Composite aortic root replacement in acute type A dissection: 
time to rethink the indications?*

James C. Halstead, David Spielvogel, Dieter M. Meier, Sindy Rinke, Carol Bodian, 
Ramin Malekan, M. Arisan Ergin, Randall B. Griepp

Department of Cardiothoracic Surgery, Mount Sinai School of Medicine, One Gustave L. Levy Place, New York, NY 10029, USA

Department of Biomathematics, Mount Sinai School of Medicine, New York, NY 10029, USA

Received 21 September 2004; received in revised form 2 December 2004; accepted 20 December 2004

Abstract

Objective: The indications for aortic root replacement in acute type A dissection are unclear. We reviewed the immediate and long-term outcome of consecutive patients in a series in which a low-threshold policy of composite aortic root replacement had evolved.

Methods: From a prospectively compiled aortic surgery database, we identified 162 patients who had either supracoronary interposition grafting, Group A (n = 89), or composite root replacement, Group B (n = 73) for acute type A dissection. Patients receiving total arch replacements were excluded. Operative and clinical details were analyzed and patient survival was compared to an age and gender matched census cohort. Need for reoperation on the proximal or distal aorta was also noted. Follow-up totaled 795.5 patient-years.

Results: Hospital mortality rates were identical in both groups (12.3%: 11 deaths in group A; 9 in group B). Chronic pulmonary disease, diabetes, malperfusion, hemodynamic compromise and aortic root dilatation were independent risk factors for hospital death. Actuarial survival estimates at 1, 5 and 10 years were 79% (71–88%), 64% (53–75%), and 55% (41–68%) for group A, and 79% (70–86%), 73% (62–83%), and 65% (52–78%) for group B (P = 0.48). Age and operative patency of the ascending false lumen were independent risk factors for death after hospital discharge. Proximal aortic reoperation was required for four patients in group A and none in group B (P = 0.085).

Conclusion: A strategy of replacement rather than repair of the dissected aortic root for specific indications in type A dissection yielded high survival and low proximal reoperation rates. These results support an aggressive policy of composite root replacement in acute type A dissection.

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Keywords: Aortic dissection; Composite root replacement

1. Introduction

Since the first successful surgical treatment of acute type A dissection, various techniques have been developed to preserve the integrity of the aortic valve and the sinuses while replacing the supracoronary aorta. Of necessity, these methods require repair of dissected tissues at the root using external, internal or intramural reinforcement with prosthetic or biological materials [1]. The introduction of tissue glues was heralded as a marked improvement over earlier techniques [2]. But although substantially improved immediate surgical mortality following initial procedures for acute type A dissection was soon forthcoming, for many patients the long-term outlook remained bleak because of limited durability of the repair, with residual problems arising from dissected tissues left at the root [3,4]. Methods that allow elimination of all dissected tissues at the root—such as composite root replacement [5], and valve-sparing root replacement [6]—are relatively recent additions to the surgical treatment of acute type A dissection. Whether these more extensive procedures—with possible additional operative risk—can be justified for the potential benefit of long-term results continues to be a subject of active debate [7,8]. We have previously reported that composite graft replacement of the aortic root in selected patients with acute type A dissection can be performed with comparable perioperative mortality and better long-term event-free survival than a more limited operation [5]. We have used composite replacement of the aortic root preferentially in all patients with acute type A dissection when there was extensive dissection of the sinuses or of the coronary ostia, and in the presence of dilated aortic sinuses or severe aortic regurgitation. The following is the analysis of the outcomes of this relatively aggressive strategy in a consecutive series of patients.
2. Materials and methods

2.1. Patient data abstraction

The aortic surgery database at Mount Sinai Medical Center contains 179 consecutive patients who underwent surgery for acute type A dissection between January 1986 and April 2003. Of these, 17 patients underwent total arch replacement (with or without intervention on the descending thoracic aorta) in addition to ascending aortic replacement; these more complex patients were excluded from the analysis. The remaining 162 patients were grouped according to the technique of proximal repair. Group A (n=89, 54.9%) had interposition graft replacement of the ascending aorta with resuspension, repair or separate replacement of the aortic valve (Table 1). Group B (n=73, 45.1%) underwent composite graft replacement of the aortic root and ascending aorta. The extent of distal resection in these patients is also shown in Table 1. The patients’ clinical characteristics, including comorbidities and hemodynamic status at presentation, are shown with between-group comparisons in Table 2.

The diagnosis of acute type A dissection was made by preoperative imaging (computed tomography, magnetic resonance imaging, aortography or echocardiography) or at surgery. Each thoracic aortic segment was classified as containing either a patent or clotted false lumen, or being unaffected by the dissection process (by definition only arch and descending segments). The severity of proximal dissection was estimated by noting whether there was aortic root dilatation, aortic regurgitation and/or coronary ostial dissection or tear. The location of the intimal tear, where identifiable, was also recorded (Table 3).

2.2. Operative procedures

Whilst surgical techniques evolved somewhat over the time course of this series, the basic principles involved replacement of the ascending aorta and resection of the primary intimal tear, with the construction of an open distal anastomosis during a period of hypothermic circulatory arrest. The site of arterial cannulation changed with time, anastomosis during a period of hypothermic circulatory arrest. During cooling, the aorta and heart were not manipulated until ventricular fibrillation occurred. The ascending aorta was then cross-clamped in its distal half and the aorta was opened. Cardioplegia was delivered directly into the coronary ostia, and the aortic root pathology assessed.

The extent of operation was determined according to the preference of the surgeon in accordance with the following general guidelines. Composite graft replacement was used almost exclusively whenever the coronary sinuses were dissected. Only where the dissection at the root was limited to the non-coronary sinus and the dissected tissues could be completely removed by scalloping this sinus to the annulus was repair of the root undertaken with a tailored graft. When aortic root enlargement with aortic regurgitation was found (including Marfan’s syndrome), repair was only undertaken in the cases of milder incompetence or lesser degrees of dilatation. An aggressive strategy of resection rather than repair of the dissected aortic root has resulted in a high proportion of composite graft replacements in this series.

When conservative repair was undertaken, the aorta was transected at the sinotubular junction and reinforced with descending aorta was carefully monitored by transesophageal echocardiography at the start of perfusion to avoid malperfusion. During cooling, the aorta and heart were not manipulated until ventricular fibrillation occurred. The ascending aorta was then cross-clamped in its distal half and the aorta was opened. Cardioplegia was delivered directly into the coronary ostia, and the aortic root pathology assessed.

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an externally placed circumferential piece of Teflon® felt and an internal gusset of felt or autologous pericardium, so as to realign the commissural geometry (81 patients). Where the non-coronary sinus was dissected, it was excised to the annulus and the graft tailored to accommodate the resultant defect. Tissue glues were not used. In five patients, separate valve replacement (with three mechanical and two stented bioprostheses) was undertaken in cases of bicuspid, stenotic, or residually regurgitant valves. In two patients, complex repair of the aortic valve was performed, and in one patient a valve-sparing (remodeling) root replacement was undertaken.

A premanufactured conduit with a mechanical valve was used in 62 patients. In 11 patients, a biological valve was sutured to an appropriately sized tubular woven graft. By far the commonest strategy for composite root replacement (54 patients, 74%) involved the reimplantation of the coronary arteries as separate buttons on the outside of the graft (button-Bentall technique). A classic Bentall procedure was used in three patients: the in situ coronary orifices were anastomosed to the conduit, which was then enclosed with the residual aortic tissue [9]. The Cabrol modification of the Bentall procedure was performed in 15 patients: in 12 of these, the Cabrol graft was sutured to buttons of reconstructed coronary ostia that were involved in the dissection [5]; in the remainder, the ostia were left in situ [10]. In one patient with previous coronary artery bypass grafts, the native coronary arteries were ligated and the proximal aortocoronary graft anastomoses reimplanted on the conduit. Following the proximal repair, during a single period of hypothermic circulatory arrest, the arch was inspected, and an open distal anastomosis undertaken. The presence and site of the intimal tear or fragile tissues in the arch determined the extent of distal resection. The dissected layers were reapproximated with supporting external Teflon® felt. The distal end of the graft was sewn within this construct, and the arch carefully de-aired. Antegrade reperfusion was instituted through an arterial cannula inserted into the ascending graft in cases in which cardiopulmonary bypass had been initiated through the femoral artery; otherwise perfusion was resumed through the right axillary artery.

Neither antegrade nor retrograde cerebral perfusion were used for brain protection during the distal anastomosis. Dissection-related and operative details are shown in Table 3.

2.3. Follow-up

All surviving patients were followed with annual computed tomography scans of the entire aorta and clinical reviews: the data, which included anticoagulant-related hemorrhage and thromboembolic events, were compiled from office visits, telephone contact with patients, and input from primary care physicians. The follow-up totaled 795.5 patient-years [Group A median 56.4 months (range 0.03-200) versus Group B 65.8 months (range 0.03-218)].

2.4. Statistical methods

Statistical analyses were performed using SAS software® (SAS Institute, Inc., Version 8, Cary, NC). Group characteristics were compared using t-tests or Fisher’s exact test as appropriate. Hospital death was defined as death within 30 days of surgery or during the same hospitalization. Actuarial survival estimates were obtained using the Kaplan-Meier method. From a wide array of potentially important clinical and operative variables, including those shown in Table 1, independent risk factors for hospital death were identified using logistic regression analysis. Similarly, the influence of these factors on late survival was examined with Cox proportional hazards regression. Late survival estimates were compared with New York State data, derived from the 1990 census [11], by standardized mortality rates obtained using Poisson regression, with log (expected numbers of deaths) as an offset. The expected number of deaths was obtained for each subset from the NY state death rates, for the corresponding gender and age, from entry to last follow-up.

Reoperations on the aorta were classified according to site, being either proximal (aortic valve and root) or distal (beyond the extent of initial repair). The cumulative incidence functions [12,13] were calculated to estimate site-specific reoperation at 1, 5 and 10 years. Reoperation rates per person-year stratified for age were compared by χ²-tests. The incidence of bleeding episodes and thromboembolic events was compared between groups over the follow-up period using χ²-tests of observed events versus expected, based on Poisson rates for the group-specific follow-up periods.

3. Results

3.1. Survival

The overall hospital mortality was 12.3% (20/162). The mortality rate was the same for each surgical strategy: 12.3% (11/89) for Group A and 12.3% (9/73) for Group B. Adverse outcome—defined as death or permanent stroke—was also similar: 16.8% (15/89) in Group A and 16.4% (12/73) in Group B, $p=0.94$.

Logistic regression analysis showed chronic pulmonary disease (OR 9.0, $p=0.01$), diabetes (9.0, $p=0.007$), malperfusion (20.2, $p<0.0001$), hemodynamic compromise (3.6, $p=0.048$) and aortic root dilatation (6.9, $p=0.036$) as independent risk factors for hospital death in the group as a whole. The Hosmer-Lemeshaw goodness-of-fit statistic for this model was $c=0.86$.

3.2. Comparability of surgical groups

This was not a randomized study, and inherent differences between the patients in each group influenced the selection of surgical strategy. There was a greater prevalence of aortic regurgitation, aortic root dilatation, coronary ostial dissection and more extensive dissection of the sinuses in patients in Group B (Table 3)—who underwent composite root replacement—putting them at a higher risk for adverse outcome. Hemodynamic compromise at presentation was seen in a similar proportion of cases in both groups (Table 2), as was malperfusion and other putative markers of severe dissection, such as new neurological deficit at presentation, patent false lumina, and distal intimal tears (Tables 2 and 3). Important comorbidities influencing survival—diabetes and chronic obstructive pulmonary disease—were also not
significantly different between the groups. As shown in Table 1, patients in Group A were significantly older, but patients in Group B were significantly more likely to be female, and to have Marfan’s syndrome, but none of the latter characteristics were identified as risk factors for hospital mortality in the group as a whole. Thus, analysis of preoperative characteristics of the groups, which we acknowledge were not entirely comparable, would have been expected to lead to a higher rate of adverse outcome for the patients in Group B, who underwent composite aortic root replacement.

3.3. Long-term survival

The overall actuarial survival estimates (together with 95% confidence intervals) at 1, 5 and 10 years after admission were 79% (73-85%), 68% (75-60%), and 59% (49-69%). Groupspecific survival estimates (Fig. 1) at the same time points were comparable: 79% (71-88%), 64% (53-75%), and 55% (41-68%) for group A, and 79% (70-86%), 73% (62-83%), and 65% (52-78%) for group B (log rank test $P=0.48$).

Moreover, group-specific survival estimates for hospital survivors (Fig. 2) were also comparable at the same time points as above: 89% (82-95%), 73% (62-84%), and 63% (48-77%) for group A, and 90% (83-98%), 83% (73-93%), and 74% (61-87%) for group B (log rank test $P=0.37$).

In order to assess survival from hospital discharge, with correction for between-group age and gender differences, these data were compared to New York State mortality rates for 1990 (Table 4). The excess mortality in the surgical populations over state controls, when corrected for age and gender differences, did not differ between groups (ratio 2.5 for group A versus 1.9 group B, $P=0.33$).

Cox proportional hazards regression showed age (hazard ratio 1.06 per year, $P<0.0001$) and preoperative patency of the false lumen (hazard 5.56, $P=0.005$) as independent risk factors for death after hospital discharge. The operative finding of aortic root dilatation came very close to significance ($2.1, P=0.07$) in predicting long-term survival, due entirely to a relatively high mortality in patients with aortic dilatation who did not receive a composite graft (33% of whom died, versus a 20% long-term mortality among patients in group A without aortic dilatation).

3.4. Reoperation

Group-specific late patient outcomes are given in Figs. 3 and 4. There was a clear trend towards a lower proximal reoperation rate after composite root replacement: reoperation was required for sinus aneurysm formation with aortic regurgitation in four patients in group A, whereas no patient in group B required a proximal reoperation for dissection-related complications ($P=0.08$).

Surgery on the distal aorta was required more frequently, but showed no significant differences between the groups. In Group A, 13 distal aortic procedures were performed in 10 patients, versus 10 such procedures in 5 patients in Group B ($P=0.67$). Aortic segments replaced at these procedures included the aortic arch in 10 (43%), the descending aorta in 4 (17%), the thoracoabdominal aorta in 3 (13%), and the abdominal aorta in 6 (26%). There were no significant differences in the distribution of the types of reoperation between surgical groups.

3.5. Incidence of bleeding episodes and thromboembolic events

Amongst the patients in group A, there was a single episode of hemorrhage (not anticoagulant-related). In group B, there were five such events ($P=0.025$). All group B
A high proportion of patients with acute type A dissection in most series have had a minimalist approach, using a supracoronary tube graft, as in our patients in Group A [17,19,20]. The results, in terms of perioperative mortality rates, have differed widely (5.3–32.5%). Despite the high proportion of more extensive operations involving composite root replacement in the present series, the perioperative mortality is within the lower end of the range in the published series. Several reports have detailed liberal use of glue in the repair of dissected sinus tissue, a practice which has been called into question by observations of tissue necrosis at these sites at reoperation [21,22], and high reintervention rates in certain series [23]. Casselman has concluded that “the use of fibrous glue for root reconstruction seems to compromise the long-term durability of the repair compared with Teflon felt and GRF glue. A dilated aortic annulus requires a more extensive root procedure.”

The combination of sinus repair and separate aortic valve replacement has been utilized when incidental leaflet calcification, a bicuspid valve or residual regurgitation have been found: we have seldom used this approach, and other reports point to a poorer outcome in this subgroup [7,18]. Recent enthusiasm for elective valve-sparing root replacement has also extended to its occasional use in acute dissections. Whilst the results from elective aneurysm surgery are acceptable, use of valve-sparing procedures in acute dissections seems to result in high proximal reoperation rates when the remodeling technique is used [24]. Some centers with particular expertise and extensive experience with elective valve-sparing operations have used valve-sparing approaches in cases of acute type A dissection with very good short-term results.

In contrast to valve-sparing techniques, composite graft replacement of the aortic root is a procedure with which most cardiovascular surgeons are now familiar, and is associated with a very low mortality [25] and proximal failure rate. As the current series demonstrates, it can be undertaken in acute dissection with a mortality rate comparable to that of conventional repairs even in patients who have severe proximal dissections [5]. The restoration of coronary blood flow can usually be achieved by direct anastomosis of dissected pericoronary tissue to the graft, the same strategy that is usually adopted in elective cases. Use of a composite graft in selected patients in this series resulted in success rates comparable to those achieved with a less aggressive approach, even though one might have expected a poorer result based on the preoperative risk factors present in each group. Based on our experience, we utilize
a composite graft in all patients with a sinus diameter > 5 cm, and we believe that all patients with a proximal diameter > 3.5 cm should be considered for composite replacement even in the absence of coronary dissection or significant aortic insufficiency. A recently published contemporary series from Stanford University, in patients with equivalent risk factors albeit a slightly higher prevalence of aortic regurgitation [7], reported an overall early death rate of 16%, and 85% 30-day actuarial survival. Sixty-seven percent of the Stanford patients were treated with a root repair, with use of glue only in the last 2 years of their series. In contrast, a contemporary report from the Hôpital Henri Mondor [19] quoted an operative mortality of 32.5% for conservative repair—involving glue in 81.3% of cases in a consecutive cohort of similar age.

If a radical approach to the aortic root can yield comparable results in terms of perioperative mortality, does it also reduce the need for proximal reoperation? There is no doubt that the retention of glued or buttressed dissected tissues in the aortic root can lead to sinus dilatation, re-dissection and aortic regurgitation. These complications can be fatal and therefore mandate reoperation, which almost always involves insertion of a composite valved conduit. Although comparison of crude reoperation rates does not tell the whole story, it is clear that the need for proximal reintervention has been low in this series as a whole, with the liberal use of composite grafts. Proximal reoperation was never required among the patients in whom a composite graft was used in the initial repair, despite the presence of more severe proximal dissection in that patient group.

One would not expect the proximal surgical strategy to influence the behavior of the distal aorta. However, one might imagine that the necessity for anticoagulation in those receiving mechanical valved composite grafts might produce a surplus of distal procedures to counterbalance proximal benefits, or a higher long-term mortality. The current series is reassuring in that neither an increase in distal reoperation rate nor a higher mortality was seen. In fact, a trend toward a better long-term outcome was observed in the composite valve group. Assessment of bleeding episodes in the two groups did reveal a significantly higher rate in those patients receiving anticoagulation therapy for a composite mechanical valve conduit, but none of these events were fatal, and the option of using a biological valve in the conduit is available for those patients for whom root replacement is indicated but anticoagulation is contraindicated or undesirable. The incidence of neurological morbidity during follow-up was comparable between the two patient groups.

5. Conclusion

Increasing experience with elective aortic root replacement has moved it outside the domain of special thoracic aortic expertise [7]. Therefore, composite valve-graft replacement is now a promising strategy for use in acute type A dissection. Historically, composite valve replacement has been used primarily in the presence of irreparable aortic root dissection, where the frailty of tissues jeopardizes hemostasis, and residual aortic incompetence is a concern. Our policy, which involves liberal use of composite graft replacement for acute type A dissection, has resulted in immediate and long-term outcomes comparable to other large consecutive series. We therefore recommend that a composite approach to this pathology be considered in any case of acute dissection with complex aortic root involvement, significant proximal aortic dilatation, or evidence of major connective tissue abnormalities such as Marfan’s syndrome. Our data suggest that composite valve conduit replacement may be a reasonable option even in relatively uncomplicated cases of acute type A dissection.

References
complete series. And distal reoperation could reflect the surgical strategy with respect to the homogenous approach to the distal aorta such that differences in survival number of total arch cases. They numbered 17 over the time course of this database? In other words, patients who presented to your hospital with a type A dissection, were they all included in the database? Do you have any information about the patients who were not included in your this condition. We generally attempt to perform a composite graft. Do you have any data about the progressive supracoronary aortic replacement do you have the data about the progressive dimension and degree of aortic regurgitation? Do you see any progression in both data has been far more complete.

Appendix A. Conference discussion

Dr J. Tan (Southport, Australia): Your paper certainly reflects our view on this condition. We generally attempt to perform a composite graft. Do you have any information about the patients who were not included in your database? In other words, patients who presented to your hospital with a type A dissection, were they all included in the database?

Dr Halstead: The only patients that were excluded from this series of acute type A dissection patients having surgery at Mount Sinai were a small number of total arch cases. They numbered 17 over the time course of this series, and they were excluded in order for us to have a series that had a homogenous approach to the distal aorta such that differences in survival and distal reoperation could reflect the surgical strategy with respect to the ascending aorta and the aortic root rather than the strategy taken with respect to the aortic arch. Other than that, other than those 17 patients, it is a complete series.

Editorial comment

Stephen Westaby*
Oxford Heart Center, John Radcliffe Hospital, Headington Way, Headington, Oxford OX3 9DU, UK

In this paper from the renowned Mount Sinai Aortic Surgery Group, Halstead and Colleagues advocate a more radical approach to aortic root pathology in acute Type A dissection. Their concluding sentence states that "These results support an aggressive policy of composite root replacement in acute Type A dissection". Is this really the case? The study design does not test the hypothesis that root replacement with a prosthetic valued conduit provides better short or long-term results than supracoronary aortic replacement with valve re-suspension. This is a retrospective analysis and comparative study of two difference circumstances. Patients with more extensive root involvement (Group B) and aortic regurgitation (in 82% of cases) were treated by prosthetic valved conduit root replacement. Those without root involvement or dissection limited to the non-coronary sinus received the less taxing approach of supracoronary aortic replacement (Group A) and valve re-suspension if prolapse occurred. More complex patients undergoing aortic arch replacement were excluded from the series so we do not know whether the more radical approach to the aortic root increased mortality in prolonged operations. Hospital mortality was satisfactorily low for both groups demonstrating that aortic root replacement can be performed safely by experienced surgeons in dissection.