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Long-term results of hybrid endovascular repair for thoraco-abdominal aortic aneurysms☆

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Abstract

Objective: The treatment of thoraco-abdominal aortic aneurysms (TAAAs) is extremely laborious, due to the surgical complexity of this condition. In particular, postoperative spinal paraplegia poses a severe complication that significantly lowers patient's quality of life. In 1997, we devised a hybrid procedure consisting of extended endovascular aortic repair (EVAR) and visceral reconstruction. In this article, we report the long-term results obtained from this procedure. **Methods:** We conducted 1106 endovascular aortic repairs between 1997 and 2008. Among these, we selected 86 cases of TAAA. The mean patient age was 71.6 years. Preoperative complications included 19 cases of stroke, 22 cases of coronary artery disease (CAD) and 16 cases of chronic obstructive pulmonary disease (COPD). Cerebrospinal fluid drainage was initiated during the operation. We performed bypasses from the aortic bifurcation to abdominal visceral arteries, and deployed stent grafts to exclude the entire TAAA. **Results:** Operative time averaged 386 min. We lost two patients and encountered only one case of graft occlusion. Two patients had acute renal failure, but neither required a tracheostomy. Furthermore, no patients exhibited paraplegia or delayed paraplegia. We observed endoleaks in nine cases, and shrunken aneurysms in 73 cases. Long-term results included survival rates of 94.8%, 85.8%, 80.2% and 66.6% at 2, 5, 8 and 10 years, respectively. Only two patients died from aortic events. Rates of freedom from aortic events were 90.7%, 80.6%, 70.8% and 70.8% at 2, 5, 8 and 10 years, respectively. **Conclusions:** The hybrid TAAA-repair protocol yielded satisfactory results. Although thorough follow-up is required for visceral bypass, this procedure could become the standard for TAAAs.

Keywords: Endovascular aortic repair; Hybrid procedure; Long-term results; Postoperative paraplegia; Thoraco-abdominal aortic aneurysm

1. Introduction

The treatment of thoraco-abdominal aortic aneurysms (TAAAs) is extremely laborious, as these aneurysms are complex and require invasive surgery [1–3]. Data from the Nationwide Inpatient Sample (NIS) database in the United States suggest a mortality rate approaching 22.3% [4]. In addition, devastating complications, postoperative paraplegia in particular, significantly lower postoperative patient quality of life (QOL). Despite refinements in surgical techniques for spinal protection, risk of postoperative neurological deficit remains high [1–4]. Although there is a considerable risk in patients with significant co-morbidity, conventional surgery remains an option because the mortality rate for conservative treatment at 2 years is ~76% [5].

Surgical treatments for thoracic aortic aneurysms have recently shifted to endovascular aortic repair because it is less invasive and improves postoperative QOL. In addition, the incidence of postoperative paraplegia in endovascular aortic repair for thoracic aortic aneurysms has decreased extremely [6–8]. In an attempt to prevent paraplegia, we developed a hybrid TAAA repair in 1997, consisting of abdominal visceral reconstruction and extended endovascular aortic repair. Early favourable outcomes encouraged another group to perform this procedure in patients suitable for this surgery as well [9–11]; however, the long-term results of their study have not been reported.

In the present study, we evaluated the early and long-term results obtained from this procedure in our single-centre experiment.

2. Patients and methods

From January 1993 to July 2009, we performed thoracic endovascular aortic repair (TEVAR) in 1050 of a total of 1458 thoracic and thoraco-abdominal aortic surgeries. Of these 1050 cases of TEVAR, 86 patients with TAAA underwent TEVAR with the reconstruction of abdominal visceral arteries in a

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Table 1
Patient's demographics and aortic characteristics.

Patients	86
Mean age (range)	71.6 years (47–86)
Gender ratio (male/female)	62/24
Mean aneurysmal size (range)	65 cm (55–88)
Aortic pathologies	
Degenerative aortic disease	55
Chronic aortic dissection (Marfan syndrome)	31 (3)
Crawford classification (modified)	
Type I (%)	15 (17.4%)
Type II	8 (9.3%)
Type III	31 (36.0%)
Type IV	11 (12.8%)
Type V	21 (24.4%)

procedure named the hybrid TAAA repair (mean age of patients: 71.6 years; range: 47–86 years; and 62 (72.1%) patients were male). With the exception of infectious TAAAs, we performed this hybrid procedure for almost all patients who were referred to our hospital during this period. Aortic pathologies included 55 degenerative aneurysms and 31 chronic aortic dissections, and three patients had Marfan syndrome. Aneurysms were classified according to the modified Crawford classification: type I ($n = 15$), type II ($n = 8$), type III ($n = 31$), type IV ($n = 11$) and type V ($n = 21$); type III TAAA was the most common (36% of patients). Median TAAA maximum diameter on the short-axis image was 65 mm (range: 55–88 mm; Table 1). Elective operations were performed in 76 cases (88.4%), and urgent operations were performed in eight patients who were symptomatic but had no radiographic evidence of rupture. The remaining two cases had radiographic evidence of rupture. These patients were high-risk cases with preoperative co-morbidity. Cerebrospinal disorders were present in 19 cases (22.1%), coronary artery disease in 22 cases (25.6%), chronic obstructive pulmonary disease (COPD) in 16 cases (18.6%), a histology of thoracotomy in 18 cases (20.9%) and a history of previous cardiovascular surgery in 29 cases (33.7% cardiac surgery, $n = 7$; ascending, $n = 4$; aortic arch, $n = 3$; descending, $n = 8$; thoraco-abdominal, $n = 2$; and abdominal, $n = 5$; Table 2). In all cases, a 64-row multi-slice computed tomography (CT) was performed for planning and sizing.

Anatomical inclusion criteria for this procedure were as follows: length of proximal and distal landing zone longer than 20 mm, aortic neck diameter of 18–42 mm and absence of circumferential thrombus and the possibility of a visceral artery de-branching. Patients were evaluated by post-operative contrast CT scans at 1, 6 and 12 months, and annually thereafter.

Table 2
Preoperative patient profiles.

Coronary artery disease (%)	22 (25.6%)
Cerebrospinal disorder	19 (22.1%)
Chronic obstructive pulmonary disease	16 (18.6%)
History of thracotomy	18 (20.9%)
History of previous cardiovascular disease	29 (33.7%)
Cardiac surgery	7
Vascular surgery	22
Ascending	4
Aortic arch	3
Descending	8
Thoraco-abdominal	2
Abdominal	5

2.1. Operative procedure

Prior to the procedure, we created cross-shaped bypass grafts with a 12-mm woven graft and an 8-mm polytetrafluorpethylene (PTFE) graft. Procedures were performed under general anaesthesia in an operating room. Following laparotomy, a coeliac artery, a superior mesenteric artery, bilateral renal arteries and the inflow site of bypassing were exposed. Bypass grafts were then constructed from the aortic bifurcation or common iliac artery to the superior mesenteric artery and bilateral renal arteries. The choice of the inflow site was based on the extent of TAAA, whether or not prior abdominal aortic repair had been performed and the quality of the walls of the native aorta and iliac arteries.

Next, side-to-end anastomoses were created by suturing the 12-mm woven graft to a superior mesenteric artery from the inflow site, and end-to-end anastomoses were created by suturing bilateral renal arteries with 8-mm PTFE grafts anastomosed to the woven graft. Finally, side-to-end anastomoses were created by connecting a saphenous vein graft to a coeliac artery with ante-pancreatic graft routing. When we confirmed good collateral circulation from the superior mesenteric artery to the coeliac artery, we occluded the coeliac artery. Grafts were covered with retroperitoneal soft tissue at the end of all procedures (Fig. 1).

We then proceeded to the TEVAR procedure. Shin incisions were made in both groins and both femoral arteries were exposed for stent-graft delivery and aortic fluoroscopy. We used a common iliac artery for the retroperitoneal approach when the femoral artery was too small for sheath insertion. The device-deployment procedure was the same for each device system. When the size discrepancy between proximal and distal sites of the landing zone was at least 120%, tapered devices were used (e.g., home-made devices or the Talent Thoracic Tapered Stent Graft). In almost all cases, TEVAR was performed on the day after the bypass procedure.

The absence of endoleaks and good patency of visceral bypasses were assessed by completion aortography after deployment of the stent-grafts in all cases.

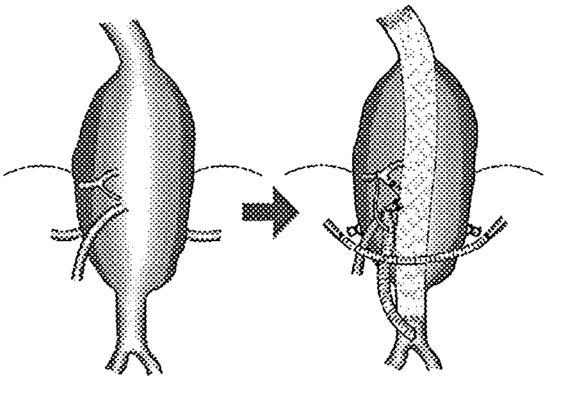

Fig. 1. The procedure of hybrid endovascular aortic repair for thoraco-abdominal aortic aneurysms (see text).

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For spinal cord protection, cerebrospinal fluid drainage and a dose of naloxone were initiated during the operation and continued for 24 and 72 h after surgery, respectively, in all cases. Cerebrospinal fluid was allowed to drain freely with gravity with a target pressure of 10 mmHg.

2.2. Statistical analysis

All data were analysed retrospectively. Continuous variables were expressed as mean + standard deviation and categorical variables as percentages. Survival and freedom from aortic events were estimated by the Kaplan–Meier method. Data analysis was performed using the Statistical Package of Social Sciences version 11 (SPSS 11.0) for Windows (SPSS Inc. Chicago, IL, USA).

3. Results

3.1. Procedural results

In 11 cases (including two cases of rupture), operations were performed simultaneously, and 75 patients received staged operations. In staged operations, the mean interval between bypass and TEVAR was 1.2 days (range: 1–6 days).

A total of 304 visceral artery bypasses were performed (56 to the coeliac artery, 86 to the superior mesenteric artery and 83 to bilateral renal arteries). Mean number of bypass grafts was 3.6. A total of 49 patients received a quadruple bypass involving all abdominal visceral arteries, 34 received a triple bypass and three received a double bypass. Bypass to the coeliac artery was not performed in 34 cases. The coeliac artery was shown to be occluded in preoperative CT scans in nine cases. In 25 cases, we verified good collateral circulation from the superior mesenteric artery to the coeliac artery, so we occluded the coeliac artery during surgery by ligation ($n = 6$) or by coiling before the operation ($n = 19$) (Table 3).

For the present study, we used home-made devices (thin-walled polyester grafts and stainless-steel Z stents) in 75 cases, TAG thoracic endoprostheses (WL Gore & Associates, Phoenix, AZ, USA) in 10 cases and the Talent Thoracic Stent Graft (Medtronic, Minneapolis, USA) in one case (mean number of devices used: 2.4). In 27 cases, we used tapered devices (home-made devices, $n = 26$: Talent devices, $n = 1$).

Mean operative time was 382 min (reconstruction of visceral arteries: 259 min; TEVAR: 123 min). The access vessels for TEVAR were the common femoral artery ($n = 75$), iliac artery ($n = 9$) and aortic prosthetic grafts ($n = 2$).

Table 3
Visceral artery bypass of the hybrid TAAA repair.

Total amount of visceral bypass grafts	304
Target vessels	
Coeliac artery	56
Superior mesenteric artery	86
Left renal artery	83
Right renal artery	83
Mean number of bypass grafts	3.6
Quadruple bypass (coeliac, SMA, bil. renal)	49
Triple bypass (SMA, bil. renal)	34
Two bypass (coeliac, SMA)	3

TAAA, thoraco-abdominal aortic aneurysm.

Intra-operative type I endoleaks were detected in four cases, so we treated these with Palmatz XL (Cordis Co., New Brunswick, NJ, USA), and endoleaks were eliminated in all cases.

3.2. Early results

Procedural success was achieved in all cases. Two patients (2.3%) died within 30 days of the operations, one due to bowel necrosis by a thrombus and the other due to sepsis from cholecystic necrosis. Shaggy aortae were detected by preoperative CT scan in both cases. No patient deaths occurred prior to discharge from our hospital.

Postoperative complications included minor brain infarction ($n = 1$), acute renal failure without haemodialysis ($n = 2$), prolonged ileus (>7 days, $n = 3$) and one graft to the renal artery was occluded at 2 months following surgery, however, the patient's other kidney remained well preserved with a functioning graft, and no further intervention was pursued. In this study, we observed no incidences of paraplegia and one case of transient paraparesis, and all patients were discharged after achieving independent gait. Median duration of hospital stay was 26 days (range: 14–69 days).

Nine endoleaks (10.5%) were detected by CT scan at the time of discharge. Type II endoleaks were observed in five cases. Back-flow from a superior mesenteric artery to the aneurysm occurred in two of these cases due to loose ligation of a superior mesenteric artery, and intervention with coiling was performed successfully. The other three patients were followed with CT scan. Type I distal endoleaks occurred in two cases; these were successfully treated by additional intervention with Palmaz XL stents. Type III endoleaks were found in two cases; one patient underwent additional TEVAR, and one patient was treated with a balloon at the site of the leak. Both type III endoleaks were eliminated with these interventions (Table 4).

We detected an Adamkiewicz artery in 25 patients within the last several years using a 320-row multi-detector CT; 23 of these were detected prior to surgery. All arteries were shown to be occluded by TEVAR by postoperative CT scan and no incidence of postoperative paraplegia occurred in any of the 23 cases.

3.3. Long-term results

Aneurysmal size was determined by follow-up CT scan (mean follow-up time: 88.5 months; follow-up completion rate: 98.8%). All-cause survival rate was 94.8% at 2 years,

Table 4
Early results of the hybrid TAAA repair.

30 days mortality	2.3% (2/86)
Postoperative complications	
Renal failure (%)	2 (2.3%)
Prolonged ileus	3 (3.5%)
Graft occlusion	1 (1.2%)
Paraplegia	0
Paraparesis (transient)	1 (1.2%)
Endoleak	9 (10.5%)
Migration	0

TAAA, thoraco-abdominal aortic aneurysm.

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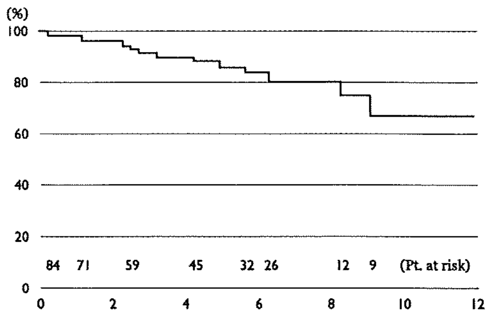

Fig. 2. All-cause survival rate; 94.8% at 2 years, 85.8% at 5 years, 80.2% at 8 years, and 66.6% at 10 years.

85.8% at 5 years, 80.2% at 8 years and 66.6% at 10 years (Fig. 2). Only two patients died due to aortic events; one patient experienced graft occlusion of a superior mesenteric artery resulting in fatal mesenteric necrosis, and the other patient experienced graft infection due to a duodenal fistula. We performed emergency resection of the duodenum and the graft, but this patient died due to multi-organ failure.

Freedom rate from aortic events was 90.7% at 2 years, 80.6% at 5 years, 70.8% at 8 years and 70.8% at 10 years (Fig. 3). Three patients underwent operations for other aneurysms (iliac aneurysm, $n = 2$; annulo-aortic ectasia, $n = 1$). We detected new endoleaks in five patients during follow-up; one patient experienced a type I distal endoleak 3 years after the operation, which was successfully treated by intervention with Palmatz XL stent, and two patients experienced type III endoleaks due to stent-graft migration after 2 years and 3 years. Both patients underwent additional TEVAR and these endoleaks were eliminated. We identified type II endoleaks in two patients during follow-up. Both patients were followed with CT scan because the size of the aneurysms did not change.

In the latest CT findings, short-axis imaging of aneurysms demonstrated shrinkage in 73 cases, no change in 11 cases and enlargement in two cases. As we were unable to detect any type of endoleak in the two cases with enlargement, both cases have been followed intensively with CT scans.

4. Discussion

Surgical treatments have recently shifted to minimally invasive procedures to improve postoperative QOL. As pioneers of this procedure, we have achieved solid results in endovascular aortic repair with stent-grafts since 1993 [12]. Postoperative paraplegia after endovascular repair for inferior thoracic aneurysms has been considerably reduced in our experience. We have, therefore, developed a new procedure, which allows for reconstruction of visceral arteries followed by TEVAR to cover the entire aneurysm.

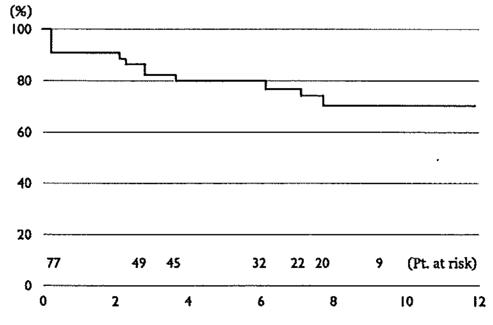

Fig. 3. Freedom rate from aortic events; 90.7% at 2 years, 80.6% at 5 years, 70.8% at 8 years, and 70.8 at 10 years.

The present study obtained excellent early and long-term results. All-cause survival rate was 80.2% at 8 years, and 66.6% at 10 years, which is significantly higher than rates observed following conventional surgical procedures. One reason for our good results was our follow-up system. For long-term follow-up, all patients received CT scans once every year to prevent serious issues such as aortic rupture due to stent-migration or endoleaks. Freedom from aortic-related events was 70.8% both at 8 and 10 years, due to migrations and endoleaks that are specific complications of endovascular repair. We identified five new endoleaks, three of which required critical attention. These patients could have died had we not detected the endoleaks by CT scan.

Graft patency is the most important factor for obtaining good long-term results from this procedure. In the long-term, only two patients died due to graft problems. We achieved excellent graft patency of bypassing to visceral arteries, which represented good long-term results Encouraging patency rates of 90–95% at 3 years have been reported in some series of bypass grafting for chronic mesenteric ischaemia and treatment of renal artery stenosis [13,14]. However, the safety and durability of retrograde bypass grafting have remained controversial. Kansal et al. [15] reported no difference in patency between antegrade and retrograde grafts in this later series.

Attainment of satisfactory patency for bypassing as well as excellent long-term results depends on the management of graft bypassing. The following three key points are recommended as ways to obtain good bypass patency.

(1) Bypass-graft shape
We created a cross-shaped graft for visceral bypassing, as described in Fig. 1. The bypass technique with this was simple and required a short operative time due to the few sites for anastomoses. In addition, graft lengths were short, especially in renal arteries.

(2) Selection of bypass-inflow sites
The appropriate choice of inflow sites is very important for excellent long-term graft patency. Prosthetic grafts are thought to be the best inflow sites for the visceral bypass to avoid sutures on the atherosclerotic native arterial wall and emboli from shaggy aortas [16]. We, therefore, performed graft replacement of abdominal aortas in 32 cases even when aneurysms were small. When the common iliac artery was used for the graft inflow, we also performed graft replacement to attain the ideal inflow.

(3) Bypass-graft route
Bypass-graft routes must also be selected carefully; we had a patient with a duodenal fistula. After experiencing this complication, we have tried to maintain separation of the grafts from the gastrointestinal tract by covering grafts with retroperitoneal soft tissue [16]. Visceral grafts require close monitoring to

reduce the risk of late enteric erosion or fistula in their extra-anatomic route.

The most significant advantage of this procedure is the extremely low incidence of postoperative paraplegia. We had only one patient with transient paraparesis on the day following surgery from hypotension due to paroxysmal atrial fibrillation; by maintaining increased blood pressure, this patient recovered completely. According to a report from Griepp and Griepp [17], the spinal cord has high collateral circulation and a collateral network. Therefore, if we occlude several intercostal arteries, spinal cord ischaemia may not occur immediately. In addition, some believe that reconstruction of the Adamkiewicz artery may be important to prevent postoperative paraplegia. However, Adamkiewicz arteries were detected by preoperative CT in 22 cases occluded by TEVAR in the present study, and there was no incidence of postoperative paraplegia in these cases. Thus, the necessity for reconstruction of intercostal arteries for TAAA repair should be reconsidered.

Some studies have reported a 'steal phenomenon', which describes back-flow from intercostal arteries in the aorta where the aorta was dissected between the aortic clamping for the graft replacement of an aortic aneurysm [17–19]. Some studies reported that postoperative paraplegia was not common when conventional surgery for thoracic descending aneurysm was performed after ligation of the intercostal arteries in the operative lesion [19,20]; this procedure may prevent the steal phenomenon in cases where conventional TAAA surgery surgeries are performed. Thus, it is not difficult to understand how the rate of postoperative paraplegia is reduced due to the absence of the steal phenomenon in TEVAR.

The choice of simultaneous or staged procedures is an issue in hybrid TAAA repair and is made according to the specific clinical situation of each case. The staged strategy reduces operative invasiveness and postoperative complications, but as the interval between the bypass operation and TEVAR is extended. The risk of rupture may increase. In our treatment strategy, we use a staged operation, and TEVAR is performed on the day after re-vascularisation of visceral arteries.

Although we have achieved satisfactory early and long-term results for the hybrid TAAA repair, this procedure is not appropriate for all TAAAs. Additional long-term results are needed prior to use of this surgery in young patients. A branched device is strongly desired in the endovascular field [21,22]; if a branched device is approved for TAAAs, surgery to treat TAAAs will shift to simple TEVAR with branched devices. In the meantime, this hybrid procedure with TEVAR may become one of the standard procedures.

5. Conclusion

We have obtained satisfactory early results for hybrid TAAA repair; in particular, the complete lack of postoperative paraplegia strongly encourages us to use this procedure without hesitation. In the long term, the rate of aortic event-related death was extremely low. There were more than a few aortic events, especially specific complications related to endovascular repair, such as migrations and endoleaks; these patients required follow-up CT scans at regular intervals.

Based on our early and long-term results, we conclude that the hybrid TAAA repair may become one of the standard surgeries for TAAAs in high-risk patients although sufficient follow-up is needed for visceral bypass.

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Appendix A. Conference discussion

Dr M. Grimm (Vienna, Austria): The results are very impressive and in contrast to the currently available literature reporting these small results in this combined approach. As a consequence, I feel that it is important to work out factors that are perhaps responsible for this difference to the current literature with your results.

In the current literature, most of the reports are dealing with Caucasian people suffering from obesity, they are suffering from COPD, so surgical exposure during the initial procedure seems to be more problematic than in people from Asia, as we know that these people are smaller. Do you think, this is my first question, that the smaller body surface area or body mass index of Japanese people maybe makes it technically simpler as compared to Caucasian patients?

The second question is: These are truly very excellent results. Nevertheless when comparing it with results of the surgical repair of a thoraco-abdominal replacement of the aorta, don't you think that the higher need of repeated investigations by CT scans may be problematic for the patient and also more costly?

And the third question is: Could you be so kind as to give us a definition. What is a high-risk patient in your cohort and what is a low-risk patient? And do low-risk patients go into conventional surgery?

Dr Kuratani: All of the Japanese patients are, as you say, very small and the Asian people are the same. But usually it is better to expose the artery or the anastomosis. The Japanese people and the Asian people have a very low rate of diabetes or hypertension, so the aorta and also the artery are good. It is better in such a small surface patient, it is better to use this operation.

And as to cost, there are many cities in Japan, and there is a difference in the insurance compared to Europe and the USA. But I think that the cost is higher than the conventional operation, because there are many CT scans and checking is a need in the difficult patient. So maybe the cost is higher. And so we selected only the high-risk patients. For the low-risk patients, it is better to do the conventional operation. Maybe the risk is maybe the same.

Dr Grimm: Could you just briefly give us an impression, what is high risk? What are risk factors that turn people into high-risk or low-risk groups in your series?

Dr Kuratani: The high-risk series, high risk is okay.

Dr G. Wheatley (Phoenix, Arizona, USA): Why did you choose a saphenous vein graft to the coeliac artery versus PTFE?

Dr Kuratani: Before we used a PTFE graft. In one case we had intestine and also a gastric fistula occurring with this PTFE graft, so that we changed it to the saphenous vein graft. After the changing, we have no problem with this graft.

Dr J. Bachet (Abu Dhabi, United Arab Emirates): I'm very impressed by the number of patients that you find in your experience, 86 patients of this kind is an important number. I have no experience in this matter, so my question should be irrelevant. But, as I observe, it is heavy surgery. So to repeat what the previous discussant said, how did you define what are high-risk patients and not high-risk patients?

And a subsidiary question: is the use of your method a systematic policy in your department or it applied only to a few selected patients?

Dr Kuratani: That's a very difficult question. This operation is not so risk invasive, I think. So this operation, I avoid thoracotomy and the postoperative paraplegia rate is very low. This point is very good for this operation. The hybrid operation with this TEVAR operation, I think in the future, if the branched stent-graft is approved, maybe we can use this stent-graft. But now we cannot use this stent-graft, so as such avoids postoperative paraplegia, maybe this operation is an advantage for such a patient.

Dr Bachet: Yes. But I'm somewhat surprised that you focus only on paraplegia. There are other complications in this kind of surgery, like death, for instance. Having done a few cases of vascular surgery in my life, I know, as everybody here, that from time to time those Dacron prostheses get occluded. For instance, when you put the two renal arteries in the same mustache on an iliac deviation as I've seen on one of your slides, in how many patients will this occlude in the future? You don't know. And we know that surgery is not always perfect. I mean, the grafts might be too long and kink, they can be too short and be stretched, et cetera. So don't you think that you may be trading a risk for another higher risk?

Dr Kuratani: You say that maybe we use a long bypass, so there is some trouble in the future. But we have a long-term result in the 10 years. We have two cases with a left occlusion. One case in the renal artery occlusion, and one case the supramesenteric artery bypass occlusion, and there is no kinking. This is a technical problem. We changed the operation and change it, change it, change it. And before we used a long bypass on each visceral bypasses. And now we use this bypass system. After changing to this bypass system, we have no occluded and also no kinking and no problem about the graft problem.

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Extended replacement of aortic arch aneurysms through left posterolateral thoracotomy

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Abstract

Objective: To present our experience of total aortic arch replacement through a left posterolateral thoracotomy. **Methods:** Sixteen patients (13 males; mean age 62.1 ± 11.3 years) with extended thoracic aortic aneurysms, including those in the thoracoabdominal aorta, underwent replacement through a left posterolateral thoracotomy. The pathology of the diseased aorta was non-dissecting aneurysm due to aortitis in 1 patient and aortic dissection in 15 patients (acute type A: 1, chronic type A: 12, chronic type B: 2). In a prior operation, the patient with aortitis had undergone the Bentall procedure with endovascular stenting of the brachiocephalic artery, and among the other 15 patients, one previously had endovascular stenting for the aortic arch and 12 had hemi-arch replacement for acute type A dissection. Extension of arch replacement was the aortic arch and descending aorta in eight patients, the ascending arch and descending aorta in five patients and the descending arch, and thoracoabdominal aorta in three patients. Additional retroperitoneal dissection was required for the repair of a thoracoabdominal aortic aneurysm. **Results:** One patient died of traumatic cerebral hemorrhage on day 145 (hospital mortality 6.3%). Average duration of ventilation support was 19.4 ± 17.0 h and length of ICU stay was 3.6 ± 1.6 days. Actuarial survival at 2 years after the operations was 67.7%. However, no aortic-related mortality was observed during follow-up. **Conclusions:** Early results of extended aortic arch replacement through a left posterolateral thoracotomy were satisfactory in selected patients.

Keywords: Extended thoracic aneurysm; Left side thoracotomy

1. Introduction

Repair of an extended thoracic aneurysm is challenging. A staged operation is often preferred with safety as the priority [1,2]; however, this strategy may result in greater than expected mortality when considering the combined mortality from the first and second procedures as well as death in the interval between procedures [3].

A one-stage operation is highly effective in terms of both long-term survival and quality of life. However, careful patient selection based on preoperative comorbidity is of vital importance. Simple incision and good aortic exposure is mandatory in the one-stage treatment for extensive thoracic aneurysms. Brain protection during the arch replacement is another important issue in obtaining a satisfactory outcome [4].

Median sternotomy is the gold standard to access the aortic arch, however, exposure of the distal descending aorta is limited even if additional left anterolateral thoracotomy is applied. Residual dissection from the aortic arch down to the descending or thoracoabdominal aorta after ascending aortic replacement for acute type A dissection is often encountered, which requires an extended replacement of the aortic arch. Kouchoukos et al. reported excellent results of a one-stage operation for extended thoracic aneurysms through a clam-shell incision using the arch-first technique [5]. Left posterolateral thoracotomy is another beneficial option to access the ascending, arch and entire descending aorta, which allows for performance of even a thoracoabdominal procedure by entering the retroperitoneal space.

This report describes the surgical experience in repair of thoracic aneurysms through the left posterolateral thoracotomy.

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Table 1
Patient profile.

Case	Age	Sex	Extent	Dissection	Previous operation	Preoperative comorbidity
1	52	M	As, A, Ds	No	Bentall	Aortitis
2	80	M	As, A, Ds	Chronic-B	Nil	DIC
3	73	M	As, A, Ds	Chronic-B	TEVAR	CRF
4	44	M	As, A, Ds	Acute-A	Nil	Leg malperfusion
5	80	M	STJ, As, A, Ds	Chronic-A	Hemi-arch	s/p AAA repair
6	70	M	A, Ds	Chronic-A	Hemi-arch	Nil
7	55	M	A, Ds	Chronic-A	Hemi-arch	Nil
8	69	M	A, Ds	Chronic-A	Hemi-arch	Epidural hematoma
9	48	M	A, Ds	Chronic-A	Hemi-arch	IgA nephropathy
10	58	M	A, Ds	Chronic-A	Hemi-arch	Nil
11	68	F	A, Ds	Chronic-A	Hemi-arch	Nil
12	77	F	A, Ds	Chronic-A	Hemi-arch	Tracheostomy, malignant
13	60	M	A, Ds	Chronic-A	Hemi-arch, TEVAR	Stroke, DIC
14	62	M	A, Ds, TA	Chronic-A	Hemi-arch	OMI, stroke, CRF
15	64	F	A, Ds, TA	Chronic-A	Hemi-arch	Nil
16	49	M	A, Ds, TA	Chronic-A	Hemi-arch	Nil

As: ascending aorta, A: aortic arch, Ds: descending aorta, STJ: sino-tubular junction, TA: thoracoabdominal aortic aneurysm, TEVAR: endovascular thoracic aortic repair, DIC: disseminated intravascular coagulation, OMI: old myocardial infarction, CRF: chronic renal failure, AAA: abdominal aortic aneurysm.

2. Methods and patients profile

From 2002 to 2007, 16 patients underwent one-stage repair of extended thoracic aneurysms (all including the aortic arch and descending aorta of varying lengths) through a left posterolateral thoracotomy. Profiles of the patients were retrospectively reviewed and are shown in Table 1. The average age was 62.1 ± 11.3 years (range: 44–80) and 13 of the 16 patients were male. Chronic type A dissection (n = 12) was the major aortic pathology among these patients and all 12 patients (cases 5–16) underwent ascending aortic replacement and had progressive enlargement of residual dissection of the aortic arch and the descending aorta. One patient (case 1), who had undergone a Bentall operation and stenting in the brachiocephalic artery aneurysm due to aortitis, had a non-dissected aneurysm from the ascending, aortic arch to the descending aorta. Another patient (case 2) had dilated chronic type B 3-channel dissection associated with the arch aneurysm. Two patients (cases 2 and 3) had chronic type B dissection. Cases 3 and 13 had undergone endovascular thoracic aortic repair (TEVAR) from the aortic arch to the descending aorta, followed by progressive aortic dilatation due to type I endoleak. One patient (case 4) had acute type A aortic dissection complicated by rupture of the descending aorta and right leg malperfusion [6]. Three patients (cases 14, 15 and 16) had extensive dilation further down to the thoracoabdominal aorta (Crawford type II, I, I) (Table 1).

3. Preoperative risk evaluation (Table 1)

With regard to preoperative brain complications, one patient (case 8) had an epidural hematoma, which required the external decompression of the brain before the aortic repair and another (case 13) had experienced a stroke after the previous TEVAR. Case 14 had stenosis of the right middle cerebral artery accompanied by an old cerebral infarction. Three patients had preoperative chronic renal failure (cases 3, 9 and 14). Case 5 had an abdominal aortic aneurysm (AAA) and previously had undergone the replacement of an AAA. Two patients (cases 2 and 13) were diagnosed to have DIC with a decreased platelet count and increased FDP level. The average standard EuroSCORE was 9.7 ± 2.5, ranging from 6 to 15. Case 4, who had acute type A aortic dissection with left leg malperfusion and a rupture in the left pleural cavity, underwent surgery on emergency basis (Table 2).

4. Surgical procedure

With the patient in the right recumbent position, the entire thoracic aorta was exposed through the 4th intercostal spaces with or without left rib-cross thoracotomy [7]. The 5th rib was transected anteriorly or posteriorly, which provided sufficient aortic exposure (Fig. 1A). The 6th rib was

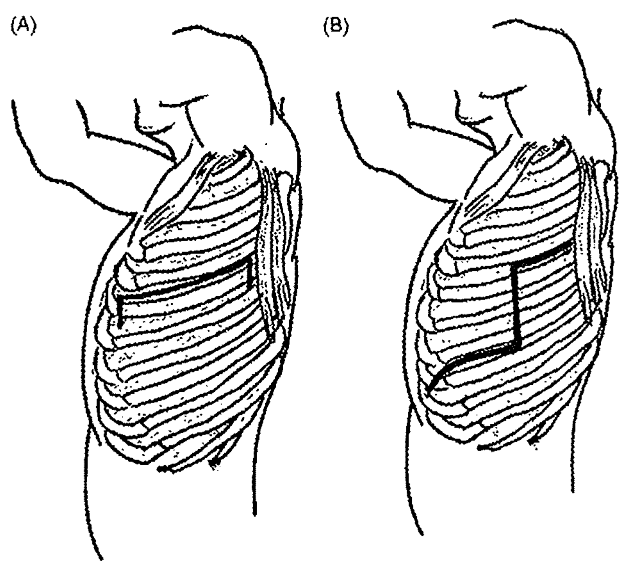


Fig. 1. Schema of thoracotomy. (A) Left side thoracotomy through the left 4th intercostal space. The 5th rib was transected anteriorly or posteriorly. (B) Left side rib-cross thoracotomy. The 4th and 7th intercostal spaces were opened. The 5th, 6th, and 7th ribs were transected at the midaxillar line, afterward the 8th costal cartilage was transected.

Table 2
Operative procedure and outcome.

Case	Urgency	Repair	Brain protection	Reconstruction of arch vessels	SCP/DHCA time (min)	Myocardial ischemic time (min)
1	Elective	As, A, Ds	DHCA, RCA	Island, arch-first	40	66
2	Elective	As, A, Ds	DHCA, RCA	Island, arch-first	30	60
3	Elective	As, A, Ds	DHCA, RCA	Island, arch-first	43	60
4	Emergent	As, A, Ds	SCP	Three branched	102	172
5	Elective	As, A, Ds	SCP	Three branched	162	91
6	Elective	A, Ds	SCP	Island	79	113
7	Elective	A, Ds	SCP	Island	84	97
8	Elective	A, Ds	SCP	Island	97	107
9	Elective	A, Ds	SCP	Island	56	68
10	Elective	A, Ds	SCP	Island	64	54
11	Elective	A, Ds	SCP	Island	55	65
12	Elective	A, Ds	SCP	Island	83	92
13	Elective	A, Ds[a]	SCP	Island	90	70
14	Elective	A, Ds, TA	SCP	Island	53	62
15	Elective	A, Ds, TA	SCP	Island	108	81
16	Elective	A, Ds, TA	SCP	Island	64	68

As: ascending aorta, A: aortic arch, Ds: descending aorta, FA: femoral artery, FV: femoral vein; mPA: main pulmonary artery, RA: right atrium, DHCA: deep hypothermic circulatory arrest, RCA: retrograde cerebral perfusion, SCP: selective cerebral perfusion.
[a] 8th intercostal artery reattachment.

transected particularly for thoracoabdominal procedure. With regard to the rib-cross thoracotomy (case 4), a skin incision was made from the midpoint between the spinal process and the scapula, around the lower end point of the scapula, down to the left subchondral lesion. The 4th and 7th intercostal spaces were opened, after which the 5th, 6th, and 7th ribs were transected at the midaxillar line. The 8th costal cartilage was transected along the incision through the 7th intercostal space (Fig. 1B). The sternum was not transected and the left internal thoracic artery was preserved in all cases. Cardiopulmonary bypass was established using the femoral artery for arterial return and the left femoral vein ($n = 7$), the pulmonary artery ($n = 8$) or both ($n = 1$) for venous drainage. Patients were cooled down to at 22.8 ± 3.8 °C (range: 16–28 °C) as measured by a tympanic thermometer. An aortic cross-clamp was placed on the mid-part of the descending aorta, maintaining lower body perfusion. The aorta was opened from the proximal descending aorta to the ascending aorta mainly up to the previous prosthetic graft for the ascending aortic replacement. Cardioplegic solution was given from inside the ascending aorta with a balloon-tipped catheter, and selective cerebral perfusion was established using balloon-tipped catheters from inside the aortic arch. A Dacron graft was anastomosed to the previous graft or the ascending aorta first in the majority of cases (Fig. 2). Afterward, arch vessels were reconstructed as an island cuff in 14 cases. Brain protection was provided by antegrade selective cerebral perfusion under deep hypothermia in 13 patients or deep hypothermic circulatory arrest with complementary retrograde cerebral perfusion in 3 patients (Table 2). Systemic rewarming was initiated after the reconstruction of the arch vessels. Perfusion of the heart and brain was re-established through the side branch of the prosthetic graft. The distal descending aorta was transected at a normal caliber, and the graft was anastomosed to both the true and false lumen to maintain patency distally and to prevent malperfusion of the visceral vital organs or legs. Three patients (cases 14, 15 and 16) with a dilated thoracoabdominal aorta underwent additional replacement down to the previous abdominal Y graft or the terminal aortic bifurcation under the selective perfusion of visceral organs (Fig. 3). Five intercostal arteries were reattached in each case.

5. Extent of the repair

The extent of the thoracic aortic replacement is shown in Table 2, which was from the ascending aorta, arch to the mid-descending aorta in five patients (cases 1–5), aortic arch to the mid-descending aorta in eight patients (cases 6–13) and from the arch down to the thoracoabdominal aorta in three patients (cases 14–16), respectively.

5.1. Statistical analysis

Data were expressed as mean ± SD. Actuarial survival was assessed by the Kaplan–Meier method using the SPSS package for Windows (SPSS Inc., Chicago, IL).

6. Results

6.1. Early results

One patient (case 2), who had the comorbidity of DIC, died during hospitalization from traumatic brain bleeding on day 145 (hospital mortality 6.3%). Cardiopulmonary bypass time was 209.1 ± 58.8 min, myocardial ischemic time was 82.9 ± 29.8 min, SCP time was 84.4 ± 29.7 min and CA with RCP time was 37.7 ± 6.8 min (Table 2). Postoperative ICU stay was 3.6 ± 1.6 days. The postoperative profiles of the patient group are shown in Table 3. A reversible ischemic neurological deficit manifested by right forearm paralysis was observed in case 11, but no other brain complications were noted. Case 14, who underwent extended replacement down to the thoracoabdominal aorta, had temporary paraparesis and ischemic colitis, but had recovered com-

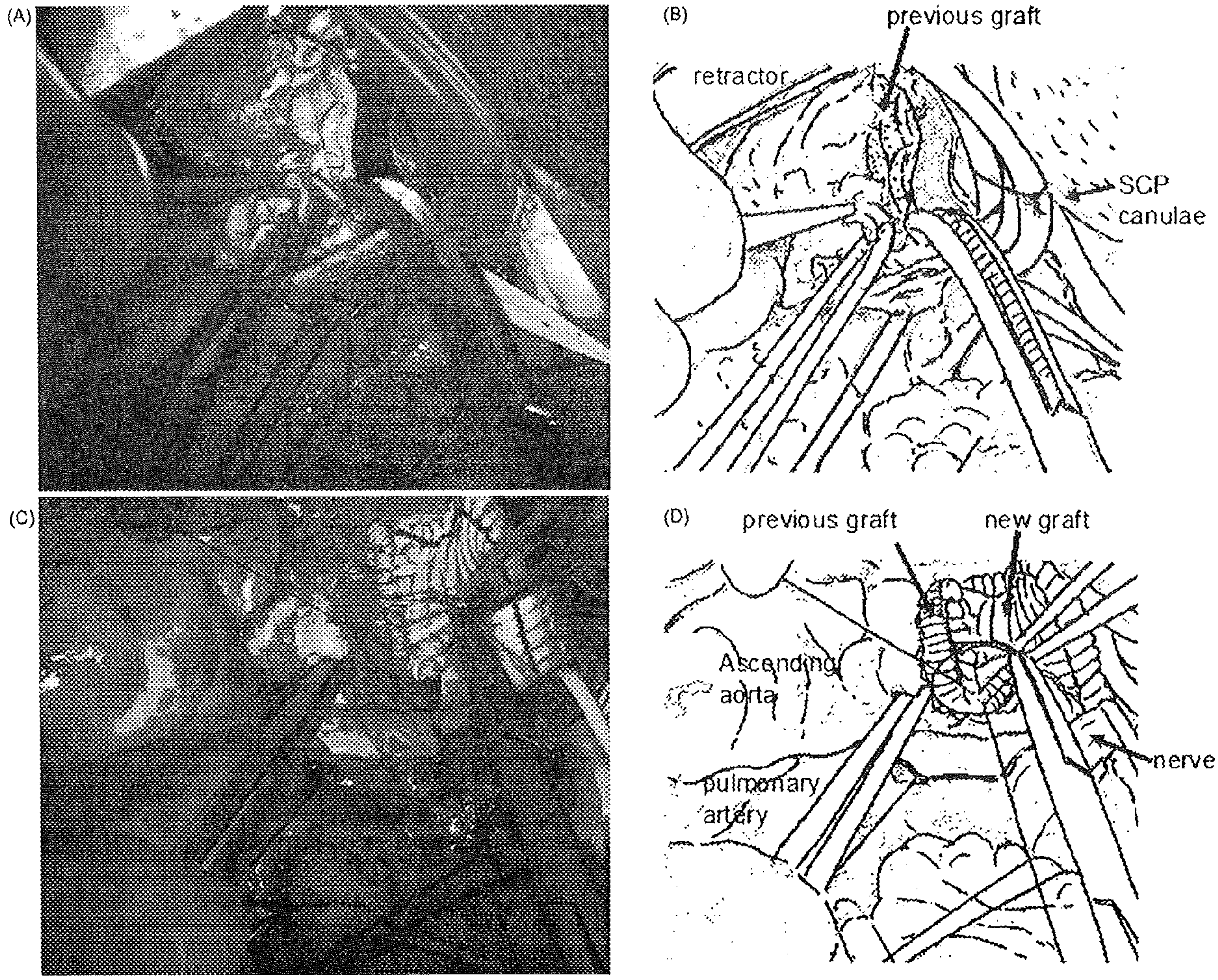


Fig. 2. Exposure of the ascending aorta and aortic arch through left side thoracotomy (case 11). (A) Surgeon's view through the left side thoracotomy through the left 4th intercostal space. Aortic arch aneurysm was opened, through which antegrade selective cerebral perfusion (SCP) cannulae was inserted into neck vessels. Previous graft was grasped by Kelly clamp. (B) Schema of (A). (C) New graft was anastomosed to the previous graft. Ascending aorta was accessible through this thoracotomy. (D) Schema of (C).

Table 3
Postoperative patent profile.

Number	Respiratory support (h)	ICU stay (days)	Complications	Outcome
1	15	4	Nil	Alive
2	19	3	Traumatic intracranial bleeding, GI bleeding	Dead
3	17	3	Hoarseness, pleural effusion	Alive
4	56	6	Phrenic nerve palsy, prolonged respiratory assistance	Alive
5	16	4	Mediastinal bleeding	Alive
6	14	3	Af	Alive
7	33	3	Pleural effusion, prolonged respiratory support	Alive
8	14	5	Nil	Alive
9	7	2	Nil	Alive
10	4	2	Nil	Alive
11	5	3	RIND	Alive
12	7	3	Pneumothorax	Alive
13	10	2	Pleural effusion	Alive
14	19	3	Paraparesis, ischemic colitis	Alive
15	13	8	Hoarseness	Alive
16	62	4	Pleural effusion, prolonged respiratory support	Alive

As: ascending aorta, A: aortic arch, Ds: descending aorta, FA: femoral artery, FV: femoral vein mPA: main pulmonary artery, RA: right atrium, DHCA: deep hypothermic circulatory arrest, RCA: retrograde cerebral perfusion, SCP: selective cerebral perfusion, GI: gastrointestinal, RIND: reversible ischemic neurological deficit.

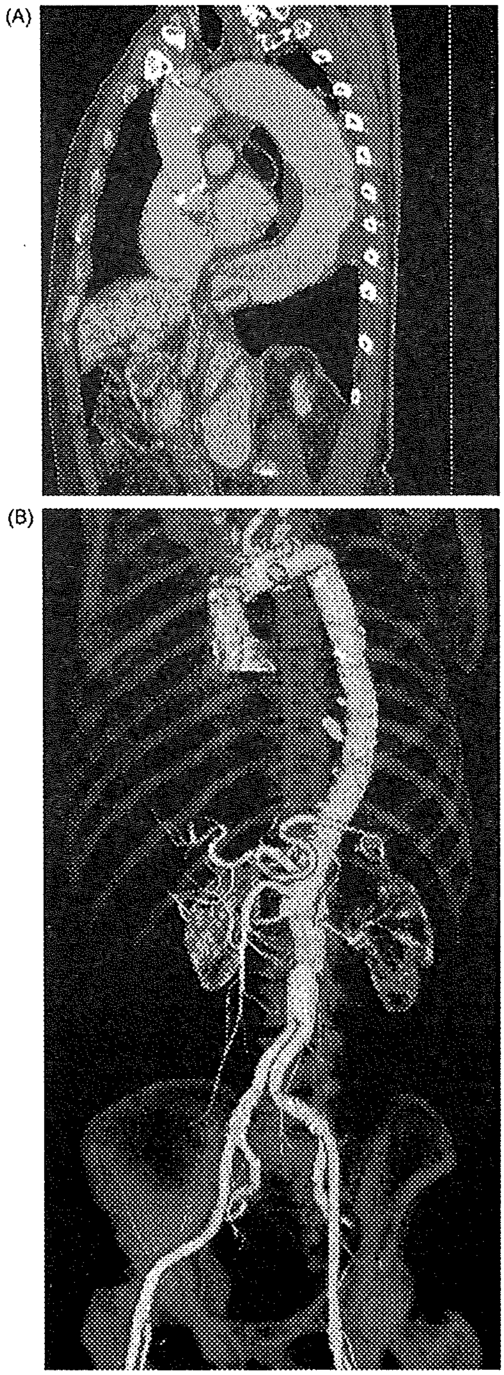


Fig. 3. Pre- and postoperative CT scan (case 10). (A) Preoperative CT scan demonstrated chronic type A dissection from the arch to thoracoabdominal aorta after hemi-arch replacement. (B) Postoperative CT scan showed entire thoracic and thoracoabdominal aortic aneurysm replacement.

pletely by discharge. Respiratory failure, defined as the necessity of more than 48 h support by mechanical ventilation, was observed in three patients (cases 4, 7 and 16). Average duration of respiratory support was 19.4 ± 17.0 h (range: 4–62 h). Intractable pulmonary bleeding was not observed.

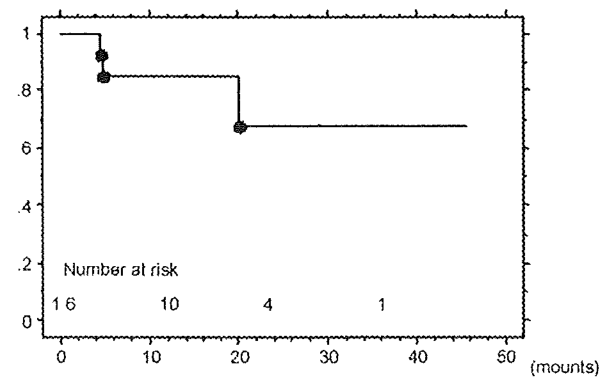


Fig. 4. Actuarial survival after the operation.

6.2. *Mid-term results*

Follow-up was 100% completed. Average follow-up was 16.4 ± 12.6 months (range: 1.4–45.5 months). During follow-up, cases 1 and 7 died due to pneumonia and the rupture of a pre-existing middle cerebral artery aneurysm, respectively. Actuarial survival at 2 years after surgery was 67.7% (95% CI: 0.13–1.23) (Fig. 4). However, no aortic-related mortality was observed.

7. Discussions

Patients who underwent ascending aorta or hemi-arch replacement for acute type A dissection sometimes had extensive thoracic aortic aneurysms due to residual flow in the distal false lumen [8]. When patients are carefully selected based on the evaluation of preoperative comorbidity, a single stage operation can be expected to be highly effective in terms of long-term survival and quality of life. Svensson et al. [9], Massimo et al. [10] and Hu et al. [11] had reported the superior outcome of one-stage surgery for extended thoracic aortic aneurysms.

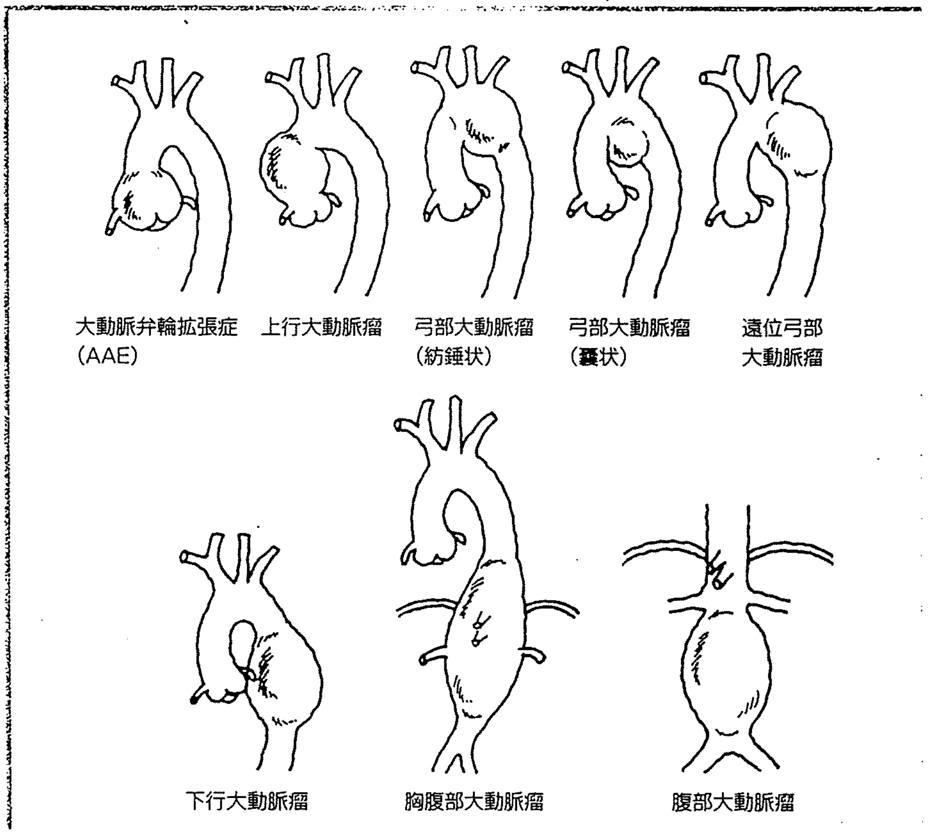
Wide exposure with a simple incision is mandatory and of primary importance in one-stage treatment for extensive thoracic aneurysms. Median sternotomy is the gold standard to access the aortic arch; however, exposure to the distal descending aorta is limited even if additional left anterolateral thoracotomy is applied. Kouchoukos et al. [5] reported the clam-shell approach as an excellent procedure for one-stage extended aortic arch replacement. We entirely agree that the clam-shell approach is highly useful if aortic root replacement is required.

In the current series, we could approach the ascending aorta, aortic arch and entire descending aorta through a left posterolateral thoracotomy alone. In case 5, who had undergone hemi-arch replacement, there was an unexpected disruption of the proximal anastomosis of the previous hemi-arch graft at the sino-tubular junction (STJ) level during the operation that required access to that level and that resulted in successful repair. A sternum transverse division might be an additional option to obtain better working space for the aortic root. However, we believe that avoiding division of the sternum while preserving the internal thoracic artery is important in terms of wound healing and possible future

❹ 大動脈瘤

久留米大学外科　准教授
明石英俊 ▌あかし ひでとし

めでみる 大動脈瘤



大動脈瘤の部位による分類　　(文献1より転載改変)

●何が起こっている？

大動脈瘤は胸部および腹部の大動脈が瘤様に拡張した状態で，多くの場合，周囲の組織や臓器を圧迫しない限り，症状はほとんどありませんが，瘤の拡大とともに大動脈瘤壁の脆弱化が進み，破裂の危険性が増大します．いったん破裂を来すと予後は不良であり，約半数の患者は病院にたどりつくことができず，死亡します．手術可能な患者さんでも，救命率は約 60 ～ 70

%です．大動脈瘤には真性大動脈瘤と仮性大動脈瘤が存在します（大動脈解離は除外する）．

大動脈瘤の部位による分類をp.44「めでみる大動脈瘤」に示しました．

1．真性大動脈瘤（図1）

真性大動脈瘤とは大動脈壁の内膜，中膜，外膜の三層構造を保ったままの状態で大動脈径が拡大して，瘤様の形態を形成するもので，多くは紡錘状です．

2．仮性大動脈瘤（図1）

仮性大動脈瘤とは大動脈壁の三層構造を有しない大動脈瘤であり，多くは血管周囲組織が瘤壁となります．

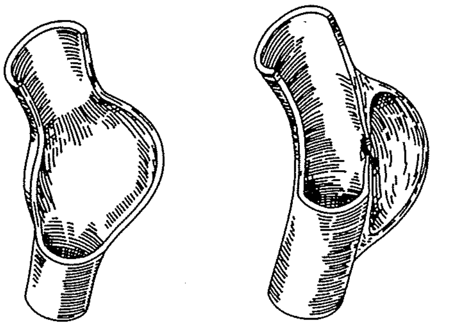
●どうして起こる？

多くの場合，真性大動脈瘤は動脈硬化性（変性性）や炎症性であり，このような原因で大動脈壁の病的変化が起こり，壁の脆弱化が起こり，大動脈が拡大して大動脈瘤を形成します．最近ではこのような形成過程で炎症性変化が関与していることが指摘されています．

仮性大動脈瘤は動脈硬化性潰瘍，外傷，大動脈壁の感染などが原因で，血管壁の一部が損傷され外方に突出するような嚢状の大動脈瘤を形成します．Marfan（マルファン）症候群は，この真性および仮性の双方の原因となり得ます．

●どんな症状がある？

基本的には大動脈瘤は破裂や周囲臓器，組織を圧迫しないかぎり無症状です．破裂の症状としては激しい胸痛，腹痛であり，多くは血圧低下などのショック症状が認められます．破裂がなくても大動脈瘤が周囲臓器などを圧迫することで症状が出現することがあり，これらの症状は大動脈瘤が形成された部位によって症状が異なってきます．



文献1より転載

図1　真性大動脈瘤（左）と仮性大動脈瘤（右）
真性大動脈瘤と仮性大動脈瘤を示す．大きな違いは大動脈壁が存在するかどうかである

1．胸部大動脈瘤

胸痛，背部痛が一般的な圧迫症状ですが，反回神経麻痺（まひ）による嗄声，気管や気管支の圧迫による呼吸困難，食道圧迫による嚥下困難や食道炎なども認められます．

2．腹部大動脈瘤

腹部の圧迫感や腹部拍動性腫瘤の触知，尿管の圧迫による水腎症や尿路感染症，まれに排便障害などが存在します．脊椎圧迫による腰痛はしばしば認められる症状です．

●どうやって診断・治療する？

1．診断

一般的には，胸部と腹部の単純X線撮影は

まず行うべき検査であり，突出した大動脈の陰影などで大動脈瘤を強く疑い，コンピュータ断層撮影法（CT）や磁気共鳴血管造影法（MRA）を施行し，確定診断に至るのが順序です．しかし現在では，前述したような症状を有する患者さんに対してはマルチスライスCT（multidetector-row CT；MDCT）を施行することが多いです．造影剤を用いれば瘤の詳細まで確定診断可能であり，これ以上の検査は必要がなくなります．また，造影剤を用いなくとも大動脈瘤の診断は可能ですが，血栓や内腔の状態については詳細な情報を得ることができません．造影剤アレルギーなどで造影剤が用いられない患者さんには，MRAを選択することもあります．超音波検査については，経胸壁的には上行大動脈の中枢側の一部と頸部から弓部の一部が診断可能です．また，腹部では消化管のガスが多くなければ胸腹部や腹部の大動脈瘤が診断できます．経食道の超音波検査はやや患者さんに侵襲が加わるため，破裂や切迫破裂の患者さんには適しませんが，胸部の上行，弓部，下行のほぼすべての胸部大動脈瘤の診断が可能です．以上，診断について述べましたが，現在の日本のようにMDCTが普及した状態では，まず第一選択をMDCTとして良いでしょう．

2．治療

手術治療

大動脈治療の基本は開胸あるいは開腹下での大動脈瘤部の人工血管（ダクロン製）による置換手術です．胸部および胸腹部の大動脈瘤の治療では補助手段が必要となります．多くの場合，上行や弓部の大動脈瘤では完全体外循環に加えて脳分離体外循環を用いることが多いです（図2）．胸部

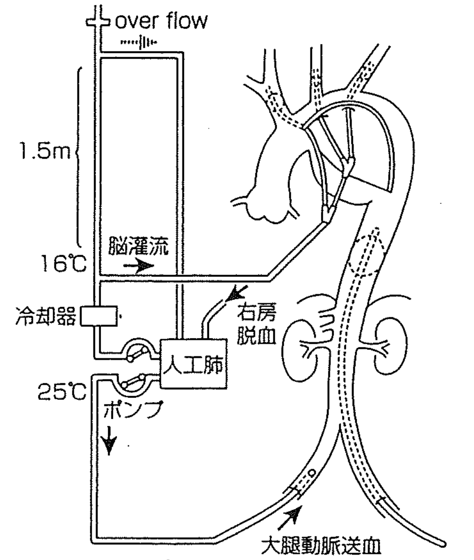
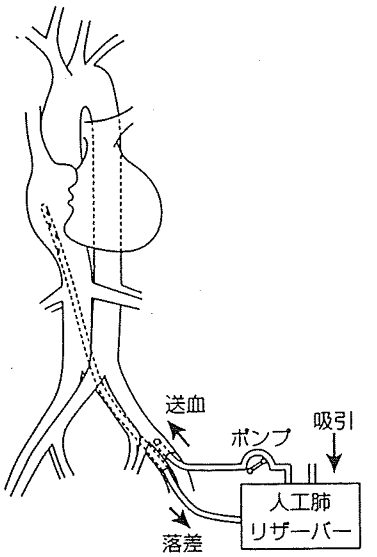


図2　選択的脳灌流法
弓部大動脈瘤に対する弓部置換手術を行うときに用いられる脳保護法としての選択的脳灌流法の回路図，および灌流法を示した

下行や胸腹部の大動脈瘤では，下半身のみの部分体外循環や左心バイパスを用います（図3）．このような補助手段で全身の血流を維持している間に大動脈の人工血管置換手術を行い，再建までを終了させます．腹部の大動脈瘤では腎動脈より末梢での大動脈遮断であるため，その末梢には重要な臓器がないために，腹部大動脈の単純遮断が可能ですが，あまりに長い大動脈遮断（2時間以上など），下肢骨盤腔の虚血は避けるべきです．

ステントグラフトによる治療（図4）

1990年代からステントグラフトによる治療が海外を中心に始まりました．国内でも各施設で手作りのステントグラフトを用いた治療が1990年代後半から行われるようになり，2006年に初めて日本国内で企業製のステントグラフトが使用可能となりました．腹部ではCOOK社製Zenith AAA®とGore社製Excluder®とENDOLOGIX



文献2より改変転載

図3　部分体外循環法
下行大動脈瘤に対する人工血管置換手術などに用いられる部分体外循環法の回路図および灌流法を示した．下半身は人工心肺で，上半身は患者さんの心臓で血液は灌流される

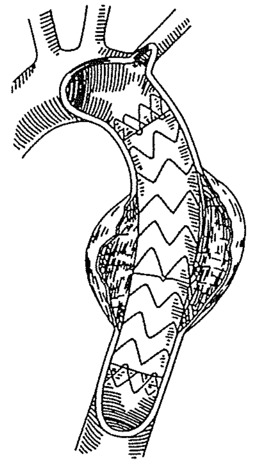

文献1より転載

図4　ステントグラフトを用いた大動脈瘤の治療
下行大動脈瘤に対するステントグラフトによる治療を示した．開胸を行わず，大腿動脈からの血管内治療で大動脈瘤を血流から隔離させる方法である

社製 Power Link®の3種類のデバイスが使用可能となりました．胸部では Gore 社製 TAG®の1種類のみです．これらに加えて現在でも胸部に対しては手作りのステントグラフトもわずかに用いられていますが，いずれすべてが企業製のものになると思われます．

ステントグラフトによる治療は多くは大腿動脈を剥離し，この大腿動脈から腹部大動脈瘤や胸部大動脈瘤の部位まで18～22Fr.のシースに内蔵されたステントグラフトを運び，大動脈瘤の前後に十分な landing zone（固定部位）を確保した上で開放し，大動脈瘤内に血流が流入しないようにする方法であり，この方法が可能な症例は landing zone が存在する限られた形態の大動脈瘤です．重要な分枝が存在する部位の大動脈瘤には困難であり，現時点では上行，弓部，胸腹部の大動脈瘤には適応困難な症例が多いです．しかし，この治療法は低侵襲，短時間で治療が可能で，デバイス進化に伴って適応症例は拡大するものと思われます．

●ナースはどうかかわる？

1．術前および経過観察時

大動脈瘤の患者さんで術前に最も注意すべきことは大動脈瘤の破裂です．手術待機で既に入院している患者さんでも，破裂で亡くなることがあります．このようなことを避けるために，重要なことは血圧の管理です．随時血圧でも140/90mmHg を超えないことを推奨します．現在では携帯型24時間自動血圧計も広く用いられるようになりましたが，自宅や外来で用い

られることが多く，病棟ではまれです．実際に血圧上昇などを伴って破裂に至ることが多いのは，激しい咳が持続するときや大便排泄時，あるいは力んで重いもの持ったときなどがあります．当然のことですが，過度の興奮状態も危険性を増します．このような状態にならないよう，大動脈瘤患者の術前では注意すべきです．

2．術後

大動脈瘤の手術後に問題となるのは，胸部では，①脳梗塞など中枢神経合併症（せん妄なども含む），②脊髄神経合併症（対麻痺や不全対麻痺），③呼吸器不全，④心不全，⑤腎不全などです．胸部大動脈瘤の患者は麻酔が持続した状態で，人工呼吸下にICUに収容されるのが一般的で，手術直後には覚醒していないため，瞳孔不同や痙攣（けいれん）などの神経学的異常がないか，また下肢の動きは見られるかなどを観察します．呼吸循環については血液ガス分析による血中酸素分圧，二酸化炭素分圧や酸塩基平衡などを確認し，血圧，脈拍，心係数などに異常がないか，尿量は適量（0.5mL/kg/hr 以上）であるかなどをチェックします．順調に回復したら，病棟では創痛，発熱，不整脈，喀痰の排出，経口摂取量と尿量などに注意を払います．腹部大動脈瘤の症例で代表的な合併症は腸閉塞，下肢動脈虚血などです．一般的には麻酔から覚醒後に病棟へ収容されるため，注意すべきことは下肢の動脈血行の状態，覚醒の程度，喀痰の排出が順調かどうかなどに気を付けます．数日経過後は経口摂取開始の時期が問題となります．排ガス，排便があれば，経口摂取開始可能です．

3分でできる★おさらいクイズ

問１●成人の大動脈瘤の原因で最も多いのは[A]である．

問２●大動脈瘤の病理組織学的分類として[B]と[C]がある．

問３●現在の大動脈瘤の診断に最も有用な検査は[D]である．

問４●現在，大動脈瘤の治療は開胸あるいは開腹による人工血管置換術と[E]による治療がある．

問５●術後の合併症として胸部では[F]や[G]などの神経学的合併症，腹部では[H]や[I]に注意を払う必要がある．

解答はp.54に☞

❸心筋梗塞の解答　A：プラーク　B：冠動脈　C：激烈な胸部痛　D：ラピチェック®　E：トロップT®　F：CK，G：カテーテル治療　H：再灌流　I：生活習慣　J：危険因子　K：薬剤の処方

引用・参考文献

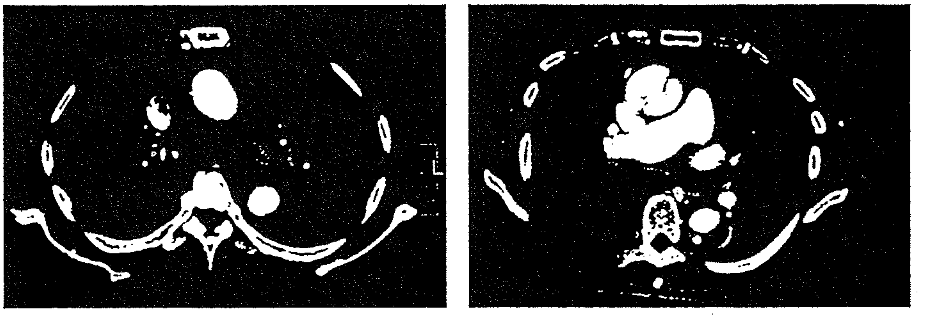
1）安達秀雄．イラストレイテッド大動脈瘤手術．東京，金原出版，1999，9・11・165．

2）安達秀雄．大動脈疾患の診断と手術．第２版．東京，メディカル･サイエンス･インターナショナル，2006，59・123．

❺ 大動脈解離

久留米大学外科　准教授
明石英俊 ▌あかし ひでとし

めでみる 大動脈解離



偽腔閉塞型と偽腔開存型の急性A型大動脈解離のCTを示した．左の偽腔閉塞型では三日月型の血栓閉塞した解離腔が認められる．右のCTでは上行大動脈が2腔に分かれ，両方が造影されている

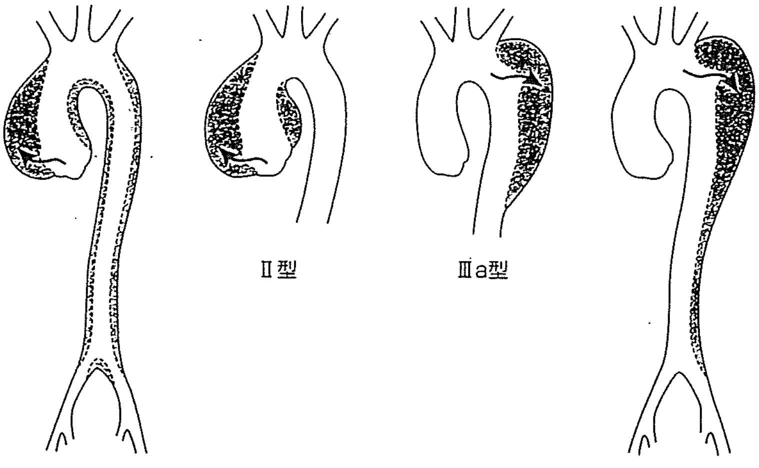
急性Ａ型大動脈解離のCT画像

●何が起こっている？

大動脈解離とは大動脈壁が動脈硬化や先天性の結合織疾患などで脆弱（ぜいじゃく）な状態のときに，血圧上昇などをきっかけとして内膜に亀裂が生じ，その亀裂が中膜の途中まで達し，その深さの部位からさらに長軸方向に裂けて，血流が流れ込み，大動脈が真腔と解離腔に分かれ，その解離が症例によっては上行大動脈から腸骨動脈まで２腔構造となるような病態です．しかし，中には解離は生じたものの，流入した血液が直ちに血栓化し，２腔構造にまで至らないものもあり，これらは血栓閉塞型（偽腔閉塞型）大動脈解離と呼ばれます．これに対して２腔構造で，真腔も解離腔も血流が存在するものを解離腔開存型（偽腔開存型）大動脈解離と称しています（「めでみる大動脈解離」）．大動脈解離の範囲は症例によってさまざまであり，解離が起こった部位と解離範囲で分類が成されています．特に，世界的に用いられているのはDeBakey（ドベーキー）分類とStanford（スタンフォード）分類です．

1．DeBakey分類（図１）

大動脈解離をⅠ型，Ⅱ型，Ⅲ型の３つの基本形に分け，さらにⅢ型はⅢａ型とⅢｂ型に分



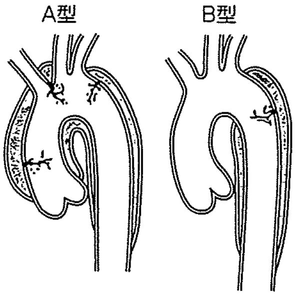
文献1より改変転載

図1　DeBakey 分類

けました．Ⅰ型はエントリー（裂け目）が上行大動脈にあり，解離病変が上行大動脈から下行大動脈にまで及ぶ例です．Ⅱ型はエントリーが上行大動脈にあり，偽腔は上行大動脈に限局しています．Ⅲ型はエントリーが下行大動脈にある例で，解離病変が胸部大動脈に限局する例はⅢａ型，そして解離病変が胸部を越えて腹部に及ぶ例はⅢｂ型としました．この分類は，エントリーの部位と解離の進展範囲を組み合わせた分類です．

2. Stanford 分類（図2)

エントリーの存在部位にこだわらず，解離病変の部位のみで大動脈解離を２つに分類しました．上行大動脈に解離病変がある例をＡ型，上行大動脈に解離病変がない例をＢ型としました．分類方法は単純ですが，上行大動脈に解離が存在するかどうかによって予後と治療法は異なり，臨床的に有用な分類法です．発症の時期により，慢性期と急性期に分類されます．



文献1より改変転載

図2　Stanford分類

急性期

解離の発症から２週間以内は種々の合併症が起こりやすく，緊急手術になることもあります．

慢性期

解離の発症から２週間以後は，比較的重大な合併症は少ないですが，年ごとに拡大傾向を呈してきます．

3．解離腔の状態による分類（p.49「めでみる大動脈解離」）

解離腔（偽腔）開存型

大動脈にエントリーを生じ，大動脈解離を来し，2腔構造となり，血流の出口となるリエントリーも形成されています．破裂の頻度が高いです．

解離腔（偽腔）閉塞型

大動脈に裂け目を生じ，大動脈解離は生じたものの，解離腔が直ちに血栓化し，閉塞した状態．比較的破裂の危険性は低いです．

●どうして起こる？

大動脈解離の原因として挙げられるものには，Marfan（マルファン）症候群のように大動脈壁構成要素の先天異常や加齢，高血圧，代謝異常あるいは外傷などがありますが，すべての原因が明らかなわけではありません．しかし，いずれにしても大動脈の内膜に亀裂が生じてその部位に血流が入り，さらに長軸方向に大動脈壁が2つの層に分かれて，解離が生じることは明らかであり，さまざまな要因による大動脈壁の脆弱性に加えて，外傷などの振動や高血圧などの内腔からの圧力が最終的な発症のきっかけとなっていることは確かです．

●どんな症状がある？

急性大動脈解離の典型的な症状は，“突然生じる激烈な胸痛および背部痛”です．症例によっては移動する疼痛を訴える患者さんも多いです．しかし，まれに疼痛を訴えない患者さんもありますが，その中には発症時に意識消失発作を来し，疼痛を自覚できなかった症例も多いようです．

疼痛以外では，前述した意識消失発作も多く見受けられます．大動脈解離では大動脈の分枝すべてに虚血を生じる可能性があり，四肢の虚血や脊髄の虚血による麻痺（まひ）が認められることもあります．さらに腹部臓器の虚血では腹痛を強く訴えるほか，冠動脈の虚血では心筋梗塞や不整脈との鑑別診断も問題となります．A型解離で誤診される可能性が高いのは，やはり脳梗塞と心筋梗塞，下肢の塞栓症です．B型解離では急性腹症や下肢の塞栓症などが考えられます．

●どうやって診断・治療する？

1．診断

大動脈解離の診断は，前述したような症状から大動脈解離を疑えば，造影によるMDCTを施行することでほぼ100％確定診断可能です（図3）．問題は大動脈解離を疑わなかった場合であり，それらの多くの症例の診断は心筋梗塞，脳梗塞，急性下肢動脈閉塞症などです．心筋梗塞の診断では胸部X線写真，心電図，心エコー検査は当然ながら施行します．これらの検査で大動脈解離の症例は胸部X線写真で縦隔陰影の辺縁不鮮明で著明な拡大，心電図では右冠動脈の虚血所見，心エコーでは上行大動脈の解離や下行大動脈の解離の所見が得られます．脳梗塞の診断では頭部のCTは当然施行しますが，その際に胸部の一部（弓部）を含んでCTを施行することで診断可能です．少なくとも頸部分枝はチェックしておく必要があります．脳虚血を来した解離では，弓部分枝に解離が進展していることが多いです．急性の下肢動脈閉塞

<急性A型> <急性B型>

図3 急性大動脈解離
Stanford分類の急性A型と急性B型の大動脈解離の造影CT像を示した．造影剤を用いれば，ほぼ100%の確率で大動脈解離の確定診断が可能である

において，最近では多くの症例でCTが最終診断検査となり，少なくとも腹部を含んでCTを施行することで大動脈解離の診断は可能となります．

以上のようなことで，最終的には診断は可能となりますが，やはり胸部痛，背部痛，意識消失発作，四肢の虚血などの症状や所見で，頭の一部に大動脈解離の診断を考えるようにしておくことが重要です．

2．治療

大動脈解離に対する基本的な治療方針は急性Stanford A型はエントリー切除を原則とする緊急手術であり，急性Stanford B型は破裂や四肢，臓器の虚血がなければ血圧コントロールを中心とした保存的治療です．

慢性期の症例では，A型は急性期と同様手術治療であり，B型は大動脈の拡大が5cmあるいは6cm以上や臓器虚血の可能性がある症例では，下行大動脈人工血管置換術などの手術治療を行います．

血栓閉塞型の急性A型解離では，まださまざまな意見がありますが，上行大動脈径が5cm以上では手術治療が推奨されています．

大動脈解離に対するステントグラフトでの治療は現時点でまだ統一した見解はみられませんが，慢性期の重要分枝がない部位での限局した解離では適応となるでしょう．広範囲解離や急性期解離では今のところ，人工血管置換による従来の手術が主流です．

大動脈解離の主たる手術は，急性A型大動脈解離に対する上行大動脈置換術か上行弓部置換手術です．これらの手術では人工心肺使用下に選択的脳灌流などの脳保護法も併用して，低体温下に上行あるいは上行弓部の人工血管置換術を行うことが通常です(図4)．日本国内では，これらの手術の成績は海外と比較しても良好です．

●ナースはどうかかわる？

大動脈解離の管理については急性期か慢性期かによって大きく異なってきます．

1．急性期症例

急性期症例はほとんどが救急車での搬入とな