Twenty-four year experience with reoperations after ascending aortic or aortic root replacement

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Abstract

Objective: A retrospective analysis of early and late outcome for late (>4 weeks) reoperations on the ascending aorta or aortic root.

Materials and methods: During a 24-year interval, starting in 1974, 834 patients underwent replacement of the ascending aorta (39.2%) or aortic root (60.8%). During the same period, 56 patients with a mean age of 51.1 ± 14.4 years underwent reoperation after ascending aortic or aortic root replacement. Predominant indications for reoperation were false aneurysm in 25 (44.6%) patients and true aneurysm in 18 (32.1%) patients. Most frequent surgical procedures were redo aortic root replacement in 30 (53.6%) patients and closure of a false aneurysm in 14 (25.0%) patients. Median interval between the operations was 51 months. Eighteen (32.2%) patients underwent concomitant partial or total aortic arch replacement.

Results: Hospital mortality was 5.4% (n = 3; 70% CL: 2.4–8.4%). Cause of death was low cardiac output in two patients and rupture of the aorta at the distal suture line in one patient. Univariate analysis identified two or more previous operations (P = 0.038) and the interval between initial operation and reoperation for complication of less than 8 months (P = 0.005) as risk factors for hospital death. Multivariate analysis indicated operation for active endocarditis or vascular graft infection as an independent risk factor for hospital death (P = 0.038, odds 14.6). Follow-up was complete, median 3.1 years. Nine (16.9%; 70% CL: 11.7–22.1%) patients died during that period. Estimated survival at 1, 5 and 10 years was 91.2, 84.0 and 76.4%. One patient underwent another reoperation. Estimated event-free survival at 1, 5 and 10 year is 84.3, 72.2 and 65.6%.

Conclusion: False aneurysm formation and progression of aneurysmatic disease are the predominant causes for late reoperations after aortic root or ascending aortic replacement. Reoperations can be performed with low hospital mortality and good late results.

Keywords: Reoperations; Ascending aorta; Aortic root

1. Introduction

Tube graft replacement of the ascending aorta (AAR), or composite valve graft reconstruction of the aortic root (ARR) for patients with ascending aortic aneurysm, or dissection has been well documented [1–4]. Improved surgical techniques, and perioperative care have resulted in low hospital mortality and improved long-term outcome. More recent techniques for ARR including the use of aortic allografts, pulmonary autografts or stentless bioprostheses have become attractive alternatives for specific indications, i.e. replacement of diseased aortic valves and/or aortic root, while in other situations, valve-sparing operations may be feasible [5,6]. As a consequence, the number of patients at risk for the development of late complications after reconstructive surgery on the ascending aorta or aortic root is increasing.

Degeneration of aortic valve substitutes, prosthetic valve endocarditis, vascular graft infection, true or false aneurysm formation are late complications that can cause substantial mortality and morbidity. All form indications for reoperation. In this report, we present our entire experience with reoperations on the ascending aorta and/or aortic root over a 24-year period.

2. Materials and methods

2.1. Patient population

From February 1974 through December 1998, 834 patients underwent ARR (n = 507, 60.8%) or AAR (n = 327, 39.2%) at our institution. Indications for operation were as follows: acute type A dissection in 260 (31.2%) patients, degenerative aneurysm involving the aortic root or ascending aorta in 238 (28.5%) patients, aortic valve disease
in 164 (19.6%) patients, annuloaortic ectasia in 75 (9.0%) patients, native or prosthetic aortic valve endocarditis in 63 (7.6%) patients and miscellaneous in 34 (4.1%) patients. Materials used for ARR included composite valve grafts in 275 (33.0%) patients (Bentall technique, 178; open technique, 96; Cabrol II, 1) aortic allografts in 135 (16.2%) patients, pulmonary autografts in 82 (9.8%) patients, stentless bioprostheses in ten (1.2%) and woven Dacron vascular prostheses for aortic valve-sparing operations in five (0.6%) patients. Materials used for AAR included woven or knitted Dacron vascular grafts in 326 (39.1%) patients and alograft ascending aorta in 1 (0.1%) patient. During the same interval, 56 additional redo procedures for late complications after ARR or AAR (>4 weeks) were performed. The overall proportion of reoperations was 6.7%, but the proportion at our institution was 6.0% as six patients were admitted to our department after a previous procedure in another hospital. Mean age of the reoperated patients was 51.1 ± 14.8 years (range, 20–75 years). Median interval between ARR or AAR and reoperation was 51 months (range, 1–219 months). Indications for reoperation in function of the previous operation are listed in Table 1. Patient characteristics are listed in the Appendix A1.

2.2. Operative considerations

Our technique of ARR with a composite valve graft consisted of both the Bentall (inclusion/wrap) technique and the Cabrol II technique until 1993 [7,8]. Since then, we have been using the open technique [4]. Technical details of aortic allograft and pulmonary autograft procedures have been described previously [9]. The technique of AAR consisted of the inclusion/wrap technique until 1993, but was then abandoned in favor of an open technique. Cardiopulmonary bypass (CPB) was instituted routinely after resternotomy with an oscillating saw (43 patients, 77%). In these patients, the common femoral artery (30 patients) or the distal ascending aorta or aortic arch (13 patients) were used for arterial inflow, and the right atrium or femoral vein for venous return. In only ten patients, CPB was started before the sternotomy. Five patients were emergency procedures, in another five patients, there was close contact between the sternum and the aortic aneurysm. Under these circumstances, the common femoral artery was used for arterial inflow and the common femoral vein for venous return (long venous 31F or 33F cannula positioned in the right atrium). CPB was not discontinued in any of these patients after division of the sternum. In the entire series, there was no need for alternative arterial cannulation sites. In three patients, there was no need for CPB as they had a small false aneurysm at an easily accessible localization. In all three patients, the leaking false aneurysm was temporarily occluded by percutaneous insertion of a balloon catheter into the mouth of the false aneurysm [10]. Cold, low sodium, normotopassive cardioplegia was used in 50 (90.0%) patients, in six other patients there was no need for cardioplegic arrest. Details of operative procedures are listed in Table 2. In 12 (21.5%) patients, deep hypothermic circulatory arrest (DHCA) with a mean duration of 18 ± 7 min (range, 5–30 min) was required. Moderate hypothermic circulatory arrest and antegrade selective cerebral perfusion (ASCP) for brain protection was used in 13 (23.2%) patients with a mean duration of 56 ± 14 min (range, 39–88 min). New saphenous vein grafts were sutured to the innominate artery or to the new aortic graft. The mean duration of CPB (for 56 patients) was 192 ± 72 min; mean myocardial ischemic time (for 50 patients) was 127 ± 48 min. Aprotinin or other hemostatic agents were not used routinely.

2.3. Statistical analysis

Group statistics were expressed as mean ± one standard deviation. Comparisons for univariate analysis were performed with the unpaired t-test, χ² or two-tailed Fisher’s exact test as appropriate. Patients who underwent more than one reoperation were only included once. End points exam-

<table>
<thead>
<tr>
<th>Indication for reoperation</th>
<th>ARR²</th>
<th>AARb</th>
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<tbody>
<tr>
<td></td>
<td>Bentall</td>
<td>Cabrol II</td>
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<tr>
<td>False aneurysm</td>
<td></td>
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<tr>
<td>Proximal suture line</td>
<td>6</td>
<td>–</td>
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<tr>
<td>Distal suture line</td>
<td>1</td>
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<tr>
<td>Coronary anastomosis</td>
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<tr>
<td>True aneurysm</td>
<td>2</td>
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<tr>
<td>Prosthetic calve endocarditis/vascular graft infection</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Failure of aortic calve substitute</td>
<td>2</td>
<td>–</td>
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<tr>
<td>Other</td>
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² ARR, aortic root replacement.

² AAR, ascending aortic replacement.
The majority of patients (49/56) required reoperation after previous operation for acute type A dissection or aneurysmatic aortic disease (degenerative or annuloaortic ectasia). Although the incidence of reoperation in both groups was similar (28/260 vs. 21/312, $P = 0.07$), the indications for reoperation were different. Most reoperations in the group of the acute type A dissection patients were required for progressive aortic root dilatation or distal ascending aortic dilatation (14/28), and for false aneurysm formation (11/28). In the other group (degenerative aneurysm and annuloaortic ectasia), reoperation for false aneurysm formation (12/21), and prosthetic valve related problems (endocarditis, thromboembolic events, valve degeneration) were predominant causes of reoperation.

### 3. Results

#### 3.1. Indication for reoperation

Hospital mortality was 5.4% ($n = 3$; 70% CL: 2.4–8.4%). Two of these patients had active endocarditis (2/8, 25%), the third patient had healed endocarditis (1/48, 2.1%) ($P = 0.05$). All had undergone replacement of the aortic root (two patients) or the ascending aorta (one patient) with aortic allograft tissue. Cause of death was low cardiac output in two patients and rupture of the aorta at the distal suture line in one patient. In the univariate analysis, two or more previous operations ($P = 0.038$) and the interval between initial operation and reoperation for complication of less than 8 months ($P = 0.005$) were risk factors for hospital death. Neither the type of previous operation, i.e. ARR vs. AAR ($P = 0.592$), nor the type of the actual intervention i.e. AAR or ARR vs. repair of false aneurysm ($P = 0.565$) had influence on overall hospital mortality. Multivariate analysis indicated operation for active endocarditis or vascular graft infection as an independent risk factor for hospital mortality ($P = 0.038$, odds 14.6).

#### 3.3. Hospital morbidity

Nine (16.0%; 70% CL: 10.7–21.3%) patients underwent early (<48 h) reoperation: three for excessive bleeding, five for removal of gauzes left in place for hemostatic purposes and one for cardiac arrest in the intensive care unit. Reintervention rate was not influenced by the type of procedure performed, i.e. AAR or ARR vs. repair of false aneurysm ($P = 0.16$). Seven (12.5%; 70% CL: 8.1–16.9%) patients required mechanical ventilation for more than 5 days, four of them needed a tracheotomy. Five (9.0%; 70% CL: 5.2–12.8%) patients experienced renal insufficiency necessitating temporary hemodialysis. One of them died, four others recovered uneventfully. Other complications included myocardial damage in one patient, requiring prolonged postoperative inotropic support and a central neurologic deficit in one patient due to massive air embolism (proven by intraoperative transcranial doppler); he recovered completely. There were no total AV blocks reported caused by the redo procedures.

#### 3.4. Late mortality and morbidity

Follow-up of the 53 hospital survivors was complete with a total of 201.2 patient-years. There have been nine late deaths (16.9%; 70% CL: 11.7–22.1%) during follow-up, which extends to 13.5 years (median follow-up 3.1 years). Three patients died of intracerebral hemorrhage, all were patients on anticoagulation for mechanical aortic valves. Two other patients died of rupture of a distant aneurysm, four patients died of unknown causes. Among the survivors, the 1-, 5- and 10-year survival rates did not differ significantly between patients having AAR or ARR and those having repair of a false aneurysm (log-rank $P = 0.69$) (Fig. 2). Due to the small numbers, Cox regression analysis failed to recognize risk factors for late death.

One patient underwent redo aortic root replacement (third operation) with an aortic allograft for active prosthetic valve endocarditis. The initial procedure consisted in composite
valve graft replacement of the aortic root, followed by repair of a false aneurysm at the left coronary reimplantation site 5 months later. A few weeks later, she presented with prothetic valve endocarditis caused by *Staphylococcus epidermidis*. Following the third operation, she required a permanent pacemaker for total atrioventricular block. Four (7.5%; 70% CL: 3.9–11.1%) patients had thromboembolic complications necessitating hospitalization. Estimated event-free survival (freedom from late death, thromboembolic complications, endocarditis, reoperation, anticoagulant-related problems) at 1, 5 and 10 years are 84.3 ± 5.1%, 72.2 ± 8.1% and 65.6 ± 9.6%, respectively: the event-rate is 0.055 events/patient-year.

4. Discussion

Hospital mortality for reinterventions on the ascending aorta and aortic root varies from 6 to 19% [11–14]. The early mortality rate is greatly influenced by the underlying disease, the technique of reoperation and the type of reintervention. In our series, the hospital mortality was 5.4%. It was highest for the subgroup with endocarditis. This is not surprising since this subgroup of patients is among the most severely ill. From our results, we could not confirm the influence of type of reintervention (ARR or AAR vs. repair of a false aneurysm) on early mortality. Reoperations can be limited to simple repair of a false aneurysm in the absence of endocarditis or progression of aortic disease with true aneurysm formation. When the false aneurysm is located at an easy accessible site, cardiopulmonary bypass may not be required. In situations of endocarditis and/or infection of a composite valve graft or ascending aortic vascular graft, an aggressive surgical approach is necessary with removal of all infected tissue. We recommend a reconstruction with aortic allograft tissue under these circumstances [9]. We do not feel that a root replacement with an allograft places the patient at a higher surgical risk. Although all three deaths in this series were patients who received allografts, one has to take in consideration that two of them presented with active endocarditis. Our multivariate analysis identified active endocarditis or vascular graft infection as the only independent risk factor for hospital mortality. Progression of true aneurysm formation on the ascending aorta or aortic arch also requires extensive repair, excluding as much as possible all diseased aortic tissue. This often includes partial or total aortic arch replacement. Reconstructions including the distal ascending aorta or the aortic arch were performed with the aid of DHCA or moderate hypothermic circulatory arrest with ASCP for brain protection. Throughout the series, we have used DHCA if repair was possible within 20 min; if not, moderate hypothermic circulatory arrest and ASCP for brain protection was used. If the descending aorta is also involved in the progression, we use a two-stage approach using an elephant trunk procedure.

A key element to successful reoperation on the ascending aorta or aortic root is a safe re-entry into the chest. In all operations on the aortic root or ascending aorta, we close the pericardium with or without the use of prosthetic material, if tolerated hemodynamically. We believe that a closed pericardium reduces the risk of damage to the right ventricle if a reoperation is required. A proper preparation and assessment of the risk of each step can decrease the incidence of severe problems. We advise a preoperative CT scan of the chest in every patient since this will allow the accurate delineation of the relation between the aorta, aneurysm or conduit and the bony structures of the chest wall. In five patients of our series, femorofemoral partial cardiopulmonary bypass was started before reopening the chest because of doubts about the safety of re-entry. Mostly, in case of laceration of major structures and important blood loss, the pump suckers can return the blood to the oxygenator, thus preventing severe hypotension. The indications for reoperation were different in patients operated on previously for acute type A dissection and patients operated on for degenerative aneurysm or annuloaortic ectasia. The incidence of reopera-

Fig. 1. Estimated survival of 53 hospital survivors. Dotted lines indicate 70% confidence limit.

Fig. 2. Estimated survival for hospital survivors: repair vs. replacement.
tion for progressive aortic root dilatation and/or dilatation of the residual ascending aorta in patients who underwent surgery for acute type A dissection might be reduced by a more aggressive surgical approach at the first operation. All of the patients with aortic root dilatation had undergone repair or involvement of the aortic arch, ASCP has been ment. In case of a time-consuming distal ascending aortic repair or due to trauma of the dissected aorta at the first operation or due to trauma of the dissected aorta at the clamping site. We now perform an open distal anastomosis in every patient, and cross-clamping of the dissected aorta is avoided. If a tear is found in the aortic arch, we do not hesitate to perform a hemiarch or total aortic arch replacement. In case of a time-consuming distal ascending aortic repair or involvement of the aortic arch, ASCP has been very useful. Advantages include cooling of the body to only 25°C and a longer safe period of brain protection as compared to DHCA. This gives the surgeon time for a more complete repair at the initial operation.

False aneurysm formation at the various suture lines with the original Bentall technique has been reported repeatedly [4,15]. The reported incidence varies from 7 to 25%, although the true incidence is probably higher [15,16]. The open technique seems to overcome the problem of false aneurysm formation, although in our series, two patients with the open technique required reintervention for false aneurysm formation at the left coronary ostial suture [4,17]. Although some continue to use the inclusion technique for hemostatic purposes, we think that the open technique is the technique of choice in every situation. As we have used the Cabrol II technique only in one patient, we can not make any conclusions on the long-term results with this technique.

The need for continued long-term cardiovascular surveillance is accentuated by the fact that eight patients needed a reintervention more than 10 years after AAR or ARR. The median interval of 51 months illustrates that patients remain at risk for later development of complications that require new repair, even if the first repair was a radical one. This warrants for annual examination by the cardiologist and/or cardiovascular surgeon including echocardiography, CT scan or MRI.

Appendix A

Preoperative patient-related and intraoperative data considered in the univariate and multivariate analysis of hospital mortality (number of patients or mean ± standard deviation).

A.1. Patient variables

Sex, male (n = 40), female (n = 16); age, ≤65 years (n = 46), >65 years (n = 10); Marfan’s syndrome, yes (n = 8), no (n = 48); previous cardiac intervention, one (n = 49), two (n = 5), three (n = 2); functional class, NYHA I or II (n = 29), NYHA III or IV (n = 27); aortic regurgitation (AR), no AR (n = 28), AR grade I–IV (n = 28); serum creatinine (µmol/l), ≤150 µmol/l (n = 52), >150 µmol/l (n = 4); indication for operation, false aneurysm (n = 25), true aneurysm (n = 18), prosthetic valve endocarditis (n = 5), vascular graft infection (n = 3), failure of aortic valve substitute (n = 4), other (n = 1); interval between operations: <8 months (n = 18), ≥8 months (n = 38).

A.2. Operative variables

Timing, elective (n = 51), urgent (n = 5); pericardium (at previous operation), open (n = 8), closed (n = 48); CPB time (min), ≤180 (n = 17), >180 (n = 36), no CPB (n = 3); myocardial ischemic time (min), ≤120 (n = 22), >120 (n = 28), no cardiac arrest (n = 6); type of procedure, ARR (n = 30), AAR (n = 10), repair false aneurysm (n = 14), aortic valve replacement (n = 2); concomitant procedures, none (n = 36), aortic arch replacement (n = 14), CABG (n = 2), aortic arch replacement and CABG (n = 4); deep hypothermic circulatory arrest, yes (n = 12), no (n = 44), antegrade selective cerebral perfusion, yes (n = 13), no (n = 43).

References


