EXTENDED TOTAL ARCH REPLACEMENT FOR ACUTE TYPE A AORTIC DISSECTION: EXPERIENCE WITH SEVENTY PATIENTS

Teruhisa Kazui, MD^a
Naoki Washiyama, MD^a
Bashar Abul Hasan Muhammad, MBBS^a
Hitoshi Terada, MD^a
Katsushi Yamashita, MD^a
Makoto Takinami, MD^a
Yukihiko Tamiya, MD^b

Objective: We sought to report the clinical experience with extended total arch replacement for acute type A aortic dissection and to determine the factors that influence early mortality, late survival, and late reoperation. **Methods:** Between December 1988 and August 1998, 70 patients underwent emergency graft replacement of both the ascending aorta and the total aortic arch for acute type A aortic dissection. All operations were performed with hypothermic extracorporeal circulation, selective cerebral perfusion for cerebral protection during aortic arch repair, and open distal anastomosis. Concomitant procedures included aortic valve resuspension in 18 patients, composite graft replacement in 10 patients, and coronary artery bypass grafting in 5 patients. **Results:** The early mortality rate was 16% (11 of 70 patients). Multivariable analysis showed that renal-mesenteric ischemia and coronary artery bypass grafting were independent determinants for early death. Survival rates at 3 and 5 years postoperatively, including the early deaths, were 75% $\pm$ 5% and 73% $\pm$ 6%, respectively. Multivariable analysis showed that renal-mesenteric ischemia and en bloc repair were independent determinants for late death. Freedom from reoperation was 91% $\pm$ 4% and 77% $\pm$ 8% at 3 and 5 years, respectively. Multivariable analysis showed that anastomotic leakage was the only significant determinant for late reoperation. **Conclusions:** Extended total arch replacement for acute type A aortic dissection could be justified in properly selected patients. (J Thorac Cardiovasc Surg 2000;119:558-65)

Ascending aortic replacement is the treatment of choice for acute type A aortic dissection. However, it still remains controversial whether to perform extended aortic replacement in these patients. With recent improvements in cerebral protection during aortic arch repair, extended aortic replacement has become an accepted surgical method for acute aortic arch dissection.¹⁻⁸ We have used antegrade selective cerebral perfusion (SCP) for cerebral protection during operation of

aortic arch aneurysm, including aortic dissection, and we have reported its usefulness.⁹⁻¹²

In this study we evaluated the operative results, late survivals, and reoperation rates in patients with acute aortic dissection who underwent extended total arch replacement under SCP.

Materials and methods

Patients' profile. The subjects were 70 patients with acute type A aortic dissection who all underwent emergency extended total arch replacement (defined as total arch replacement simultaneously performed with ascending aortic replacement) by the senior author (T.K.) between December 1988 and August 1998. Forty-eight patients underwent only ascending aorta or hemiarch repair for acute aortic dissection, and another 69 patients underwent various operations for chronic aortic dissection during the same period.

The patients of the present study were 31 to 79 years of age (mean, 65 $\pm$ 8 years) and consisted of 47 men and 23 women. All patients had anterior chest pain, back pain, or abdominal pain at the onset of aortic dissection. Table I summarizes their preoperative complications. For confirmation of the diagnosis, aortography or digital subtraction angiography was per-

From the First Department of Surgery, Hamamatsu University School of Medicine,^a Hamamatsu, and the Second Department of Surgery,^b Sapporo Medical University, Sapporo, Japan.

Received for publication June 14, 1999; revisions requested Aug 16, 1999; revisions received Oct 5, 1999; accepted for publication Oct 6, 1999.

Address for reprints: Teruhisa Kazui, MD, First Department of Surgery, Hamamatsu University School of Medicine, 3600 Handa-Cho, Hamamatsu, Japan, 431-3192 (E-mail: surg1ss@hama-med.ac.jp).

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0022-5223/2000 \$12.00 + 0 12/1/103462

doi:10.1067/mtc.2000.103462

Table I. Preoperative complications

Preoperative complications	No. of patients (%)
Shock	20 (29)
Cardiac tamponade	29 (41)
Left pleural rupture	3 (4)
Aortic regurgitation	28 (40)
Myocardial ischemia	7 (10)
Transient cerebral ischemia	9 (13)
Paraplegia	1 (1)
Renal-mesenteric ischemia	8 (11)
Leg ischemia	9 (13)
Ischemia of 2 or more organs	8 (11)
Annuloaortic ectasia	10 (14)
Marfan syndrome	6 (9)
Renal dysfunction	7 (10)
Chronic obstructive pulmonary disease	3 (4)
Old cerebral infarct	2 (3)

formed in 27 (39%) of the 70 patients before surgery. In the remaining patients, computed tomography or echocardiography, including the transesophageal Doppler technique, was performed. By preoperative diagnostic examinations, together with observation during operation, a primary intimal tear was detected at the ascending aorta in 15 (21%) patients, between the ascending aorta and the aortic arch (near the origin of the innominate artery) in 9 (13%), at the aortic arch in 18 (26%), and at the proximal descending aorta (within 5 cm from the origin of the left subclavian artery) in 16 (23%). In the remaining 12 (17%) patients intimal tear was not found at the ascending aorta, aortic arch, and proximal portion of the descending aorta. In some of these patients, the tear might have been present in the more distal descending aorta, which could not be reached by the anterior approach. The rest of them had intramural hematoma-type dissection.

All the operations were performed on an emergency basis during the acute stage within 2 weeks after the onset of symptoms. The median and 75th percentile for the time interval between the onset of symptoms and surgery were 24 hours and 48 hours, respectively. Our indications for extended total arch replacement in the patients with acute type A aortic dissection were as follows:

1. Acute aortic arch dissection with the intimal tear in the aortic arch (n = 28)
2. Acute aortic dissection with the intimal tear in the descending aorta (n = 16)
3. Rupture, massive false lumen (defined as true lumen being smaller than false lumen and which was significantly compressed by the false lumen), or both of the aortic arch (n = 5)
4. Compromised arch vessels (defined as dissection extending to the arch vessels and jeopardizing the cerebral circulation producing neurologic signs, n = 9)
5. Coexistent aortic arch aneurysm (n = 4)
6. Young age, particularly in patients with Marfan syndrome without serious preoperative complications (n = 8).

Table II. Operative techniques

Operative techniques	No. of patients (%)
En bloc repair	2 (3)
En bloc repair with aortic valve resuspension	1 (1)
En bloc repair with composite graft replacement	1 (1)
Separated graft	34 (49)
Separated graft with aortic valve resuspension	17 (24)
Separated graft with composite graft replacement	9 (13)
Separated graft with CABG	5 (7)
Separated graft with Doty's aortoplasty	1 (1)
Total	70

Operative techniques. Table II summarizes the operative techniques used. The details of hypothermic extracorporeal circulation, antegrade SCP, and the operative techniques used for aortic arch reconstruction, such as the en bloc repair technique and the separated graft technique have been described previously.^{7,9,10} Briefly, after systemic heparin administration, extracorporeal circulation was instituted, with the arterial return cannula placed in the femoral artery and a single 2-stage cannula for venous drainage in the right atrium. The heart was protected by blood cardioplegia. During the period of cooling by extracorporeal circulation, the proximal repair was performed. When the patient was cooled by extracorporeal circulation to a rectal temperature of 22°C, systemic circulation was arrested. Both the innominate artery and the left common carotid artery were cannulated through arteriotomy. SCP was then started at the rate of 10 mL · kg⁻¹ · min⁻¹. The left subclavian artery (LSA) was clamped during SCP. The distal graft anastomosis was performed while the systemic circulation was arrested. For aortic arch reconstruction, the en bloc repair technique was used in the first 4 patients, whereas the separated graft technique was used in the remaining 66 patients. For the latter, grafts with 3 limbs were used in the first 22 patients, and those with 4 limbs were used in the remaining 45 patients after 1993. Gelatin-resorcin-formaldehyde (GRF) glue (Laboratoires Cardial, Saint-Etienne, France) was used to obliterate the false lumen in 43 patients, and a short segment of the graft was inserted into the true lumen as a modified elephant trunk to prevent leakage at the site of distal graft anastomosis in 8 patients. Fig 1 depicts the recent separated graft technique with modified elephant trunk.

The running 5-0 polypropylene suture was placed circumferentially on the descending aorta just 1 cm below the aortic stump to prevent dislodgment of GRF glue. Then GRF glue was infused into the false lumen (Fig 1, A). As an elephant trunk, a woven Dacron graft of 20 to 22 mm in diameter and 5 cm in length was inserted into the true lumen of the descending aorta. After the outer side of the aorta had been reinforced with a Teflon felt strip, the false lumen was obliterated in a sandwich-like fashion (Fig 1, B). A collagen-pre-treated Dacron graft with 4 limbs (Hemashield, Boston Scientific) was anastomosed to the stump of the descending aorta (Fig 1, C), and the third limb was anastomosed to LSA.

Fig 1. Schema of the recent surgical technique of the ascending aorta and aortic arch with modified elephant trunk technique by using a separated graft for acute type A aortic dissection. See details in text.

The proximal graft was crossclamped, antegrade systemic circulation from the fourth limb was started, and the patient was rewarmed by means of extracorporeal circulation (Fig 1, *D*). The proximal graft was anastomosed to the stump of the ascending aorta, and coronary circulation was started. The innominate artery and left common carotid artery were anastomosed to respective limbs of the graft in succession (Fig 1, *E*). After the termination of extracorporeal circulation, the fourth limb used for antegrade systemic perfusion was resected (Fig 1, *F*).

Concomitant procedures. Concomitant procedures were performed in 34 patients: aortic valve resuspension in 18 patients, composite graft replacement with coronary reimplantation for annuloaortic ectasia in 10, coronary artery bypass grafting (CABG) for myocardial ischemia related to dissection or coronary lesions in 5, and Doty's extended aortoplasty for supravalvular aortic stenosis in 1 (Table I).

Follow-up. The patients were followed up until October 1998 at the outpatient clinic or were contacted by telephone or letter. The follow-up was 100% complete. The mean follow-up period was 3.3 years, and the longest period was 8.8 years.

Statistical methods. The continuous data in this study are expressed as means $\pm$ SD. From the 27 preoperative and perioperative variables (appendix), independent risk factors of

early mortality (death within 30 days after operation) and those of late dissection-related reoperation were examined by multivariable analysis with the backward, stepwise, logistic regression model. Independent risk factors of late death were examined by using Cox proportional hazards regression analysis. Each variable showing a significant difference ($P < .05$) by univariable analysis was examined by multivariable analysis. Survival and freedom from reoperation were estimated by the Kaplan-Meier method and expressed as means $\pm$ SEM.

Results

Early mortality. The overall early (30-day) mortality rate was 16% (11 of 70 patients), and the in-hospital mortality rate was 21% (15 of 70 patients).

Table III shows the preoperative and intraoperative determinants of 30-day mortality, as determined by multivariable analysis. Multivariable analysis indicated that CABG and renal-mesenteric ischemia were significant predictors of early mortality. Early mortality rates in patients without CABG and renal-mesenteric ischemia were 12% and 11%, respectively.

Early morbidity. Early morbidities included cere-

Table III. Summary of multivariable statistics for the significant preoperative and intraoperative determinants of early mortality

Independent variables	No. of deaths (%)	Odds ratio	95% Confidence interval	P value
All patients	11 (15.7)			
CABG				
Yes	3 (60.0)	3.42	1.22–9.62	.02
No	8 (12.3)			
Renal-mesenteric ischemia				
Yes	4 (50.0)	2.90	1.24–6.80	.01
No	7 (11.3)			

Table IV. Summary of multivariable statistics for the significant preoperative and intraoperative determinants of late death

Independent variables	Hazards ratio	95% Confidence interval	P value
Renal-mesenteric ischemia	11.21	2.41–52.22	<.01
En bloc repair	5.52	1.28–23.82	.02
Renal dysfunction	5.20	0.88–30.74	.07
Chronic obstructive pulmonary disease	2.70	0.64–4.35	.18
Onset >3 d	1.62	0.60–4.35	.34
Cerebral ischemia	0.83	0.25–2.72	.76

Onset >3 d indicates an operation performed more than 3 days after the onset.

broneurologic deficit in 2 patients, late paraplegia in 1, pulmonary failure in 23, renal failure in 8, hepatic failure in 3, low cardiac output in 2, and multiorgan failure in 6.

Causes of early mortality. The causes of early death were multiorgan failure in 3 patients, hemorrhage in 2, low cardiac output in 2, suture line rupture due to infection in 1, rupture of the abdominal aorta into the retroperitoneal space in 1, and disseminated intravascular coagulopathy in 1.

Extracorporeal circulation data. The data of extracorporeal circulation for all patients are as follows: mean total pump time, 214.9 ± 55.3 minutes; mean cardiac ischemic time, 126.2 ± 50.9 minutes; mean SCP time, 97.4 ± 22.9 minutes; and mean open distal anastomosis time, 42.9 ± 45.4 minutes. There was not any relation between pump or SCP time and morbidity-mortality.

Late survival. The 59 patients who survived the early postoperative period were followed up. Table IV shows significant preoperative and intraoperative determinants of late death, as determined by the Cox proportional hazards regression analysis. Multivariable analysis showed that renal-mesenteric ischemia and en bloc repair were significant risk factors of late mortality.

Fig 2 shows the actuarial survival curves estimated by

the Kaplan-Meier method. Survivals for all patients at 3 and 5 years after the operation, including the early deaths, were $75\% \pm 5\%$ and $72\% \pm 6\%$, respectively. The 3- and 5-year survivals for patients in the low-risk group without either renal-mesenteric ischemia or en bloc repair were $84\% \pm 5\%$ and $84\% \pm 5\%$, respectively.

Causes of late mortality. Late deaths included both in-hospital deaths that occurred more than 30 days after the operation ($n = 4$) and out-of-hospital deaths ($n = 4$). In 5 of the 8 patients, the cause of death was related to complication or extension of dissection: sepsis in 2 patients, renal dysfunction in 1, aortic reoperation in 1, and rupture of pseudoaneurysm in 1. The remaining 3 patients died of dissection-unrelated diseases: one after operation of gall bladder cancer and the other 2 because of pneumonia.

Reoperation. In 7 patients reoperation was performed because of the development of lesions in the distal aorta. In 5 of these patients, total graft replacement of the thoracoabdominal aorta was performed for dilation of the false lumen in the distal aorta from 1 to 6 years after the initial operation. One patient died of bleeding at the time of reoperation, and the remaining 4 patients were discharged in good condition without paraplegia. Two other patients underwent graft replacement of the descending aorta: one was operated on for

Fig 2. Survival for the patients undergoing extended total arch replacement according to the presence or absence of risk factors.

Fig 3. Freedom from reoperation after extended total arch replacement.

rupture of the descending aorta 2 months after the first operation, and the other was operated on for ulcer-like projection in the descending aorta 6 months after the first operation. Both of them survived the reoperation and were discharged in good condition.

One patient who underwent aortic valve resuspension for acute aortic regurgitation had aortic valve replacement for congestive heart failure because of recurrent

aortic valve insufficiency 3 years after the initial operation and is now free from symptoms. Multivariable analysis showed anastomotic leakage (odds ratio, 3.27; 95% confidence interval, 1.21-8.83; $P = .02$) to be the only significant determinant of late dissection-related reoperation.

Fig 3 shows freedom from reoperation estimated by the Kaplan-Meier method. Freedom from reoperation

for all the patients was $91\% \pm 4\%$ and $77\% \pm 8\%$ at 3 and 5 years after the operation, respectively.

Discussion

Hypothermic circulatory arrest,¹³⁻¹⁶ retrograde cerebral perfusion,¹⁷⁻¹⁹ and SCP^{9,20,21} have been used for protection of the brain during operation of the aortic arch. SCP is physiologically superior to hypothermic circulatory arrest and retrograde cerebral perfusion because it supplies, in an antegrade manner, oxygenated blood to the brain and is basically free from time limitation with regard to the protection of the brain. This allows unhurried and meticulous reconstruction of aortic arch tissue that becomes friable because of acute aortic dissection. A drawback of SCP is that it requires insertion of a cannula into the arch vessels, which might be involved in dissection. However, it is not difficult to insert the cannula directly through the arteriotomy into the true lumen, and we have never experienced any complications related to this technique.

We used en bloc repair and separated graft techniques for reconstruction of the aortic arch. The advantages of the latter technique are that (1) the total pump time and SCP time are shorter than those of en bloc repair,⁷ (2) anastomosis can be performed at the intact distal site of the arch vessel where dissection has not extended, (3) hemostasis at the posterior anastomosis of the arch vessel is easy, (4) there is no risk of dilation of the false lumen in the aortic arch in the late postoperative period.

Artificial grafts used for the separated graft technique were those with 3 limbs in the early period and those with 4 limbs in the later period. With the grafts with 3 limbs, reconstruction of LSA had to be performed after extracorporeal circulation was terminated. In one patient in whom complication of left cerebellar infarct developed because of ischemia of the left vertebrabasi-lar artery, we considered it necessary to shorten the duration of ischemia in the LSA region as much as possible. For this reason, we modified our technique and started to use the grafts with four limbs without cannulation of LSA. The LSA was reconstructed during the cooling period and then was perfused from the fourth limb to protect ischemia of LSA region.

It has been reported that the distal false lumen remained patent in 50% to 70% of patients who underwent ascending aortic replacement for acute type A aortic dissection.^{22,23} In young patients,²⁴ and particularly patients with Marfan syndrome,²⁵ reoperation is often required for dilation of the false lumen distal to the proximal aortic arch. Crawford and colleagues²⁶ reported that previous operation on the ascending aorta or the aortic arch is a significant risk factor in patients

requiring aortic arch repair. These facts indicate that it may be appropriate to perform aortic arch repair at the same time in the same surgical field during the first operation in young patients with acute type A aortic dissection, even if the primary intimal tear is located at the ascending aorta. However, the patients have to be free from serious preoperative complications.

There remains a problem with extended total arch replacement for acute type A aortic dissection as to whether it increases the risk of early mortality. It has been reported that simultaneous aortic arch replacement generally results in less satisfactory outcome compared with that of ascending aortic arch replacement.^{6,27,28} Recent reports by other investigators¹⁻⁶ indicate that the early mortality rate after simultaneous aortic arch replacement is 20% to 55%. The early mortality rate of ascending aortic replacement for acute type A aortic dissection complicated with renal-mesenteric ischemia is reported to be about 70%.²⁷ Thus it is clear that the severity of the patient's condition before the operation considerably affects the outcome of the operation irrespective of whether simultaneous aortic arch replacement is performed. Crawford and colleagues⁶ also reported a similarly high early mortality rate (50%) for total aortic arch replacement combined with CABG. Risk factors, such as visceral ischemia (eg, renal-mesenteric ischemia and myocardial ischemia), could be reduced by early surgical intervention. However, for patients with serious dissection-related complications, such as myocardial ischemia requiring CABG, a relatively conservative surgical procedure, such as ascending aortic replacement alone or partial arch replacement, will be preferable. In our study the early mortality rate for the low-risk patients without these two risk factors was 11%, which is almost identical to recently reported mortality rates of around 10% for patients who received ascending aortic replacement alone or partial arch replacement.^{6,29,30} These results suggest that recent technical improvements have made concomitant total arch replacement a safer technique that does not increase the operative risk in the patients with acute type A aortic dissection without serious complications.

It is necessary to evaluate whether extended total arch replacement for acute type A aortic dissection decreases the risk of reoperation. The reoperation event-free rate for patients with acute type A aortic dissection who have undergone ascending aortic replacement has been reported to be 70% to 80% at 5 years postoperatively.^{6,23} On the other hand, the Stanford group⁴ reported that reoperation for patients with aortic arch dissection who received ascending aortic replace-

ment without resection of intimal tear was as high as 30% at 1 year postoperatively. Ergin and colleagues²⁴ reported that for patients in whom the distal false lumen remained patent, reoperation was higher and the long-term results were worse compared with those in whom the distal false lumen was closed. None of our patients required reoperation of arch lesions, and the overall reoperation event-free rate was $77\% \pm 8\%$ at 5 years. These suggest that extended reconstruction for aortic arch dissection could reduce the risk of reoperation. Anastomotic leakage on the distal side of the graft (ie, leakage into the false lumen through the needle hole in the inner layer) was a risk factor for reoperation. Recent improvements of surgical technique by the introduction of GRF glue and modified elephant trunk eliminated leakage from the needle hole on the distal side of the graft. GRF glue had a favorable effect on the early results through its hemostatic effect on the suture line as it imparts a rigidity to the friable aortic wall, but it had no statistically significant effect on the late outcome, such as reoperation, in our series.

Finally, it is necessary to assess whether extended aortic replacement for acute type A aortic dissection improves the long-term results. The 5-year survival of patients with acute type A aortic dissection who received ascending aorta replacement has been reported to be 55% to 70%.^{6,23,30} In our series the 5-year survival was 72% for all patients and 85% for low-risk patients. It can be concluded from these results that extended aortic replacement carried out with advanced techniques improves long-term results if applied to properly selected patients.

In summary, we evaluated the results of extended total aortic arch replacement for acute type A aortic dissection and concluded that this surgical technique is justified for treatment of properly selected patients. The procedure is mainly indicated for type A dissection with a tear in the arch. However, it could also be applied to type A dissection with compromised arch vessels, massive false lumen of the aortic arch, and coexistent arch aneurysm and in young patients, particularly those with Marfan syndrome, despite the fact that the tear is located in the ascending aorta or the proximal descending aorta.

REFERENCES

- Massimo CG, Presenti LF, Marranci P, Favi PP, Poma AG, Ponzalli M, et al. Extended and total aortic resection in the surgical treatment of acute type A aortic dissection: experience with 54 patients. *Ann Thorac Surg* 1988;46:420-4.
- Bachet J, Teodori G, Goudot B, Diaz F, el Kerdany AE, Dubois C, et al. Replacement of the transverse aortic arch during emergency operations for type A acute aortic dissection. *J Thorac Cardiovasc Surg* 1988;96:878-86.
- Lansman SL, Raissi S, Ergin MA, Griepp RB. Urgent operation for acute transverse aortic arch dissection. *J Thorac Cardiovasc Surg* 1989;97:334-41.
- Yun KL, Glower DD, Miller DC, Fann JI, Mitchell RS, White WD, et al. Aortic dissection resulting from tear of transverse arch: Is concomitant arch repair warranted? *J Thorac Cardiovasc Surg* 1991;102:355-70.
- Heinemann M, Laas J, Jurmann M, Karck M, Borst HG. Surgery extended into the aortic arch in acute type A dissection: indications, techniques, and results. *Circulation* 1991;84(Suppl):III25-30.
- Crawford ES, Kirklin JW, Naftel DC, Svensson LG, Coselli JS, Safi HJ. Surgery for acute dissection of ascending aorta: Should the arch be included? *J Thorac Cardiovasc Surg* 1992;104:46-59.
- Kazui T, Kimura N, Yamada O, Komatsu S. Total arch graft replacement in patients with acute type A aortic dissection. *Ann Thorac Surg* 1994;58:1462-8.
- Ando M, Nakajima N, Adachi S, Nakaya M, Kawashima Y. Simultaneous graft replacement of the ascending aorta and total aortic arch for type A aortic dissection. *Ann Thorac Surg* 1994;57:669-76.
- Kazui T, Inoue N, Yamada O, Komatsu S. Selective cerebral perfusion during operation for aneurysms of the aortic arch: a reassessment. *Ann Thorac Surg* 1992;53:109-14.
- Kazui T, Kimura N, Yamada O, Komatsu S. Surgical outcome of aortic arch aneurysms using selective cerebral perfusion. *Ann Thorac Surg* 1994;57:904-11.
- Kazui T. Selective cerebral perfusion for brain protection during surgery of the aortic arch. In: Ennker J, Coselli JS, Treasure T, editors. *Cerebral protection in cerebrovascular and aortic surgery*. Darmstadt: Springer; 1997. p. 211-8.
- Kazui T, Tamiya Y, Tanaka T, Komatsu S. Extended aortic replacement for acute type A dissection with the tear in the descending aorta. *J Thorac Cardiovasc Surg* 1996;112:973-8.
- Griepp RB, Stinson EB, Hollingsworth JF, Buehler D. Prosthetic replacement of the aortic arch. *J Thorac Cardiovasc Surg* 1975;70:1051-63.
- Crawford ES, Saleh SA. Transverse aortic arch aneurysm: improved results of treatment employing new modifications of aortic reconstruction and hypothermic cerebral circulatory arrest. *Ann Surg* 1981;194:180-8.
- Svensson LG, Crawford ES, Hess KR, Coselli JS, Raskin S, Shenaq SA, et al. Deep hypothermia with circulatory arrest: determinants of stroke and early mortality in 656 patients. *J Thorac Cardiovasc Surg* 1993;106:19-31.
- Ergin MA, Galla JD, Lansman SL, Quintana C, Bodian C, Griepp RB. Hypothermic circulatory arrest in operations on the thoracic aorta: determinants of operative mortality and neurologic outcome. *J Thorac Cardiovasc Surg* 1994;107:788-99.
- Ueda Y, Miki S, Kusuhara K, Okita Y, Tahata T, Yamanaka K. Surgical treatment of aneurysm or dissection involving the ascending aorta and aortic arch, utilizing circulatory arrest and retrograde cerebral perfusion. *J Cardiovasc Surg* 1990;31:553-8.
- Coselli JS, Buket S, Djukanovic B. Aortic arch operation: current treatment and results. *Ann Thorac Surg* 1995;59:19-27.
- Deeb GM, Jenkins E, Bolling SF, Brunsting LA, Williams DM, Quint LE, et al. Retrograde cerebral perfusion during hypothermic circulatory arrest reduces neurologic morbidity. *J Thorac Cardiovasc Surg* 1995;109:259-68.

20. Bachet J, Guilmet D, Goudot B, Termignon JL, Teodori G, Dreyfus G, et al. Cold cerebropoplegia: a new technique of cerebral protection during operations on the transverse aortic arch. *J Thorac Cardiovasc Surg* 1991;102:85-94.
21. Veeragandham RS, Hamilton IN, O'Connor C, Rizzo V, Najafi H. Experience with antegrade bihemispheric cerebral perfusion in aortic arch operations. *Ann Thorac Surg* 1998;66:493-9.
22. Bachet J, Goudot B, Teodori G, Brodaty D, Dubois C, De Lentdecker P, et al. Surgery of type A acute aortic dissection with Gelatine-Resorcine-Formol biological glue: a twelve-year experience. *J Cardiovasc Surg* 1990;31:263-73.
23. Fann JJ, Smith JA, Miller DC, Mitchell RS, Moore KA, Grunkemeier G, et al. Surgical management of aortic dissection during a 30-year period. *Circulation* 1995;92(Suppl): III13-21.
24. Ergin MA, Phillips RA, Galla JD, Lansman SL, Mendelson DS, Quintana CS, et al. Significance of distal false lumen after type A dissection repair. *Ann Thorac Surg* 1994;57:820-5.
25. Bachet JE, Termignon JL, Dreyfus G, Goudot B, Martinelli L, Piquois A, et al. Aortic dissection: prevalence, cause, and results of late reoperations. *J Thorac Cardiovasc Surg* 1994;108:199-206.
26. Crawford ES, Svensson LG, Coselli JS, Safi HJ, Hess KR. Surgical treatment of aneurysm and/or dissection of the ascending aorta, transverse aortic arch, and ascending aorta and transverse aortic arch: factors influencing survival in 717 patients. *J Thorac Cardiovasc Surg* 1989;98:659-74.
27. Miller DC, Mitchell RS, Oyer PE, Stinson EB, Jamieson SW, Shumway NE. Independent determinants of operative mortality for patients with aortic dissections. *Circulation* 1984;70(Suppl): I153-64.
28. Borst HG, Bühner B, Jurman M. Tactics and techniques of aortic arch replacement. *J Cardiol Surg* 1994;9:538-47.
29. Rizzo RJ, Aranki SF, Aklog L, Couper GS, Adams DH, Collins JJ Jr, et al. Rapid noninvasive diagnosis and surgical repair of acute ascending aortic dissection: improved survival with less angiography. *J Thorac Cardiovasc Surg* 1994;108:567-75.
30. Galloway AC, Colvin SB, Grossi EA, Parish MA, Culliford AT, Asai T, et al. Surgical repair of type A aortic dissection by the circulatory arrest-graft inclusion technique in sixty-six patients. *J Thorac Cardiovasc Surg* 1993;105:781-90.

Appendix. Preoperative and perioperative variables analyzed

Sex
Age
Shock
Endotracheal intubation
Cardiac tamponade
Myocardial ischemia
Cerebral ischemia
Paraplegia
Renal-mesenteric ischemia
Leg ischemia
Two or more organ ischemias
Aortic regurgitation
Pleural rupture
Renal dysfunction
Chronic obstructive pulmonary disease
Marfan syndrome
Interval between onset and operation (≥ 3 days vs < 3 days)
Site of intimal tear
Entry-resection
Aortic valve resuspension
Composite graft replacement
CABG
Technique of arch reconstruction (en bloc repair vs separated graft technique)
GRF glue
Elephant trunk
Period of reoperation (1988-1992 vs 1993-1998)
Anastomotic leakage