Long-term results of ascending aorta-abdominal aorta extra-anatomic bypass for recoarctation in adults with 27-year follow-up

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Abstract

Objective: The surgical treatment of recurrent coarctation in adults supposes a redo left thoracotomy with adhesions and high risk of bleeding and injury of adjacent nerves. The rate of paraplegia in these cases may reach 2.6%. Extra-anatomic aortic bypass avoids these complications. We present our results with ascending-to-abdominal aorta extra-anatomic bypass for recurrent aortic coarctation in adults.

Methods: Between September 1979 and November 2006 12 patients underwent ascending-to-abdominal aorta bypass. There were 10 males and 2 females. Mean age was 36.2 ± 11.3 (range 21—57) years old. Mean age at primary repair was 14.3 ± 4.2 years old (range 8—21). Operative technique consisted of performing an ascending-to-abdominal aorta bypass via median sternotomy extended into the epigastrium with a supra-umbilical laparotomy through the mid-line abdominal fascia. Concomitant procedures were performed in six patients: three isolated aortic valve replacements (AVR), two ascending aorta graft replacements and one AVR associated with coronary artery bypass graft (CABG).

Results: No postoperative mortality was observed. Mean follow-up time was 10.4 ± 9.3 years (range 0.3—27.8). No patients had any graft-related complication or death and all grafts were patent at the end of the follow-up. One patient developed a dilated myocardiopathy, dying at 14 years of follow-up. Four patients had persistence of arterial hypertension controlled with one drug therapy and five patients were asymptomatic.

Conclusions: Ascending-to-abdominal aorta extra-anatomic bypass is a safe, effective and less invasive technique for aortic recoarctation in adults with good results at long-term.

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Keywords: Coarctation; Reoperation; Adult

1. Introduction

Coarctation of the aorta is a common cardiovascular congenital abnormality. Its first surgical treatment was reported by Crafoord in 1945 [1], who performed a resection of the abnormal aortic segment and end-to-end anastomosis. From that date until the present various other techniques have been described: subclavian flap aortoplasty, onlay graft patch aortoplasty with synthetic material or autogenous arterial wall, bypass grafting and percutaneous balloon aortoplasty [1].

Recurrent coarctation of the aorta is a more challenging problem. The classical surgical options including resection with direct end-to-end anastomosis, patch aortoplasty, or interposition tube grafts will require re-entering the left chest to expose previously operated aortic segments with adhesion, instauration of cardiopulmonary bypass (CPB) and aortic cross-clamping with its inherent risk of bleeding, injury of adjacent nerves and paraplegia due to abnormal collateral circulation and spinal cord ischemic insult [2—4]. Extra-anatomic aortic bypass through the mid-line, however, avoids local dissection of previously operated zone and cross-clamping of the aortic arch. In this report, we present our experience with ascending-to-abdominal aorta extra-anatomic bypass, for recurrent aortic coarctation in adults.

2. Material and methods

Between September 1979 and November 2006 12 patients were operated on in our institution with an ascending-to-abdominal aorta bypass (AAbB) graft for recoarctation of the aorta. Preoperative assessment included clinical examination, echocardiography, angio-computed tomography scan or angio-magnetic resonance imaging; for patients operated at the beginning of the series invasive aortography was performed.

All data are presented as mean ± standard deviation. They were 10 males and 2 females. Their mean age was 36.2 ± 11.3 (range 21—57) years old. Mean age at primary
repair was 14.3 ± 4.2 years old (range 8—21). All patients presented arterial hypertension. All but two presented diminished femoral pulse, and one patient had total abolition of femoral pulse. A murmur was present in 10 patients. Mean left ventricle ejection fraction was 60±12% (range 37—70). Half of the patients were in NYHA class I and the other 50% were in class II.

Six patients (cases 3, 4, 5, 6, 8, 12) presented concomitant cardiac pathologies: aortic valve insufficiencies [3], ascending aorta aneurysms [2], one patient had an aortic valve stenosis and a right coronary artery stenosis. One patient presented with acute aortic valve infectious endocarditis 3 months before surgery (case 8). Patient characteristics are summarized in Table 1.

### 3. Surgical technique

The surgical approach for this extra-anatomic bypass graft is based on two anatomical conditions: (a) collateral circulation is reduced in the mid-line; and (b) the celiac aorta segment regains the mid-line between the pillars of the diaphragm, making it more accessible in the epigastrium without the need of retracting the heart cephalad for exposure (with the consequent hemodynamic instability due to restriction imposed to the left ventricle) as it is the case with the retro-pericardial portion of the descending thoracic aorta.

Following these principles, surgery is performed via median sternotomy extended into the epigastrium with a supra-umbilical laparotomy through the mid-line abdominal fascia. To expose the supra-celiac abdominal segment of the aorta between the pillars of the diaphragm, the transverse colon and the big curve of the stomach are retracted downward and the triangular ligament of the left hepatic lobe is divided to mobilize the liver to the right. After systemic heparinization (1 mg/kg) the abdominal aorta is partially side-clamped and an end-to-side anastomosis with a Dacron graft (diameter 20—22 mm) is performed (Fig. 1). After local control for hemostasis, the graft is passed through an incision made on the fibrous part of the diaphragm and positioned along the inferior aspect of the right ventricle and lateral to the right atrium to reach the right aspect of the ascending aorta. A 25—30 cm graft length is usually adequate in most adults. After side-clamping the ascending aorta, the proximal end-to-side anastomosis is performed; then the graft is de-aired and de-clamped (Fig. 2). The operation is finished with closing of the chest and abdomen in the standard fashion. In case of the need to implant the graft on the distal segments of the aorta (infrarenal aorta or iliac arteries), a full mid-line laparotomy is performed, and the graft is passed behind or through the mesenteric root and in front of the pancreas.

All procedures were performed through a median sternotomy with upper median laparotomy as described above. In one patient (case 1) who presented a thoracic descending aorta to abdominal aorta graft stenosis, a full laparotomy was performed. Concomitant procedures were needed in six patients, all of them required CPB: four aortic valve replacements (AVR) one of them associated to a right coronary artery bypass graft and two supra-coronary ascending aorta graft replacements.

### 4. Results

All patients survived the surgical intervention. Postoperative course was uneventful in all patients but two. One patient presented a postoperative morganella related pulmonary infection treated successfully with antibiotics.

![Fig. 1. Distal anastomosis. The supra-celiac abdominal aorta is dissected between the pillars of the diaphragm and the aorta is partially side-clamped and an end-to-side anastomosis with a Dacron® graft is performed.](image)
The second patient (patient 12), who underwent concomitant AVR + CABG, presented a cardiac arrest related to the right coronary artery bypass graft kinking. He had to be reoperated in the immediate postoperative period. Afterwards he presented renal failure necessitating hemodialysis. No patient had any neurological complication. For the patients with no concomitant procedure blood loss in the postoperative period was minimal, chest tubes were removed between postoperative day 2 and 3 and no blood transfusions were required.

Mean stay time in intensive care unit for all patients excluding patient 12 was 67 ± 32 h (range 24—96). Follow-up was completed by the end of February 2007. Two patients were lost to follow-up. Both patients moved overseas soon after surgery.

For the 10 other patients mean follow-up time was 124 ± 111 months (range 4 months to 27.8 years). No patient had any graft-related complication or death and all grafts were patent at the end of the follow-up period. One patient developed dilated cardiomyopathy and was entered in the transplant waiting list, dying at 14 years of follow-up due to congestive heart failure while on the waiting list.

In four patients arterial hypertension (AHT) persisted after surgery which was well controlled by one medication treatment. The remaining five patients are asymptomatic (Table 2).

### 5. Discussion

Recurrence of coarctation after surgical repair may vary from 3% to 35% according to the age of primary intervention and surgical technique employed [5,6].

Percutaneous balloon dilation would be one of the treatment options in this situation [7,8]; however, when extensive calcification of the previous operated area exists, this option may be precluded.

Surgical options by direct approach include: resection of the narrowed segment and tube graft replacement, patch graft aortoplasty or subclavian artery patch [2,3,9,10]; all of which require a redo left thoracotomy, dissection of the previous operative site and, eventually in case of difficulty, the instauration of cardiopulmonary bypass and deep hypothermic circulatory arrest with an increasing risk for bleeding, paraplegia, recurrent laryngeal and phrenic nerves injury and pulmonary tissue injury.

Paraplegia is the most devastating complication. The real incidence is difficult to discern from the literature, but reported rate is about 2.6% [4]. Paraplegia occurs due to an ischemic insult to the spinal cord when a cross-clamp is applied to the descending aorta. Shunts, CPB, hypothermic cardiopulmonary arrest and left heart bypass are used to avoid spinal cord ischemic insult [2—4,10]. However, all these techniques have morbidity on their own.

Another way is to avoid reopening the left chest and to perform an extra-anatomic bypass graft. There are various reports with extra-anatomical aortic bypass for recurrent aortic coarctation. Most of these reported series require institution of CPB or re-entering the left chest [11—16]. In the

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**Table 2**

<table>
<thead>
<tr>
<th>No.</th>
<th>Intervention</th>
<th>ICU stay (h)</th>
<th>Complication</th>
<th>Follow-up</th>
<th>Follow-up time (in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AABB</td>
<td>24</td>
<td>None</td>
<td>Asymptomatic</td>
<td>6.9</td>
</tr>
<tr>
<td>2</td>
<td>AABB</td>
<td>72</td>
<td>None</td>
<td>Asymptomatic</td>
<td>24.6</td>
</tr>
<tr>
<td>3</td>
<td>AABB + AAoR</td>
<td>24</td>
<td>Morganella related pneumonia</td>
<td>Persistence AHT</td>
<td>6.3</td>
</tr>
<tr>
<td>4</td>
<td>AABB + AVR</td>
<td>96</td>
<td>None</td>
<td>Persistence AHT</td>
<td>9.0</td>
</tr>
<tr>
<td>5</td>
<td>AABB + AAoR</td>
<td>24</td>
<td>None</td>
<td>Asymptomatic</td>
<td>5.6</td>
</tr>
<tr>
<td>6</td>
<td>AABB + AVR</td>
<td>120</td>
<td>None</td>
<td>Dilated myocardiopathy.</td>
<td>14.2</td>
</tr>
<tr>
<td>7</td>
<td>AABB</td>
<td>72</td>
<td>None</td>
<td>Death at 14 years post-op.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>AABB + AVR</td>
<td>72</td>
<td>None</td>
<td>Asymptomatic</td>
<td>0.3</td>
</tr>
<tr>
<td>9</td>
<td>AABB</td>
<td>72</td>
<td>None</td>
<td>Asymptomatic</td>
<td>0.3</td>
</tr>
<tr>
<td>10</td>
<td>AABB</td>
<td>96</td>
<td>None</td>
<td>Persistence AHT</td>
<td>27.8</td>
</tr>
<tr>
<td>11</td>
<td>AABB</td>
<td>72</td>
<td>None</td>
<td>Lost to follow up</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>AABB + AVR + CABG</td>
<td>720</td>
<td>CABG kinking, cardiac arrest,</td>
<td>Persistence AHT</td>
<td>8.7</td>
</tr>
</tbody>
</table>

AABB, ascending-to-abdominal aorta bypass graft; AAoR, ascending aorta replacement; AHT, arterial hypertension; AVR, aortic valve replacement; CABG, coronary artery bypass graft.
posterior pericardial approach technique [14—16] the authors had to use CPB in all cases to retract the heart cephalad to abort the retro-pericardial portion of the thoracic descending aorta. In their series, Caspi et al. [13] and Aralkeyyan et al. [12] utilized a right thoracotomy to perform the bypass avoiding the already operated zone. Even though it is a simple technique that does not need the instauration of CPB, it does not solve the whole spectrum of concomitant cardiac pathology. In our experience, ascending-to-abdominal aorta bypass through a median sternotomy and upper mid-line laparotomy is recommended because it avoids the utilization of CPB, cross-clamping of the thoracic descending aorta and dissection of a heavily scarred zone of the previous operation; thus, the risk of damaging of nerves structures and/or the friable aortic wall and important collaterals which be inaccessible in the adherent tissue (with its inherent potential hemorrhagic complication) is minimized; reducing at the same time, the risk of ischemic injury of the spinal cord.

This surgical approach gives an excellent exposure of the ascending aorta and the heart allowing concomitant cardiac and/or ascending aorta pathology surgery, which is quite frequent in this group of patients. Reported mortality for direct repair of recoarctation varies from 0% to 8% [2,3,10]. In this series there were no postoperative deaths. Although the present work presents a small number of patients, its mortality and morbidity rates compares favorably [11,12,14].

Reported morbidity rates for direct repair of recoarctation as high as 50% [3,10]. Ralph-Edwards et al. [3] in a series of 43 patients, who underwent reoperation for recoarctation of the aorta, described a 4.7% rate of recurrent laryngeal nerve palsy, 2.3% rate of phrenic nerve palsy and 7% rate of postoperative bleeding requiring reoperation. In the present series only two patients presented a major postoperative complication. One morganella related pulmonary infection which responded favorably to antibiotic treatment, and a cardiac arrest, related to a coronary artery bypass graft kinking. No patient had any neurological complication. Another issue concerning these patients is the concomitant cardiac pathology. Of interest, due to its frequency and surgical implications in adult patients, are bicuspid aortic valve and ascending aortic aneurysm. A bicuspid aortic valve is found in 20—85% of patients [5,17—20], significant stenosis and/or regurgitation develops in up to 65% of the cases [18], of whom at least 7—10% [17] will require aortic valve replacement. Roos-Hesselink et al. [21] in a series of 124 patients operated for recoarctation of the aorta, found that 28% of the patients presented a dilated ascending thoracic aorta and 63% developed aortic valve insufficiency. However is a small series, the results in the long-term are very good, as in the other papers cited in the literature [12,13]. There were no graft-related complications or death during the follow-up period (ranging from 4 months to 27 years). Nine patients were alive. One patient died at 14 years of follow-up, he developed a dilated cardiomyopathy dying while he was on the transplant waiting list.

The main clinical feature was persistence of arterial hypertension [3,6], which in this report accounts up to 30% and was well managed with one drug therapy in all patients. In conclusion recoarctation of the aorta in adult patient population is a complex entity. Associated cardiac pathologies are common. Preoperative assessment is of vital importance in order to draw the best surgical strategy. Ascending-to-abdominal aorta extra-anatomic bypass with Dacron grafts through a median sternotomy and mid-line upper laparotomy approach is a safe, effective and less invasive technique for repairing aortic recoarctation in adults. This technique allows performing the correction of the eventually concomitant cardiac pathology. It presents good results in the long-term.

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References


