	Pressures mmHg	Oxygen Saturation (2) VanSyke	Oximeter
SVC			12	48				16.5	62		21.0	73
RA	13		11.6	46	16	7	11/4	19.0	71	4	22.2	77
LA	13	10	17.4	69	16	7	12/2	19.2	72	3	25.6	89
RV					69	42	110/0-12	20.4	74		27.6	96
LV	42	34	17.6	70	42	100/13	22.4	84		110/0-11	26.5	92
RV										106/0-11	23.0	80
AsAo					83	97/60	19.6	72		108/74	24.8	86
Ao										110/72	24.2	84
LPV	18				17	7	15/10				27.0	94
PVW	20				23	11	15/10					
O <sub>2</sub> Consumption										280 ml/min		
Syst. Flow										4.85		
Cardiac Index										2.5		
RV dp/dt										1500mmHg/sec		
LV dp/dt										1840mmHg/sec		
R-L shunt										1.8		

### Case Report

This 15-year-old white female was known to have cyanosis and a heart murmur since birth. She had undergone cardiac catheterizations at the age of 9 days and at 4 years of age. The diagnosis was transposition of the great arteries with sub-pulmonary stenosis. Because of severe cyanosis and failure to thrive, she had a left Blalock shunt in 1963 when she was four years old. Her clinical condition remained stable until the age of 14 when she developed breathlessness, tiredness and increased cyanosis. She was re-admitted to Henry Ford Hospital on 9/29/72. Cardiac catheterization (Table I) and angiography confirmed the diagnoses of D-loop, D-transposition of the great arteries with combined bilateral conus, ventricular septal defect with subpulmonary stenosis, and a large atrial septal defect. Total correction was advised and she was admitted for elective surgery on 6/13/73.

Physical examination revealed a young, active white female with severe cyanosis, moderately overweight, and blood pressure of 120/80 with a pulse of 70/min and regular. Pertinent findings were confined to the precordium. The heart was not enlarged and had regular rhythm. The first heart sound was normal. The second heart sound was single. There was an ejection click followed by an ejection systolic murmur, Grade IV/VI, at the

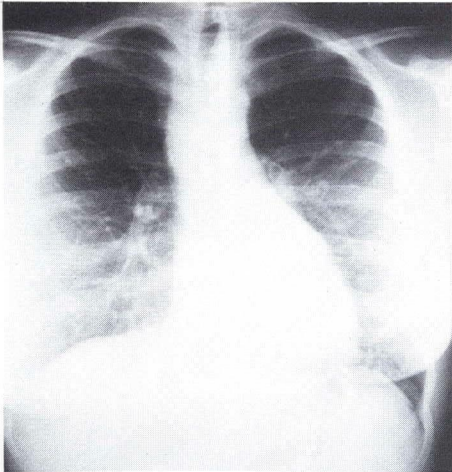
left sternal border. A continuous machinery-like murmur was present in the left subclavicular area.

Chest x-ray (Figure 1A and B) and electrocardiogram (Figure 2) were compatible with TGA and LVOTO.

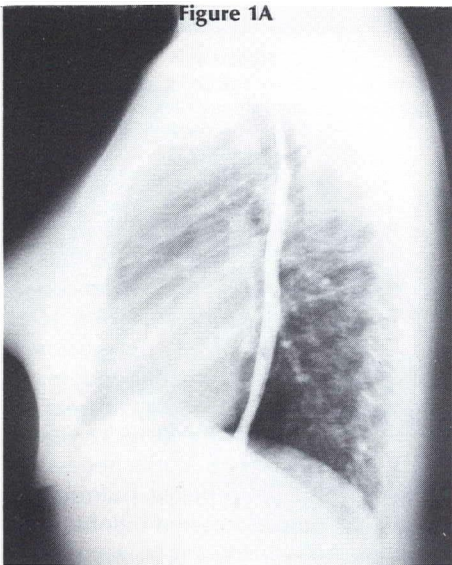
Coagulogram on admission was abnormal. Phlebotomies were performed on four occasions, removing a total of 1,400 cc of blood which was replaced with 1,000 cc of fresh, frozen plasma. Repeat coagulogram four days later was normal.

Surgical operation on 6/20/73 was done through a mid-line incision. Multiple collateral vessels were divided and ligated. When the pericardium was opened, the external appearance of the heart was that of TGA. A large aorta was placed anteriorly, taking off from the right ventricle and forming a right aortic arch. A hypoplastic pulmonary artery was placed posteriorly, taking off from the left ventricle. There was juxtaposition of the atrial appendages with a consequent absence of atrial appendage of the right atrium. Dissection and control of the previous Blalock anastomosis was performed. While preparations for the institution of cardiopulmonary bypass were in progress, a 23 mm diameter Dacron tubular

## Porcine Valve in Great Artery Correction



**Figure 1A**



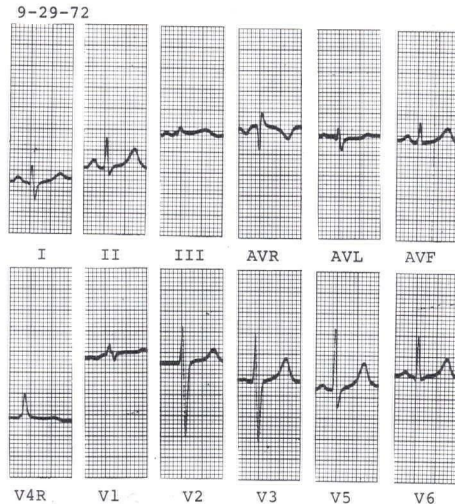
**Figure 1B**

**(A and B) Pre-operative roentgenogram of the chest. Cardiac silhouette is compatible with transposition of the great arteries and right aortic arch.**

graft\* was preclotted and a 21 mm stented porcine xenograft valve\*\* was sutured into the lower third of the Dacron graft. An oblique

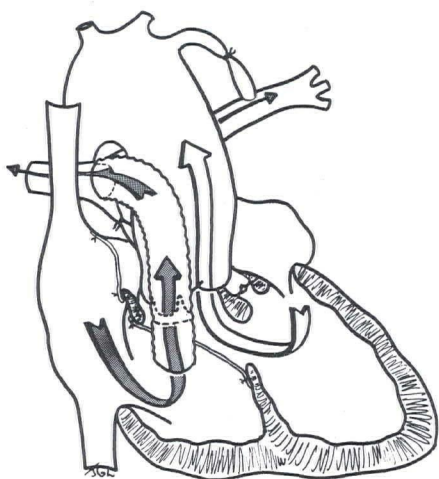
\*Woven Dacron Seamless Tubular Graft, USCI, Glen Falls, NY 12801.

\*\*Hancock Laboratories, Inc., 4633 E. LaPalma Ave., Anaheim, CA 92807.



**Figure 2**  
**Pre-operative electrocardiogram disclosing right ventricular hypertrophy.**

right ventriculotomy was performed. A large (3 cm x 4 cm) subaortic, ventricular septal defect was visualized. The infundibulum of the right ventricle was formed by a well-developed muscular ring consisting of the crista supraventricularis together with its parietal and septal bands and the moderator band forming a ring of myocardial tissue. The aortic valve was over the right ventricular outflow tract. The left ventricular outflow tract was severely narrowed by hypertrophy of the conus, forming a well-defined ring of myocardium. There was no continuity between the mitral and pulmonary valves. The pulmonary valve was tricuspid with a narrow and hypoplastic ring that would not admit a finger. An intraventricular repair was performed. A Dacron patch was used to re-direct the blood flow from the left ventricle through the ventricular septal defect into the aorta. The patch was attached to the edges of the ventricular septal defect and the infundibular muscle below the aortic valve and was secured with multiple interrupted sutures of a 3-0 Tevdek. The pulmonary artery was tied off at its origin and a 25 mm longitudinal incision was made above the ligature. The previously prepared composite graft was then sutured between the right ventricle and the pulmonary artery with running sutures of 4-0 Tevdek. The right atrium was then opened and a large atrial septal defect was closed with a pericardial patch using running stitches of 4-0 Tevdek. The total repair is illustrated in Figure



**Figure 3**  
Diagram illustrating the completed repair.

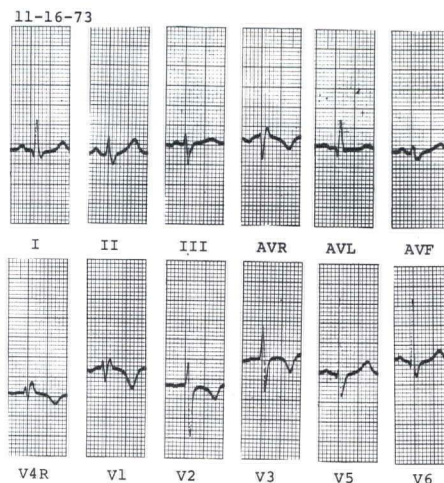
3. Intraoperative pressures, taken before closing the chest, were: LV 110/12 mm Hg; RV 45/0-10 mm Hg; MPA 40/15 mm Hg; left atrium mean pressure 15 mm Hg.

The patient's postoperative course was uneventful and she was discharged home on 7/14/73.

When last seen, six months after surgery, she was asymptomatic and going to school full time. Physical examination at that time revealed her blood pressure was 110/80, pulse rate 90/min and regular. Neck appearance was unremarkable. On auscultation of the precordium, there was soft ejection systolic murmur, Grade III/VI; a good closing sound of the xenograft valve was present on the third intercostal space at the left sternal border. Both lungs were clear to percussion and auscultation. Abdominal findings were within normal limits, there was no organomegaly, no peripheral nor central cyanosis. The electrocardiogram (Figure 4) showed a lesser degree of right ventricular hypertrophy. The heart shadow on chest x-rays was within normal limits and there was normal vascularity in both lung fields (Figure 5).

#### Comment

Patients with "poor mixing" forms of TGA, particularly those with LVOTO, do



**Figure 4**  
Electrocardiogram taken 4 months after surgery depicting some regression of the right ventricular hypertrophy.

not develop pulmonary vascular disease, as the lungs are protected from high pressures and flows. Thus, survival through early life is relatively good, making it possible often to delay corrective surgery until the age of 10 to 12 years. Palliative surgery may become necessary in the interim to improve pulmonary blood flow and prevent hemoglobin and blood viscosity from rising to dangerous levels.<sup>4,7</sup>

The LVOTO associated with TGA is usually due to a hypoplastic pulmonary conus. In angiograms it appears muscular and contractile, but in some cases it is secondary to abnormal attachment of the mitral valve.<sup>12,13</sup> It appears to develop in some patients after the first few months of life,<sup>14</sup> but in others is due to a hypoplastic pulmonary valve.<sup>15</sup> From the surgeon's viewpoint, complete relief of LVOTO by direct approach, either through the pulmonary artery,<sup>16</sup> or the

## Porcine Valve in Great Artery Correction

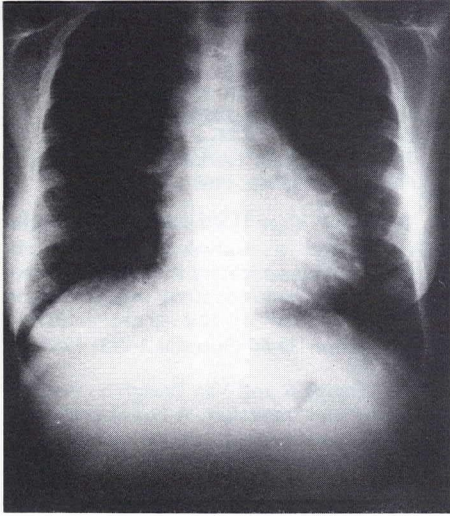


Figure 5A

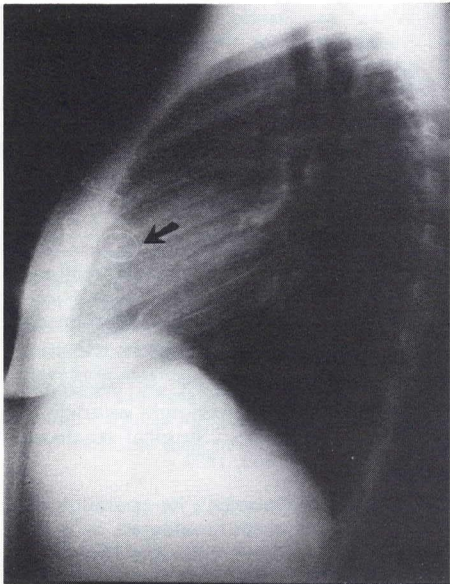


Figure 5B

(A and B) P.A. and lateral chest x-ray 4 months after surgery. Arrow in lateral view points out location of metal ring of the stented porcine xenograft valve.

ventricular septal defect has been far from satisfactory. The inadequate relief of this obstruction has had a definite bearing on the surgical mortality.<sup>9</sup>

The advent of the anatomical repair as proposed by Rastelli<sup>9,10,11</sup> has improved greatly the long term prognosis in this type of patients. The success of this approach is based on several factors: (1) the pulmonary vascular resistance is low, (2) the presence of a large VSD and LVOTO produced left ventricular hypertrophy enabling the left ventricle to withstand systemic resistance; and, most important, (3) the left ventricular outflow tract obstruction is completely relieved without employing a direct approach.

The use of aortic valve homografts to reconstruct the right ventricular outflow tract has gained wide clinical application although there has been some concern about the high incidence of early calcification among these grafts.<sup>17-19</sup> More recent reports of pseudoaneurysm formation<sup>20</sup> and severe obstruction due to calcification of the grafts<sup>21</sup> tend to support the use of some other conduit between the right ventricle and pulmonary artery. A composite type of Teflon conduit with an aortic homograft valve has been used with good early results by Kouchoukos and Kirklin, and long term function of this type of conduits appears to be superior to the previous methods.<sup>22</sup> A modification of this approach was used in the case presented here: A frame-mounted porcine xenograft was sutured into the lower third of a woven Dacron tubular graft. The conduit was of sufficient length and tailored to avoid acute angulations. Due to the small size of the hypoplastic pulmonary artery, the distal anastomosis was placed end-to-side to allow as large a graft as possible.

We believe that with the commercial availability of Dacron grafts and stented porcine xenograft valves, this approach is a practical one. It also can be applied in the total correction of congenital anomalies where there is lack of anatomic continuity between the right ventricle and the pulmonary artery.

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