Dissection of the descending thoracic aorta extending into the ascending aorta

A therapeutic challenge

Proper management of dissections of the descending thoracic aorta with intimal disruption close to the left subclavian artery and retrograde extension of the dissection into the aortic arch or the ascending aorta is controversial, because the standard approach for ascending aortic aneurysms is surgical repair, which is difficult to achieve through a median sternotomy if the predominant aortic lesion is located in its descending part. Sixteen patients with descending thoracic aortic dissection, intimal disruption close to the subclavian artery, and extension of the dissection into the aortic arch or the ascending aorta are described here: Eleven patients underwent surgical repair including 9 emergency (82 %) and 2 elective (18 %) procedures. Retrograde aortic dissection included the aortic arch in 11 of 11 patients (100 %) and the ascending aorta in 7 of 11 (63 %). Pericardial effusion was present in 1 of 11 patients (9 %) and mild aortic regurgitation was found in 1 of 11 (9 %). Repair of the ascending aorta and arch with transaortic closure of the entrance tear in the descending thoracic aorta was performed in 4 of 11 patients (36 %) via a median sternotomy. In 6 of 11 patients (55 %) a lateral thoracotomy was used for repair of the descending thoracic aorta and closure of the entrance tear. Hospital mortality occurred in 1 of 11 patients (9 %) and there was 1 late death. Paraplegia occurred in 1 of 11 patients (9 %). Five patients with descending thoracic aortic dissection, intimal disruption close to the subclavian artery, and extension into the ascending aorta but without ascending aortic aneurysm (diameter 4.2 ± 0.2 cm), pericardial effusion, or aortic incompetence were treated medically without early mortality. These results are compared with those achieved in 120 patients operated on during the same period for type A (89/120) and type B (31/120) aortic dissections. Considering the technical difficulties of simultaneous repair of dissections of the ascending and the descending thoracic aorta, we recommend that descending thoracic aortic dissection extending into the arch or the ascending aorta be managed in accordance with the site of the predominant lesion. Replacement of the arch with a varying portion of ascending aorta via a median sternotomy is recommended in patients with enlarged aortic diameter, pericardial effusion, and/or aortic insufficiency. Predominantly distal dissections with dilated descending thoracic aorta and/or distal complications are best approached via a lateral thoracotomy. (J THORAC CARDIOVASC SURG 1994;108:755-61)

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In accordance with Crawford,¹ aortic dissection is defined as a splitting process that occurs in the aortic media. The dissecting process may be either acute or chronic. In the past, various classifications have been suggested to describe the patterns of aortic dissections. In the sixties, DeBakey and associates^{2,3} identified four types of aortic dissections. Both types I and II originate from the ascending aorta. Type I extends into the arch and distal aorta whereas type II is confined to the ascend-

Table 1. Demographic data, type of dissection, and surgical approach selected for patients with descending thoracic aortic dissection, intimal tear close to the subclavian artery, and extension of the dissection into the arch or the ascending aorta

Patient	Age (yr)	Sex	Extension		Complication		Approach
			Distal	Proximal	Pericardial effusion	Aortic incompetence	
1	54	M	Aortic bifurcation	Arch	—	—	Thoracotomy
2	72	M	Aortic bifurcation	Ascending aorta	—	—	Medical
3	60	M	Aortic bifurcation	Right coronary	+	—	Thoracotomy
4	58	F	Descending aorta	Ascending aorta	—	—	Thoracotomy
5	67	M	Aortic bifurcation	Ascending aorta	—	+	Sternotomy
6	53	M	Descending aorta	Ascending aorta	—	—	Sternotomy
7	70	M	Aortic bifurcation	Arch	—	—	Thoracotomy
8	78	F	Aortic bifurcation	Ascending aorta	—	—	Medical
9	62	F	Aortic bifurcation	Ascending aorta	—	—	Medical
10	44	F	Femoral artery	Ascending aorta	—	—	Sternotomy
11	60	F	Aortic bifurcation	Ascending aorta	—	—	Sternotomy
12	15	M	Iliac artery	Aortic anulus	—	—	Thoracotomy
13	49	M	Aortic bifurcation	Arch	—	—	Thoracotomy
14	77	M	Aortic bifurcation	Ascending aorta	—	—	Medical
15	77	M	Abdominal aorta	Arch	—	—	Thoracotomy
16	78	M	Aortic bifurcation	Ascending aorta	—	—	Medical
Mean	61 ± 16						

ing aorta. Type III dissections begin in the descending aorta, with type IIIA extending toward the diaphragm and type IIIB extending below it. In 1970, Dubost, Guilmet, and Soyer⁴ suggested a classification referring to the site of the intimal tear only. Four groups were identified: group A for patients with the intimal tear in the ascending aorta, group B for patients with the intimal tear in the transverse aortic arch, group C for patients with the intimal tear in the descending thoracic aorta, and group D for patients with the intimal tear in the abdominal aorta. At about the same time, Daily and colleagues⁵ classified, regardless of the site of the intimal tear, dissections involving the ascending aorta as type A and all other dissections as type B. The latter approach, which was later denominated the "Stanford classification," has been most widely used in recent years because of its close relationship to clinical practice: type A dissections require in general primary surgical repair of the ascending aorta whereas type B dissections are mostly confined to medical initial treatment and surgery is recommended for handling of complications only. All classifications cited evolved before safe surgical techniques for the replacement of the aortic arch were developed. In the meanwhile a number of techniques for inspection as well as safe repair of the ascending aorta and the aortic arch emerged.^{6,7} As a result, an increasing number of intimal tears extending into the aortic arch and also aortic dissections originating from intimal tears in the aortic arch were identified and simultaneous repair of the aortic

arch was recommended by several authors.⁸⁻¹¹ Furthermore, there is increasing evidence that aortic dissection may develop not only in an antegrade but also in a retrograde fashion.^{4,5,12}

However, proper management of descending thoracic aortic dissection with intimal disruption close to the left subclavian artery and retrograde extension of the dissection into the aortic arch or the ascending aorta is controversial. Although the standard approach for a dissection involving the ascending aorta (Stanford type A) is nowadays surgical repair, a number of distal complications occurring in concurrent descending aortic dissections originating from an intimal tear close to the subclavian artery are difficult to manage through a median sternotomy. These difficulties, which are particularly troublesome in the acute phase as well as the case report of (Stanford) type A aortic dissection "without" intimal rupture which finally evolved in a (Stanford) type B aortic dissection,¹³ prompted the present review.

Patients and methods

Case histories of 16 patients with descending thoracic aortic dissection, intimal disruption close to the subclavian artery, and extension of the dissection into the aortic arch or the ascending aorta observed during a 7-year period are presented here. Demographic data and extent of dissection in this group of patients are given in Table 1. Eleven patients underwent surgical repair, including 9 of 11 emergency (82%) and 2 of 11 elective (18%) procedures. Retrograde aortic dissection included the aortic arch in all 11 patients (100%) and the ascending aorta in

7 of 11 (63%). Pericardial effusion was present in 1 of 11 patient (9%) and mild aortic regurgitation was found in 1 of 11 (9%).

Five patients with descending thoracic aortic dissection, intimal disruption close to the subclavian artery, and extension into the ascending aorta but without ascending aortic aneurysm (diameter 4.2 ± 0.2 cm), pericardial effusion, or aortic incompetence were treated medically.

So that the surgical techniques used as well as the results achieved in these 11 patients could be evaluated, the corresponding data for 89 consecutive patients with classic Stanford type A dissection defined as aortic dissection of the ascending aorta and 31 patients with classic Stanford type B aortic dissection operated on throughout the same time frame are given herein. Emergency procedures were necessary in 64 of 89 (72%) patients with type A aortic dissections and 13 of 31 (42%) patients with type B aortic dissections.

Type A aortic dissection. The surgical procedure selected for repair of type A dissections has evolved over time and is similar to that reported by other groups.^{6,7} Surgery is now directed to the repair of the dilated aortic segments, closure of the primary intimal tear, and, if necessary, aortic valve repair or replacement. Standard exposure of the ascending aorta and the aortic arch is through a median sternal splitting incision. An external iliac artery and the right atrium are cannulated after full systemic heparinization (activated clotting time > 480 seconds) and connected to the heart-lung machine, which is primed with clear fluid as is standard in our institution.¹⁴ In acute cases with significant pericardial effusion the iliac artery is cannulated before the sternotomy is performed. After the onset of cardiopulmonary bypass the coronary sinus is cannulated and cooling is started. Ventricular fibrillation is initiated, the aorta is crossclamped, and blood cardioplegic solution is given in a retrograde fashion. After a longitudinal aortotomy, the ascending aorta is thoroughly inspected. The intimal tear is identified and the competence of the aortic valve is evaluated. If the aortic valve is intact or if it can be repaired, it is left in place and the intimal tear is studied. In patients with normal aortic diameters local repair of the ascending aorta is evaluated, whereas in patients with dilated ascending aorta a graft repair is performed. French glue⁸ is used to seal the dissected ascending aorta before suturing is started. Core cooling down to 18° C is continued while the proximal anastomosis is completed either for a composite graft, if the aortic valve has to be resected and the aortic sinuses enlarged, or for a straight graft to be inserted in the supracoronary position with or without aortic valve replacement, if the aortic sinuses are of acceptable quality. When deep hypothermia is reached, extracorporeal circulation is discontinued and the aortic arch is opened. If the entrance tear reaches into the aortic arch or if primary or secondary tears are located in the aortic arch, hemiarch or total arch replacement is performed. If there are no intimal tears in the aortic arch, the distal anastomosis is made in an open fashion and extracorporeal circulation is resumed after proper venting. This group of patients included all those having a dissected ascending aorta and the entrance tear in the ascending aorta or arch but not those with dissections originating from the descending thoracic aorta, which are the purpose of this paper and therefore reported separately.

Type B aortic dissection. The standard approach for repair of type B aortic dissection is a lateral thoracotomy or thoracophrenolaparotomy. Partial cardiopulmonary bypass for proximal unloading and distal protection is initiated before aortic

crossclamping. For this purpose the external iliac vein and artery are cannulated on one side and connected to a heparin-coated perfusion system (Duraflo II, Baxter Bentley, Irvine, Calif.) after low systemic heparinization (Liquemin, Roche, Basel, Switzerland: 100 IU/kg body weight). Distal circulatory support is started with a pump flow corresponding to 50% of cardiac output as determined by thermodilution and adapted after aortic crossclamping to maintain adequate proximal and similar distal perfusion. During perfusion, the activated coagulation time (Hemochron, International Technidyne, Edison, N.J.) is kept above 180 seconds.¹⁵ Staged segmental repair of the dilated descending thoracic aorta and if necessary the thoracoabdominal aorta is performed beginning proximally, the aortic clamps being replaced distal to the completed anastomoses.¹⁶ Use of French glue, sealed prostheses, and reimplantation of large intercostal arteries as well as reimplantation of visceral and renal arteries are routine. Shed blood is recovered in all groups by a red cell spinning device and pumped back to the patient (Autotrans: Dideco Spa, Mirandola, Italy). More recently, heparin-coated cardiectomy reservoirs have been used during perfusion.^{17,18} So that stagnant flow in the cardiopulmonary bypass circuit can be avoided, recirculation through a shunt in the operating field is started immediately after weaning. Graft inclusion is used systematically. If necessary, a piece of glutaraldehyde-preserved equine xenopericardium¹⁹ is implanted for this purpose. More recently, systemic hypothermia^{20,21} has been used to improve spinal cord protection during the procedure. This group of patients included all those with dissections originating from the descending aorta excluding those with extension into the arch or the ascending aorta.

Descending thoracic aortic dissection extending into the arch or the ascending aorta. Surgical approach in these patients is selected in accordance with the predominance of the aortic segments involved. In patients with a large ascending aorta, aortic incompetence, or pericardial effusion/tamponade, the approach described for type A aortic dissection is selected, including peripheral arterial cannulation, median sternotomy, total cardiopulmonary bypass, repair of ascending aorta, and transaortic repair of aortic arch and proximal part of descending thoracic aorta.

In patients with a small ascending aorta, absence of aortic incompetence, and pericardial effusion, but complicated dissection of the descending thoracic aorta, the approach described for complicated type B aortic dissection is selected including peripheral cannulation, lateral thoracotomy, partial cardiopulmonary bypass with low systemic heparinization, and resection of the entrance tear through the descending thoracic aorta and/or distal aortic arch, respectively. The detail of the procedures performed is given in Table II. According to these guidelines, repair of the ascending aorta and arch with transaortic closure of the entrance tear in the descending thoracic aorta was performed in 4 of 11 patients (36%) via median sternotomy. In 7 of 11 patients (54%) lateral thoracotomy was used for repair of the descending thoracic aorta and closure of the entrance tear.

In patients with a small ascending aorta and neither pericardial effusion, aortic regurgitation, nor complications of the descending thoracic aortic dissection, the initial treatment selected is medical: blood pressure is reduced as aggressively as possible by intravenous medication allowing for acceptable diuresis. The relative proportion of these patients (5/16: 31%) can also be seen in Table I.

Data analyses. Continuous variables are presented as the

Table II. Surgical approach selected and type of repair for patients with descending thoracic aortic dissection, intimal tear close to the subclavian artery, and extension of the dissection into the arch or the ascending aorta

Patient	Approach	Aortic repair	Crossclamp time (min)	Pump time (min)	Circulatory arrest time (min)	Outcome
1	Thoracotomy	Proximal descending	30	35	0	Abdominal aortic repair after 26 mo
3	Thoracotomy	Proximal descending	48	14	0	Discharged
4	Thoracotomy	Proximal descending	62	41	0	Discharged
5	Sternotomy	Ascending and arch	62	86	22	Discharged
6	Sternotomy	Ascending	13	75	5	Discharged
7	Thoracotomy	Proximal descending	45	0	0	Paraplegia, late death after 7 mo
10	Sternotomy	Ascending and arch	64	120	27	Discharged
11	Sternotomy	Ascending and arch	55	93	19	Abdominal aortic fenestration + left renal bypass after 3 mo
12	Thoracotomy	Proximal descending	60	0	0	Early death (bleeding)
13	Thoracotomy	Proximal descending	15	20	0	Discharged
15	Thoracotomy	Local repair	46	54	0	Discharged
Mean $\pm$ standard deviation (min)			45 $\pm$ 18	60 $\pm$ 34	18 $\pm$ 8	

mean $\pm$ standard deviation. Comparison of continuous variables was made by Student's *t* test for paired or unpaired variables where applicable. Univariate analysis of descriptive data was performed by Fisher's exact test (Solo: BMDP Statistical Software Inc., Los Angeles, Calif.). Statistical significance was confirmed by the probability value ($p < 0.05$).

Results

Descending thoracic aortic dissection extending into the arch or the ascending aorta. Eleven patients underwent repair of non-A/non-B type aortic dissection including 9 emergency (82%) and 2 elective (18%) procedures. Retrograde aortic dissection included the aortic arch in all 11 of 11 patients (100%) and the ascending aorta in 7 of 11 (63%). The presence of a large ascending aorta in 4 of 11 patients (36%), and/or mild aortic regurgitation in 1 of 11 patients (9%) directed surgery to the repair of the ascending aorta and arch with transaortic closure of the entrance tear in the descending thoracic aorta in 4 of 11 patients (36%) via median sternotomy. No aortic valve replacement or composite graft was necessary in this group. In 7 of 11 patients (54%) lateral thoracotomy was used for repair of the descending thoracic aorta and closure of the entrance tear. There was 1 hospital death (1/11, 9%; cause of death was bleeding) and 1 late death. Paraplegia occurred in 1 patient (9%), who died after 7 months.

In the subgroup of 5 patients with predominantly distal aortic dissection, small ascending aortic diameter,

absence of pericardial effusion, or aortic incompetence, which was primarily confined to medical treatment, there was no early mortality and all patients were discharged from our hospital. One late death unrelated to the aortic dissection was observed in this subgroup (1/5; 20%) after 12 months of follow-up. Diagnoses at readmission were pneumonia and subarachnoidal hemorrhage.

Type A aortic dissection. Surgery for type A dissection was performed in 89 patients. The ascending aorta was replaced in 65 of 89 patients (73%) without and in 24 of 89 (27%) with the aortic arch and the entrance tear was closed simultaneously. Four of 89 patients (5%) underwent simultaneous aortic valve replacement and 30 of 89 (34%) required the implantation of a composite graft. Mean cardiopulmonary bypass time was 115 $\pm$ 51 minutes for patients without arch repair as compared with 111 $\pm$ 29 minutes for patients with arch repair (no significant difference). Mean aortic crossclamp time was 73 $\pm$ 26 minutes for patients without arch repair as compared with 56 $\pm$ 21 minutes for patients with arch repair ($p < 0.05$). In the latter group, circulatory arrest duration accounted for 19 $\pm$ 13 minutes. Hospital mortality was 20 of 89 patients (23%) for type A dissection and 19 of 64 (30%) for emergency as compared with 1 of 25 (4%) for elective procedures. Over the analyzed 7-year time frame, hospital mortality decreased from 8 of 18 (44%) in the first year to 0 of 17 (0%) in the last year ($p < 0.002$).

Fig. 1. Aortic dissection types: *Far left and left*, Ascending aortic dissection, Stanford type A. *Middle*, Descending aortic dissection, Stanford type B. *Right and far right*, Descending aortic dissections with intimal tear close to the left subclavian artery and extension of the dissection into the aortic arch and the ascending aorta.

Type B aortic dissection. Surgery for type B aortic dissection was performed in 31 patients. Repair of the descending thoracic or thoracoabdominal aorta was again combined with simultaneous closure of the entrance tear. Mean duration of partial cardiopulmonary bypass was 64 ± 28 minutes and mean aortic crossclamp time was 37 ± 21 minutes. For type B dissection, there were 3 hospital deaths (10%), including 2 deaths among 13 patients (15%) having emergency procedures as compared with 1 death among 18 patients (6%) having elective procedures. Paraplegia and paraparesis occurred in 1 patient each (total: 2/31 patients; 6%).

Discussion

Patients with descending thoracic aortic dissection, intimal disruption close to the subclavian artery, and extension of the dissection into the aortic arch or the ascending aorta require individual evaluation for optimal management. Replacement of the arch with a varying portion of ascending aorta via median sternotomy is recommended in patients with enlarged aortic diameter, pericardial effusion, aortic regurgitation, and/or mobile intimal ascending aortic contour, as in patients with type A aortic dissection. Predominant distal dissection with almost intact, relatively small ascending aorta and already thrombosed false ascending aortic lumen is treated like type B aortic dissection. The patients with dilated descending thoracic aorta or complications caused by dissection of the descending aorta are best approached via a lateral thoracotomy or thoracophrenolaparotomy, whereas medical treatment may be considered in patients having a relatively small ascending aorta, absence of pericardial effusion or aortic regurgitation, thrombosed false ascending aortic lumen, and stable descending aortic dissection.

Fig. 2. Management of descending aortic dissection with extension of dissection into the ascending aorta, which we termed *non-A/non-B aortic dissection*: *Left*, Significant involvement of the ascending aorta suggesting primary transsternal repair of the ascending thoracic aorta and arch, as in classic Stanford type A dissection. *Right*, Predominantly descending thoracic aortic dissection. In the absence of pericardial effusion and aortic incompetence, medical treatment may be evaluated. In case of distal complications (e.g., pseudocoarctation) trans-thoracic repair as in type B aortic dissection can be indicated.

This management evolved from the surgical difficulties encountered during repair of acute dissections of the descending thoracic aorta through a median sternotomy in patients with small and almost intact ascending aorta. We have now observed a number of patients in whom no entrance tear in the ascending aorta or the aortic arch could be found and in whom the primary lesion was more distal. A case of type A aortic dissection without an entrance tear in the ascending aorta or the aortic arch

which finally evolved as a type B dissection was also described by Lui, Menkis, and McKenzie¹³ in 1993. The therapeutic difficulties encountered as a result of the wrong surgical approach, as well as the unnecessary repair of an only minimally affected aortic segment, eventually without repair of the primary lesion (i.e., without resection of the entrance tear), and the potential harm resulting from such a questionable procedure, warrant careful evaluation of patients with ascending aortic dissection originating from the descending aorta. Although there are few reports on concomitant repair of the ascending aorta, aortic arch, and descending thoracic aorta,²² there is, to the best of our knowledge, no larger series published reporting on successful one-stage repair of the entire dissected aorta in the acute phase. The surgical approach selected for repair of the ascending aorta and aortic arch is different from that for repair of a thoracoabdominal lesion. Hence, in any case with dissection of the ascending aorta or arch and entrance tear in the descending aorta, the selected surgical approach is a trade-off. Under these circumstances the simple therapeutic scheme given by the Stanford classification suggesting primary surgical treatment for all type A dissections as opposed to primary medical treatment for all type B dissections no longer applies to all aortic dissections. We have termed these dissections that obviously do not fit the Stanford treatment groups *non-A/non-B aortic dissections* (Fig. 1).

Erbel and coworkers²³ reported in a prospective follow-up study of 168 patients with proven aortic dissection 35% type I dissections, 17% type II dissections, and 48% type III dissections, which is equivalent to 52% type A dissections and 48% type B dissections. They identified a subgroup termed *type III cr asc* for communicating and retrograde dissection in the ascending aorta. In this subgroup there were 22 patients with 19 acute and 3 chronic dissections. There was no preoperative mortality. Surgical treatment was selected in 21 and medical treatment in 1. Interestingly, the patient with medical treatment survived whereas surgical mortality was 19% during the operation and 29% after the operation. An additional patient was lost at reoperation, which brings the overall surgical mortality in this subgroup up to 47% (10/21 surgical patients). These results are in sharp contrast to the decreasing mortality rates reported for type A aortic dissections, which can nowadays be below 10% (see also evolution of surgical mortality in this study). Erbel and coworkers²³ think that the poor results in the subgroup with entrance tear in the descending thoracic aorta and retrograde extension of the dissection in the aortic arch are due to the fact that present surgical techniques cannot eliminate flow in the false lumen. Another important

finding of their study is the identification of perfused false lumina as a predictor of high mortality. According to Erbel's group, thrombus formation in the false lumen can be regarded as a good prognostic sign.

We recommend evaluation for patients with an entrance tear in the descending thoracic aorta and retrograde dissection of the aortic arch or the ascending aorta (non-A/non-B aortic dissections) as a function of the predominant lesion. Primary surgical treatment appears to be indicated in cases mimicking type A aortic dissection and include patients with aneurysm of the ascending aorta or arch (Fig. 2, *left*), aortic regurgitation, pericardial effusion, and/or mobile ascending intimal aortic contour. In patients with predominantly distal disease, small ascending aorta, and small aortic arch, as well as thrombosed proximal false lumen and absence of pericardial effusion and aortic regurgitation, primary medical treatment should be considered similar to that for patients with type B aortic dissections (Fig. 2, *right*). Furthermore, if the descending thoracic aortic dissection is complicated by pleural effusion, rupture, or inadequate distal perfusion, repair of the descending thoracic or thoracoabdominal aorta will yield superior results to surgery of the ascending aorta without resection of the entrance tear in the descending thoracic aorta. Proximal unloading and distal perfusion with cardiopulmonary bypass using more biocompatible equipment¹⁵⁻¹⁸ allows high perfusion pressures in the ascending aorta to be avoided, with limited blood loss. At the same time, improved tolerance of distal ischemia can be achieved with hypothermia.^{20, 21}

Although long-term results are not available yet, the selected treatment protocol for non-A/non-B aortic dissections has proved to provide in our hands early results that are similar to those that can be achieved with the standard approach for classic, less complex Stanford type A and B aortic dissections.

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