Early and moderate long-term results of a new surgical technique for repair of aortic coarctation

Abstract  Objective. From June 1987 to September 1995, 53 patients underwent a new technique of coarctation repair. This technique consists of complete mobilization of the left subclavian artery so that it can be pulled down as far as possible.

Method. After all the necessary clamping, the anterior wall of the aorta is incised longitudinally beginning on the anterior wall of the left subclavian artery and extending distally to the descending aorta 1–2 cm past the coarctation. The left subclavian artery is pulled down so that the proximal end of the incision can reach the distal end. Then, this longitudinal incision is sutured transversely with 5/0 or 6/0 polydioxyanone and continuous technique, enlarging the coarctation site and also preserving the blood flow to the left upper limb. The ages of the patients ranged from 16 days to 20 years (mean 3.7 years). Thirty patients were younger than 1 year old. One patient (1.9%) died postoperatively due to persistent pulmonary hypertension.

Results. There was no pressure gradient perioperatively through the coarctation site after the repair. The mean follow-up was 34.4±27.5 months (range 1–99 months). All patients but one were in class I effort capacity (NYHA). Doppler echocardiographic studies were performed in 45 patients postoperatively. There was no restenosis or aneurysm formation at the coarctation site and the mean pressure gradients were between 19.8±16.2 mmHg.

Conclusion. The authors experience indicates that this technique could be a good alternative to the subclavian flap aortoplasty because of the preservation of blood flow to the left upper limb. [Eur J Cardio-thorac Surg (1996) 10:884–889]

Key words  Coarctation of the aorta • Subclavian aortoplasty

Introduction

The first successful intervention for aortic coarctation, which represents 8% of congenital heart diseases, was applied by Crafoord and Nylin in 1945 [3]. Today two commonly used methods are resection and end-to-end anastomosis and subclavian flap aortoplasty, but, the incidences of recoarctation remain controversial. On the other hand, although reserved for some specific cases, patch angioplasty technique is not preferred by surgeons because of its contribution to aneurysm formation [5].

This study describes a new technique that we performed in 53 patients operated on between June 1987 and September 1995. We feel that this technique can be regarded as a convenient alternative to subclavian flap aortoplasty because of its advantage that the coarctation can be readily and quickly repaired and the blood flow to the left upper limb preserved.
Material and methods

Surgical technique

The essence of this new technique is to provide enlargement of the coarctated segment using an angioplastic procedure that includes preserving the continuity of the subclavian artery, pulling it down and placing it along the coarctation site. The technique was essentially the same throughout the study period as reported previously [20].

A left posterolateral thoracotomy is performed through the fourth intercostal space. The descending aorta, distal aortic arch, subclavian artery, coarctation segment and the distal aorta are mobilized. The intrathoracic branches of the subclavian artery, other than internal thoracic artery, are ligated and divided. Whether the subclavian artery can be pulled down distally about 1–2 cm past the coarctation site is tested using a vascular clamp placed temporarily on the first third of the subclavian artery (Fig. 1). After the aorta and the subclavian artery have been clamped, the aorta is incised longitudinally, as shown in Fig. 2. The distal end should be extended 1–2 cm beyond the coarctation. The coarctation membrane in the aorta is excised if it is too prominent. The subclavian artery is pulled down so that the proximal end of the incision reaches the distal end. Thereafter, the incision is sutured transversely by using continuous technique with 5–0 or 6–0 polydiaxanone (PDS). This provides the extension of the subclavian artery, over the aorta resulting in the widening of the coarctation site (longitudinal incision and transverse repair, Figs. 3, 4).

If extreme tension occurs during the pulling down of the subclavian artery, then the subclavian artery is transected and pulled down and the aortoplasty procedure is completed. The continuity of the subclavian artery is then obtained by interposing a polytetrafluoroethylene graft of 6–8 mm in size (Fig. 5).

Patients

The coarctation was repaired using this technique in 53 patients between June 1987 and September 1995. The ages of the patients ranged from 16 days to 20 years. Thirty patients (56.6%) were under the age of 1 year (mean 3.8 months; Table 1). Diagnosis was made through echocardiographic examination. Cardiac catheterization was

<table>
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<th>Age Group</th>
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<tr>
<td>0–1 month</td>
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<tr>
<td>1–3 months</td>
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<td>&gt;6 years</td>
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Table 1 Ages of the patients (33 male, 20 female)
performed in eight patients. Additional cardiac pathology was detected in 22 patients, two of whom had complex cardiac anomalies. Severe hypoplasia of the transverse aortic arch (less than 50% of the ascending aorta) was not encountered in any patient. There was moderate to severe hypoplasia of the isthmus in 25 patients (47%). All cases presented left ventricular hypertrophy. The average blood pressure was 146±30.6 mmHg and the mean pressure gradient across the coarctation was 74.95±13.2 mmHg. Preoperative echocardiographic examination in patients less than 1 year of age revealed that the average interventricular septum thickness was 0.82±0.24 cm and the average posterior wall thickness of the left ventricle was 0.67±0.29 cm. Despite preoperative intensive medical therapy, severe cardiac failure persisted in six of these patients, who had to be operated on in this condition. Among these, two had dilated cardiomyopathy. One patient underwent concomitant pulmonary banding. Extreme tension occurred during the pulling down of the subclavian artery in three patients (over 10 years of age), in whom polytetrafluoroethylene grafts were interposed between the proximal and distal parts of the subclavian artery (with a diameter of 8 mm in two cases, and 6 mm in one). The duration of the aortic clamping varied between 4 and 18 min. Perioperative pressure measurements were made in all patients following the coarctation repair. All patients had a control echocardiographic examination in the first postoperative month, and most a regular one every 6 months thereafter.

Results

One patient (1.9%; CL 70: 0.2–6%) died of persistent pulmonary hypertension in the early postoperative period. Early postoperative complications were bleeding in one patient and transient paralysis of the left arm in another. Seven patients were lost to follow-up. A total of 45 patients (86.5%) were followed for an average of 34.4±27.5 months. Twenty-four patients who were younger than 1 year were followed up for 26.8±19.1 months postoperatively. The gradient measured intraoperatively ranged from 0 to 8 mmHg. During the follow-up period echocardiographic and Doppler examination showed no typical coarctation flow pattern, with the mean peak systolic gradient being 19.8±16.2 mmHg. Five out of ten cases whose echocardiographic peak systolic gradients were over 20 mmHg underwent catheterization. The actual gradient was found to be between 0 and 10 mmHg in those patients. Signs of left ventricular hypertrophy disappeared without medical therapy and arterial blood pressures remained within normal ranges (113.1±10.8 mmHg) in all but one patient who was followed up for more than 1 year. We did not encounter any aneurysm formation or restenosis. Left arm pulses were clearly elicited in all patients (Fig. 6).

Discussion

Coarctation of the aorta is a narrowing of the lumen of the thoracic aorta at or near the isthmus. Two embryologic factors are considered to cause this type of aortic obstruction. These are not mutually exclusive and may actually influence each other. One is underdevelopment or hypoplasia of the aortic arch or isthmus. The second factor is the presence of ectopic ductal tissue in the aorta around the aortic insertion of the ductus [7, 8, 19]. Theoretically, this anomaly can result in discrete aortic coarctation as ductal tissue constricts after birth. If both mechanisms are present, a discrete coarctation will be associated with proximal or distal aortic arch hypoplasia [2]. The reported incidence of aortic arch or isthmal hypoplasia is about 25–50% in infants with coarctation [21].

During the surgical repair of aortic coarctation these morphologic features should be taken into consideration. Currently, two techniques have been used as the methods of choice for routine coarctation repair: The subclavian flap
The major criterion for comparison between the types of repair is the incidence of residual or recurrent coarctation.

The subclavian flap aortoplasty, as described by Waldhausen and Nahewald, was widely accepted for the repair of coarctation until recent years and excellent short- and long-term results have been reported by many surgeons [11, 26]. In 1985, Metzdorff and Cobano [11] reported a high incidence of recurrence (17%) in infants younger than 8 weeks of age operated with the subclavian flap aortoplasty technique [18]. They proposed that the higher incidence of recurrence in young infants may be due to the continued involution of residual ductal tissue. A considerable amount of histologic and clinical evidence has been reported showing that ductal tissue plays an important role in the mechanism of coarctation formation [1, 6-8, 10, 12, 19]: as the ductus constricts and subsequently fibrous tissue is formed, a constriction in that area is created. On the basis of these considerations, various techniques of resection and primary anastomosis have gained favor in current times [6, 10, 12, 24]. However, a reduction in the incidence of restenosis after resection and end-to-end anastomosis compared with subclavian flap aortoplasty has not yet been confirmed (Table 2). Craig et al. [11] concluded that resection and end-to-end anastomosis do not diminish the rate of restenosis compared with subclavian flap aortoplasty. In fact, Merrill et al. [17] found that restenosis was significantly higher after resection and end-to-end anastomosis than after subclavian flap aortoplasty, in patients followed up for more than 5 years postoperatively.

Although the major advantage of resection and end-to-end anastomosis is the complete removal of the ductal tissue in the pericoarctation region, it has some disadvantages, including the potential for tension on the suture line, more extensive dissection and the presence of circumferential scar. Restenosis may occur either from lack of growth of the anastomotic suture line or from active narrowing as a result of fibrosis. Subclavian flap aortoplasty has the advantage of autogenous tissue with the potential for growth and provides a non-circumferential, nonconstricting suture line that might reduce the incidence of restenosis and provides a definitive repair of the narrowed isthmus. The major disadvantage of this procedure is the potentially ill effect resulting from sacrificing the left subclavian artery [5, 14, 23, 25]. In the early postoperative period, ischemic necrosis of the upper limb has been reported in rare instances (1-3%). Some reports have also demonstrated long-term shortening of the upper limb and reduced muscle mass or potential for ischemia during exercise [14, 23, 25].

We think that our technique incorporates the benefit of subclavian flap aortoplasty without sacrificing blood supply to the left arm and could be considered as a preferable procedure. We noticed that the left subclavian artery can be pulled down very easily if its intrathoracic branches are ligated and divided. Many patients, especially infants and young children, have very elastic and pliable tissue and in these pulling down the left subclavian artery is much easier. In most of the patients we were able to preserve the continuity of the left internal thoracic artery by preparing it from the internal thoracic fascia along with a few centimetres at its beginning, so that it could be used for coronary surgery in the event of ischemic heart disease later in the patient's life. There may be some patients, especially in the older age group, in whom the rigidity of the left subclavian artery is much more apparent. In these patients the left subclavian artery can be transected and the interposition of a graft undertaken, as performed in a few of our patients (Fig. 5).

It is proposed that one of the advantages of resection and end-to-end anastomosis with its extended modifications is the enlargement of the small distal aortic arch and isthmus. Siewers et al. [22] have suggested that extended resection should be limited to only those patients in whom the ratio of the transverse aortic arch to the ascending aorta is less than 0.25, which is very uncommon. Knott-Craig et al. noticed that in the ratios larger than this, the size of the transverse aortic arch did not influence the incidence of persistent obstruction or restenosis after resection and end-to-end anastomosis and subclavian flap aortoplasty repair [11, 15]. Nevertheless, in our technique isthmal hypoplasia, which may be present in various degrees in 25-50% of the patients [21] with aortic coarctation, is enlarged during the procedure.

Although our technique is an effective method for repair of aortic coarctation, there is still some concern regarding the rate of restenosis and aneurysm formation. None of our patients required reintervention during the follow-up of a mean period of 34.4±27.5 months. Echo-cardiographic examination showed no typical coarctation flow pattern with the mean peak systolic gradient being 19.8±16.2 mmHg. It has been shown that echocardiographic Doppler usually overestimates the actual gradients [16]. In fact, at catheterization there was no significant pressure gradient (0-10 mmHg) in our patients who had Doppler echocardiographic gradients of more than 20 mmHg. Even in 24 patients less than 12 months of age there was no restenosis during the follow-up beyond 1 year.

<table>
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<tr>
<th>References</th>
<th>RETE (%)</th>
<th>SFA (%)</th>
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<tbody>
<tr>
<td>Ziomer et al. (27)</td>
<td>25%</td>
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<tr>
<td>Amato et al. (1)</td>
<td>21%</td>
<td>11%</td>
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<td>Hopkins et al. (9)</td>
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<td>Merrill et al. (17)</td>
<td>17%</td>
<td>11%</td>
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Table 2: Recoarctation (RETE resection and end-to-end anastomosis, SFA subclavian flap aortoplasty)
This finding indicates that the viable flap of subclavian artery has probably enough potential for growth in our technique. In addition, we have not seen any aneurysm formation at the site of coarctation so far.

The technique of subclavian advancement flap as described by Mendonça and associates incorporates the benefits of subclavian flap aortoplasty without sacrificing blood flow to the left arm, as our technique does [4]. But the Mendonça technique is presumably technically more demanding and time-consuming and creates a long circumferential suture line, which might cause restenosis [13].

The debate regarding which surgical procedure is the best for repair of aortic coarctation has not yet been resolved. Our experience leads us to suggest that our technique is an effective method for repair of aortic coarctation and could be a good alternative to the subclavian flap aortoplasty, because of preservation of the blood supply to the left upper limb.

References

Discussion

Mr. J. Stark (London, England) I enjoyed your presentation. I would be worried about leaving the ductal tissue in, but my question is slightly different. You had a relatively small number of patients under the age of 3 months. In all our series this is the group where there is often a hypoplasia of the aortic arch, which obviously your technique does not treat. Did you exclude such patients from your series or do you think that there is no need to enlarge the arch in any of your patients?

Dr. Sarioglu: Thank you for your question, Dr. Stark. I agree with you that some degree of hypoplasia of the transverse arch is seen in 25%-60% of the patients, particularly under the age of 3 months. However the quantification of the hypoplasia that produces obstruction remains to be clarified. There is an important study reported by Sievers from University of Pittsburgh indicating that excellent growth of the transverse arch can be seen after the conventional repair of aortic coarctation. He stated that the enlargement of the arch should be reserved for the small group of infants with extreme degrees of arch hypoplasia in whom the transverse aortic arch to ascending aorta diameter ratio is less than 0.25. In our series, the number of the patients under the age of 3 months is small. We have seen mild to moderate hypoplasia of the isthmus in almost 50% of other patients under the age of 1 year. Our technique obviously provides the enlargement of the isthmus.

Dr. Ghosh (Lucknow, India): Dr. Sarioglu, the technique looks strikingly similar to a technique described earlier by Mendonca-Meier. They also gave angiographic criteria of the cases where this may be feasible and the cases where it may not be feasible. Do you have any criteria of choosing particular cases for this technique?

Dr. Sarioglu: I think this technique can be applied for the patients with classical discrete coarctation, and also for relatively short distances of segmental coarctation. Regarding the Mendonça technique, I think that it is somewhat different and a little bit more demanding technically and it may be more time-consuming. Also his technique consists of long circumferential suturing lines, which might cause restenosis. Thank you.

Dr. V. Polyakov: I appreciate your report highly. This is a good method, and we will be glad to use it in the future. I would like to tell you about our method, so-called "figure anastomosis", that we introduced in our clinic in 1987. We usually resect only a thin portion of coarctation with fetal tissue around the ductus (or ligamentum) arteriosus. Further we perform longitudinal incisions of narrowed ends of aorta approximately 6-10 mm (lateral and medial incisions of the central end of the aorta and anterior and posterior incisions of the peripheral end). With the help of these incisions we construct four triangular adjoining flaps and when anastomosing them to each other we finally obtain a long tortuous suture line. We consider that this anastomosis will straighten while the aorta is growing and will prevent recoarctation.

In such a manner we have operated on approximately 100 patients without mortality and recoarctation. Thank you.