Left ventricular outflow tract obstruction after arterial switch operation

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Received 23 April 2008; received in revised form 23 July 2008; accepted 24 July 2008; Available online 30 September 2008

Abstract

Objective: Postoperative left ventricular outflow tract obstruction (LVOTO) after arterial switch operation (ASO) is rare. In this retrospective study, we reviewed the cases of 10 patients with LVOTs post-ASO and analyzed the options used for the LVOTs corrections and the patients’ outcomes.

Methods: From December 1982 to December 2006, 1689 consecutive ASO were performed. Ten patients presented with postoperative LVOTs (0.59% of all ASO and 7.62% of ASO for Taussig—Bing anomaly (TBA)) leading to reoperations. Before ASO they presented with significant subaortic gradients (n = 4) or predisposing anatomical features (n = 9) such as: conal septum malalignment (7/9), abnormal tricuspid cords insertions (4/9), muscular bundle hypertrophy (3/9) and mitral accessory tissue (2/9).

Results: No patient was lost in the follow-up: 117–33 months. Subaortic gradients had developed between 5 months and 14 years after ASO (mean 41–35 months) leading to reoperations. Most LVOTs post-ASO were due to fibrotic membranes or fibro-muscular hypertrophy, removed at first reoperation. After their first reoperations, seven patients (70%) had non-significant or low gradients and were not reoperated for LVOTO. Three patients underwent iterative surgical procedures for LVOTs leading to two aortic valve replacements associated with LVOTO release or Konno procedure.

Conclusion: Postoperative LVOTO after ASO is rare but happens more frequently in TBA. Most of them can benefit from resections of subaortic obstacles or septal plasters. In more complex cases iterative surgical procedures may lead to complications such as block or severe aortic valve regurgitation.

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Keywords: Congenital heart disease; Arterial switch; Cardiac anatomy; Reoperation; Outcomes

1. Introduction

Left ventricular outflow tract obstruction (LVOTO) can be associated with transposition of the great arteries (TGA) and double outlet right ventricle with subpulmonic ventricular septal defect (VSD) or Taussig—Bing anomaly (TBA) and can persist or may be revealed after anatomical repair by arterial switch operation (ASO). These anomalies can be secondary to conal septum malalignment, accessory mitral tissue, muscular bundle hypertrophy or abnormal tricuspid chordae attachments [1]. Although transposition of the great arteries associated to LVOTO is better approached by the Rastelli procedure [2], with Lecompte [3] or Metras [4] procedure, or by aortic root translocation described by Nikaidoh [5–7], in some patients resection of the cause of LVOTO is feasible and the arterial switch procedure may offer an anatomical and definitive result in most cases [8,9]. However, despite resection of the obstacle and attention not to narrow LVOT at initial surgery, a subaortic stenosis may appear or reappear. In this retrospective study, we review the cases of 10 patients with postoperative LVOTO after ASO and analyze the options used for their corrections and their results.

2. Patients and methods

From December 1982 to December 2006, among 1565 survivors after 1689 ASO, 10 developed a subaortic obstruction and required reoperation (0.59% of all ASO and 7.62% of ASO for TBA, n = 118). Data summarized in Table 1 indicate the preoperative anatomical features of the patients who have developed LVOTO after ASO. They were seven males and three females. Average age and weight at the time of ASO were 45 ± 38 days [11–125] and 3435 ± 647 g [2700–5800], respectively. Initial anatomy included: TGA and VSD, n = 1; TBA, n = 7 and TBA with aortic arch obstruction or interruption, n = 2. These last two children had been operated on with a two stage approach; aortic arch obstruction or interruption repair associated with pulmonary artery banding.
during the neonatal period, followed by an ASO 83 and 119 days later, respectively. The diagnosis of TBA was based on the lack of fibrous continuity between the pulmonary and mitral valve, a subpulmonic VSD, and a preferential blood flow from the left ventricle to the pulmonary artery. Before the ASO, four patients presented a LVOTO with a significant subaortic gradient. All but one (nine patients) presented predisposing anatomical features such as conal septum malalignment (7/9), abnormal tricuspid chordae insertions (4/9), muscular bundle hypertrophy (3/9) and mitral accessory tissue (1/9).

Initial ASO was performed as previously described [10]. Ventricular septal defect was closed in all patients through pulmonary or aortic valves or through a right ventriculotomy. Subvalvular LVOTO was analyzed and corrected by resections of conal septum, parietal band or anomalous valvular tissue (Table 1). The coronary arteries were reimplanted in the appropriate sinus of the PA according to their anatomy. At discharge, four patients presented low or moderate subaortic gradients (Table 1). Three of them had preoperative significant gradients. One of these patients with postoperative subaortic stenosis had no preoperative significant gradient.

Since 1985, all survivors after ASO have had at least a yearly examination including a clinical assessment, an electrocardiogram, and a two-dimensional echocardiogram with color Doppler study done by the referring cardiologist. Subaortic gradients had developed in all these 10 patients, 9 of them were referred to our institution for evaluation and reoperation. The last patient was reoperated on in another institution.

Results are expressed as mean ± SEM and range. Statistical analysis performed with a $\chi^2$ test was considered significant for $p < 0.05$ (Statview, SAS Institute Inc.).

### 3. Results

No patient was lost in follow-up. Results regarding LVOTOs post-ASOs are presented in Table 2. In all 10 patients, subaortic gradients have developed progressively between 5 months to 14 years after ASO (average delay: 41 ± 35 months) leading to reoperation. These LVOTOs were significantly more frequent in patients with TBA than in patients with TGA or TGA—VSD (7.62% and 0.59%, respectively, $p < 0.001$). At this time, average gradient was 79 ± 12 mmHg. During these first reoperations, most LVOTOs (in nine patients) were due to fibrotic membranes or fibro-muscular hypertrophies which were removed. Resection of one muscular bundle (patient 5) and two septal enlargements with patches (patients 3 and 4) were also achieved. In patient 7 the previous patch used for VSD closure participated in the LVOTO and was folded into the right outflow tract in order to reduce the subaortic obstacle and abnormal tricuspid attachments were resected. In patient 8, LVOTO was caused by accessory mitral tissue which was also resected. Mitral valvuloplasty, residual VSDs closure and plasty of the left coronary ostium were also performed in patients 1, 3 and 4, respectively. After these first reoperations, seven patients (70%) had non-significant or low gradients and, to date, were not reoperated on for LVOTO (for these seven patients the average follow-up is 122 ± 33 months after these
<table>
<thead>
<tr>
<th>No.</th>
<th>Time to first reoperation (month)</th>
<th>Indication for first reoperation</th>
<th>First reoperation procedure</th>
<th>Postoperative result</th>
<th>Time from first to second reoperation (month)</th>
<th>Indication for second reoperation</th>
<th>Second reoperation procedure</th>
<th>Postoperative result</th>
<th>Time from second to third reoperation (month)</th>
<th>Indication for third reoperation</th>
<th>Third reoperation procedure</th>
<th>Postoperative result</th>
<th>Total follow-up (month)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>SAS (LVOT max grad: 100 mmHg)/MV regurgitation grade 3</td>
<td>Subaortic membrane resection (on patch), MV plasty</td>
<td>LVOT max. gradient: 45 mmHg, MVR grade 3</td>
<td>3</td>
<td>SAS (LVOT max grad: 77 mmHg)/MV regurgitation grade III–IV/AV regurgitation II–III</td>
<td>Enlargement of the previous VSD patch, MV replacement (mechanical 1B), suspension of one aortic cusp, TV valvuloplasty and annuloplasty</td>
<td>LVOT max. gradient: 44 mmHg, atrio-ventricular block (temporary PM)</td>
<td>43</td>
<td>Rejection of subaortic membrane, MV replacement (mechanical 21), AV replacement (mechanical 16)</td>
<td>LVOT max. gradient: 23 mmHg</td>
<td>146</td>
<td>Alive, LVOT max gradient: ns</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>SAS (LVOT max grad: 75 mmHg)</td>
<td>Subaortic fibro muscular hypertrophy resection</td>
<td>LVOT max. gradient: 15 mmHg, AV regurgitation grade I</td>
<td>152</td>
<td>TV regurgitation grade IV</td>
<td>TV valvuloplasty and annuloplasty</td>
<td>LVOT max. gradient: ns, AV regurgitation grade II</td>
<td>170</td>
<td>Alive, LVOT max gradient: ns</td>
<td></td>
<td>170</td>
<td>Alive, LVOT max gradient: ns, AV regurgitation grade II</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>53</td>
<td>SAS (LVOT max grad: 40 mmHg), residual VSDs, AV regurgitation grade I–II</td>
<td>Subaortic membrane resection, myotomy and septal plasty (patch) VSDs closure</td>
<td>LVOT max. gradient: ns, AV regurgitation grade II</td>
<td>47</td>
<td>SAS (LVOT max grad: 75 mmHg)/AV regurgitation II/stenosis of left coronary ostium</td>
<td>Resection of subaortic membrane, LDA bypass grafting by left mammary artery</td>
<td>LVOT max. gradient: ns, inferior hypokinesia (stenting of right coronary artery)</td>
<td>88</td>
<td>Heart transplantation</td>
<td></td>
<td>88</td>
<td>Alive</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>SAS (LVOT max grad: 70 mmHg), AV regurgitation grade I–II, stenosis of left coronary ostium</td>
<td>Subaortic membrane resection, septal plasty (patch), plasty of the left coronary ostium</td>
<td>LVOT max. gradient: 60, AV regurgitation grade I-II</td>
<td>44</td>
<td>SAS (LVOT max grad: 75 mmHg)/MV regurgitation grade III–IV/AV regurgitation II–III</td>
<td>Resection of subaortic membrane, LDA bypass grafting by left mammary artery</td>
<td>LVOT max. gradient: ns, inferior hypokinesia (stenting of right coronary artery)</td>
<td>88</td>
<td>Heart transplantation</td>
<td></td>
<td>88</td>
<td>Alive</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>SAS (LVOT max grad: 92 mmHg), AV regurgitation grade II, stenosis of pulmonary infundibulum</td>
<td>Subaortic fibro muscular hypertrophy resection, resection of the parietal bundle</td>
<td>LVOT max. gradient: 20, AV regurgitation grade I-II</td>
<td>94</td>
<td>SAS (LVOT max grad: 75 mmHg)/MV regurgitation grade III–IV/AV regurgitation II–III</td>
<td>Resection of subaortic membrane, LDA bypass grafting by left mammary artery</td>
<td>LVOT max. gradient: ns, inferior hypokinesia (stenting of right coronary artery)</td>
<td>94</td>
<td>Alive, LVOT max gradient: 15, AV regurgitation grade I</td>
<td></td>
<td>94</td>
<td>Alive, LVOT max gradient: 15, AV regurgitation grade I</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>SAS (LVOT max grad: 90 mmHg)</td>
<td>Subaortic membrane and fibro muscular hypertrophy resection</td>
<td>LVOT max. gradient: 19, AV regurgitation grade II</td>
<td>110</td>
<td>SAS (LVOT max grad: 114 mmHg), AV regurgitation grade II–III</td>
<td>Resection of subaortic membrane, a muscular hypertrophy and anomalous tricuspid cords, reduction of the VSD patch</td>
<td>LVOT max. gradient: 29 mmHg, AV regurgitation grade II–III, atrio-ventricular block (PM)</td>
<td>110</td>
<td>Alive, LVOT max gradient: 39, AV regurgitation grade II</td>
<td></td>
<td>110</td>
<td>Alive, LVOT max gradient: 39, AV regurgitation grade II</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>SAS (LVOT max grad: 90 mmHg)</td>
<td>Resection of a subaortic membrane, a muscular hypertrophy and anomalous tricuspid cords, reduction of the VSD patch</td>
<td>LVOT max. gradient: 15, AV regurgitation grade I-II</td>
<td>49</td>
<td>SAS (LVOT max grad: 75 mmHg), AV regurgitation grade III–IV/AV regurgitation II–III</td>
<td>Resection of subaortic membrane, a muscular hypertrophy and anomalous tricuspid cords, reduction of the VSD patch</td>
<td>LVOT max. gradient: 29 mmHg, AV regurgitation grade II–III, atrio-ventricular block (PM)</td>
<td>49</td>
<td>Konno procedure with mechanical aortic prosthesis (21), resection of anomalous mitral valve cords, and pulmonary unvalved conduit</td>
<td></td>
<td>49</td>
<td>Alive, LVOT max gradient: ns, AV max gradient: 23 mmHg</td>
<td></td>
</tr>
</tbody>
</table>
first reoperations). One of them (patient 2) was reoperated on for tricuspid valvuloplasty 12 years later.

Patient 5 underwent a second reoperation 44 months later for a LVOTO (caused by a subaortic membrane) and a proximal stenosis of the left coronary artery. Ischemic complications led this patient to a successful heart transplantation 18 months later.

Patients 1 and 7 both underwent an enlargement of the VSD patch during their second reoperation and experienced postoperative atrio-ventricular blocks requiring a pace maker implantation for patient 7. They both developed aortic valve regurgitations requiring aortic valve replacements and a new LVOTO resection for patient 1 and a Konno procedure for patient 7 (Fig. 1).

To date, all these 10 patients are alive with a total follow-up of 117 + 33 months [46—178]. Seven patients had no recurrence of LVOTO after their second procedure.

4. Discussion

When possible, the arterial switch operation is considered as the optimal surgical treatment for TGA with or without VSD or TBA, leading to an anatomic correction without implantation of exogenous material [1,11]. The classical contraindication to ASO is a hypoplastic pulmonary annulus, or a LVOTO considered as non-resectable. Then, other strategies can be used as Rastelli, Lecompte or Metras procedures [2—4,12], but they require the presence of a large subpulmonary ventricular septal defect. These procedures are not always feasible and have their drawbacks such as reoperations for conduit replacement or pulmonary regurgitations in case of repair without valved conduit. When the VSD is small or when tunneling the left ventricle to the aorta is not feasible because of atrio-ventricular valves straddling, aortic root translocation described by Nikaidoh [5] and modified procedures [6,7] can be used but also implies the implantation of a homograft. To date, if the LVOTO can be resected, only ASO can result in a definitive treatment for these anomalies. Our indications for these ASO were based on favorable anatomical features such as anteroposterior great vessels, or, if the great vessels were side by side, a tricuspid to pulmonary valve distance inferior to aortic valve diameter [13]. It is difficult to assess if arterial switch operation was the most appropriate initial repair regarding the small cohort of patients presenting this rare and late complication.
Despite our attitude and other studies [1,11,12] designed to optimize the choice of the best procedure, LVOTO recurrence is still possible after ASO. In our group of patients operated on by ASO for TGA with or without VSD or TBA, postoperative LVOTO is a rare complication (0.59 %), affecting preferentially patients with TBA (7.62 %). All but one of these patients (n = 9) presented anomalies of the LVOT before ASO, but only four had a preoperative significant subaortic gradient, which was major (112 mmHg) in only one patient (patient 8). Preoperative LVOTs or predisposition for LVOTO were caused by anomalies already described [1] such as conal septum malalignment (7/9), abnormal tricuspid chordae insertions (4/9), muscular bundle hypertrophy (3/9) and mitral accessory tissue (1/9). A malaligned conal septum is part of the TBA and may contribute to a postoperative LVOTO after the closure of the VSD by a patch. Muscular bundle and accessory valvular tissue can be resected; however, incomplete resection may result in early recurrence of LVOTO. Abnormal tricuspid chordae insertions were present in two patients (1 and 7) who underwent iterative surgical procedures and these should be looked for and treated during the first operation. LVOTs were considered to be resectable in all these patients and therefore supported the chosen strategy.

For two patients, on postoperative evaluations after ASO, one LVOTO appeared (patient 6) and one gradient had increased compared to preoperative value (patient 4). Preoperative LVOTOs or predisposition for LVOTO were caused by anomalies already described [1] such as conal septum malalignment (7/9), abnormal tricuspid chordae insertions (4/9), muscular bundle hypertrophy (3/9) and mitral accessory tissue (1/9). A malaligned conal septum is part of the TBA and may contribute to a postoperative LVOTO after the closure of the VSD by a patch. Muscular bundle and accessory valvular tissue can be resected; however, incomplete resection may result in early recurrence of LVOTO. Abnormal tricuspid chordae insertions were present in two patients (1 and 7) who underwent iterative surgical procedures and these should be looked for and treated during the first operation. LVOTs were considered to be resectable in all these patients and therefore supported the chosen strategy.

5. Conclusion

Postoperative LVOTO after ASO is a rare complication after an ASO but is more frequent in TBA. ASO should be preferred if the correction of factors enabling postoperative LVOTO is feasible. However postoperative subaortic gradients may develop. Most of these patients can benefit from a reoperation by resection of the subaortic obstacle or septoplasty. In more complex cases, iterative surgical procedures may lead to complications such as block or severe aortic valve regurgitation.