Initial Analysis of the Use of the L-D-Hydro (Eato L-D-Hydro) Organic Tubular Graft for Performing the Modified Blalock-Taussig Procedure in Congenital Heart Diseases with Decreased Pulmonary Blood Flow


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Objective
To analyze the initial results of the use of an organic tubular graft for systemic-pulmonary anastomoses.

Methods
From March 2002 to April 2003, 10 patients underwent systemic-pulmonary shunt of the modified Blalock-Taussig type, using a new type of biological graft originating from the bovine mesenteric artery treated with polyglycol, the so-called L-D-Hydro. The patients’ ages ranged from 3 days to 7 years, and 60% of them were of the male sex. The diagnoses of heart disease were determined on echocardiography. All patients had clinical signs of severe hypoxia (cyanosis). The heart diseases were as follows: tetralogy of Fallot (40%), tricuspid atresia (50%), and atrioventricular septal defect (10%).

Results
One patient died due to sepsis and 9 had an immediate improvement in O₂ saturation on pulse oximetry and in the partial oxygen pressure on arterial blood gas analysis. The intensive care unit length of stay ranged from 2 to 6 days. No patient had obstruction of the shunt on the immediate postoperative period or any other complication. All patients had a patent shunt on the echocardiographic studies performed in the immediate postoperative period and later, in the third postoperative month. No bleeding occurred during surgery or in the postoperative period.

Conclusion
The tubular L-D-Hydro graft proved to be promising for performing systemic-pulmonary shunt as an alternative for the inorganic products available in the market, however, we need a greater number of implantations and late follow-up for definitive assessment.

Key words
systemic-pulmonary anastomosis, modified Blalock-Taussig

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ration of a nonsteroidal anti-inflammatory agent and an antithrombotic agent to the tissue. The third stage consists of sterilization of the tissue in the aqueous phase of hydrogen peroxide. The fourth stage is the D-Hydro process, which consists of lyophilization and replacement of the water molecules in the matrix and extracellular space by glycerol, a flexible polymer that replaces water.

The surgical technique was as follows: 8 patients were placed in the right lateral decubitus position; they underwent left lateral thoracotomy according to the anatomic location of the aortic arch; opening was performed in the third or fourth intercostal space; anastomosis of the graft to the subclavian artery and the pulmonary artery was performed with Prolene 7-0 thread, taking care not to clamp the graft, according to the recommendation of the manufacturer (fig. 1). The other 2 patients underwent right thoracotomy, and the shunt was performed with the right subclavian artery and the right pulmonary artery, due to the location of the aortic arch. In all patients, the anastomoses were preceded by heparinization at the dosage of 1 mg/kg, and no patient required heparin reversion (fig. 2).

In the postoperative period, the immediate follow-up protocol was similar to that of the procedure used for patients undergoing the Blalock-Taussig shunt with expanded polytetrafluoroethylene (PTFE) graft, which is as follows: all patients were heparinized with 400 to 600 U/kg/day of sodium heparin in continuous infusion beginning 2 hours after admission at the ICU; their APTT was maintained 1.5 to 2.5 times the normal value, and heparin was kept for 24 hours, being then replaced by acetylsalicylic acid, at the dosage of 5 mg/kg/day, for 3 months.

In late follow-up, our protocol included clinical, echocardiographic, and arteriographic assessments in all patients on the occasion of indicating definitive correction (fig. 3).

### Results

Of the 10 patients studied, one died due to sepsis on the third postoperative day. The 9 remaining patients had an immediate

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Surgery</th>
<th>Graft size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 months</td>
<td>M</td>
<td>AVSD + RVOT stenosis</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>8 days</td>
<td>F</td>
<td>T4F + Pulmonary atresia</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>3 days</td>
<td>F</td>
<td>Pulmonary and tricuspid atresia</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>2 months</td>
<td>F</td>
<td>Pulmonary and tricuspid atresia</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3 months</td>
<td>M</td>
<td>Tricuspid atresia + TGA + PVS</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>4 days</td>
<td>F</td>
<td>Pulmonary and tricuspid atresia</td>
<td>MBT to the R</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>7 years</td>
<td>M</td>
<td>Pulmonary and tricuspid atresia</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>12 days</td>
<td>M</td>
<td>Coronary cavitary fistula RC-RV</td>
<td>MBT to the L</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>10 months</td>
<td>M</td>
<td>T4F + Pulmonary atresia</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>10 months</td>
<td>M</td>
<td>T4F</td>
<td>MBT to the L</td>
<td>4</td>
</tr>
</tbody>
</table>

M- male; F- female; AVSD- atrioventricular septal defect; RVOT- right ventricular outflow tract; TGA- transposition of the great arteries; PVS- pulmonary valve stenosis; T4F- tetralogy of Fallot; RC- right coronary; RV- right ventricle; MBT- modified Blalock-Taussig; R- right; L- left; mm- millimeter.
improvement in oxygen saturation on pulse oximetry and arterial blood gas analysis. The mean initial arterial oxygen saturation was 69.4% ± 1.17%, with a significant increase to 90.1% ± 1.85% immediately after the procedure. The length of stay in the intensive care unit ranged from 2 to 6 days.

No patient had obstruction of the shunt in the immediate postoperative period or any other complication, although the classical modified Blalock-Taussig murmur could not be heard with its usual intensity, which can be explained by the elasticity of the graft. All patients showed, on the echocardiographic study, a patent shunt with turbulent flow (fig. 4). In the immediate postoperative period, the diameter of the graft ranged from 4.3 to 5.4 mm (4.68±0.29), and, in the third month, from 4.2 to 5.2 mm (4.48±0.29) (tab. II).

No bleeding was observed during surgery or in the postoperative period.

Discussion

Usually, the indications for the use of the systemic-pulmonary shunt varied among the institutions as follows: cyanogenic complex defects; hypoplasia of the pulmonary arteries; hypoplasia of the pulmonary ring, which required a transannular flap for complete repair; abnormality of the pulmonary arteries; neonates with tetralogy of Fallot and pulmonary atresia; and young low-weight neonates. In addition, the systemic-pulmonary shunt is used when the mortality of the total correction is greater than that of the 2-stage repair 5-12.

Currently, the most used shunt in most services is the modified Blalock-Taussig, which has a mortality rate lower than 1% 12. De Leval and Stark 5, McKay et al 6, and other authors reported excellent results with the modified Blalock Taussig. The shunt has adequate patency, a low index of surgical complications, low mortality, and allows the growth of the pulmonary tree, without the risks of the secondary repair 13-21. In our study, no patient died in the immediate postoperative period; all patients had an immediate improvement in oxygen saturation on pulse oximetry and arterial blood gas analysis (from 69.4% ± 1.17% to 90.1% ± 1.85%). The diameter and characteristic of the flow, shown on echocardiography, confirmed the efficacy of the shunt.

Berger 19 and other authors 22-26 have reported high postoperative morbidity and mortality in the procedures of Potts et al 2 and Waterston 3. Kirklin et al 10 have identified age (below 3 months) as a risk factor for postoperative mortality, mainly when other risk factors coexisted. Arciniegas et al 29 have also identified age as a risk factor for postoperative mortality as follows: 6% for one month, 4% for 3 months, 3% for 6 months, and 2.5% for 12 months 6,28. Alkhulaifi et al 30 have identified low weight and preoperative ventilation as risk factors for mortality. Khalid et al 31 have related low weight (below 3 kg) to the early failure of the shunt, and identified the use of intra- and postoperative heparin as a protective

Table II - Postoperative assessment through Doppler echocardiography in patients undergoing systemic-pulmonary anastomosis with the L-D Hydro graft

<table>
<thead>
<tr>
<th>Patient</th>
<th>Diagnosis</th>
<th>Graft diameter</th>
<th>Type of flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Immediate (mm)</td>
<td>3 months (mm)</td>
</tr>
<tr>
<td>1</td>
<td>AVSD + RVOT stenosis</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>T4F + Pulmonary atresia</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td>3</td>
<td>Pulmonary and tricuspid atresia</td>
<td>4.9</td>
<td>4.2</td>
</tr>
<tr>
<td>4</td>
<td>Pulmonary and tricuspid atresia</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td>5</td>
<td>Tricuspid atresia + TGA + PVS</td>
<td>4.6</td>
<td>4.4</td>
</tr>
<tr>
<td>6</td>
<td>Pulmonary and tricuspid atresia</td>
<td>4.8</td>
<td>4.5</td>
</tr>
<tr>
<td>7</td>
<td>Pulmonary and tricuspid atresia + Coronary cavity fistula RC-RV</td>
<td>5.4</td>
<td>5.2</td>
</tr>
<tr>
<td>8</td>
<td>T4F + Pulmonary atresia</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td>9</td>
<td>T4F</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td>10</td>
<td>T4F</td>
<td>4.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

AVSD- atrioventricular septal defect; RVOT- right ventricular outflow tract; TGA- transposition of the great arteries; PVS- pulmonary valve stenosis; T4F- tetralogy of Fallot; RC- right coronary; RV- right ventricle; mm- millimeter.
factor for reducing shunt failure and early obstruction in 1.6% of
the modified Blalock Taussig. They have also reported that patients
with shunts with a greater caliber and those who received no
heparin had a greater incidence of occlusion. In our study, no
obstruction was observed in the period assessed, and permeability
of the shunt was shown on Doppler echocardiographic study.

In our case series, one patient died due to sepsis on the third
postoperative day, and, therefore, a cause not directly related to
the graft.

Berger et al 32, using the PTFE graft, reported 12% of serum
in the postoperative period, a complication that was not observed in our
series, although some cases may have remained undetected.

On clinical assessment, we observed that the intensity of the
murmur was lower than usual, which may be explained by the
elasticity of the graft.

In conclusion, the L-D-Hydro graft proved to be effective for
replacing inorganic grafts in systemic-pulmonary shunts, because
of its excellent performance with no bleeding during surgery and
in the postoperative period, graft patency in all patients, easy
technical management, technical reproducibility, in addition to
being of organic material and low cost.

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