In this retrospective study we reviewed our results of secondary surgery for complications after emergency placement of aortic stents for acute type B dissection. From October 2000 to June 2006, endovascular stent-grafting (ESG) was performed in 13 patients as an emergency procedure for acute type B dissection. Self-expanding nitinol stents (mean diameter 39.8 $\pm$ 4.7 mm) were placed into the descending aorta distal to the left subclavian artery. In-hospital mortality was 15.4% (2/13) and related to persistent visceral malperfusion. Three patients (23%) required consecutive open surgery of the thoracic aorta after emergency endovascular stent-grafting for acute type B dissection. Indications for surgery included acute development of retrograde type A aortic dissection and acute stent dislocation by fractured wires and secondary leakage. Elective surgery was necessary in one patient 6 months after stent-grafting for late formation of an aneurysm of the descending aorta. There were no deaths or major morbidity after surgery of the thoracic aorta early or during follow-up. Mean follow-up was 38.0 $\pm$ 13.9 months (range 1–70 months) and complete. We conclude from our study that stent-grafting of the descending aorta is a feasible, relatively safe and effective approach even in the emergency treatment of patients with complicated acute type B dissection.

It is not clear if stent-grafting of the descending aorta in the acute setting of type B dissection will increase the incidence of early and late complications that require consecutive surgery. The incidence of adverse effects of stent grafting might be higher in the acute stage of complicated type B aortic dissections because the aortic wall tends to be weaker in these patients.

It is the aim of this retrospective single-center study to outline the complications after endovascular repair and review the results of secondary surgery for complications after emergency stent-grafting for acute life-threatening type B dissection.

### 2. Patients and methods

Between October 2000 and June 2006, 13 patients (ten males, three females) with a mean age of 59.5 $\pm$ 6.3 years (range: 46–66 years) underwent emergency endovascular stent grafting for complicated acute type B aortic dissection within a mean of 14 $\pm$ 8 h of diagnosis of complications.

In these patients stent-grafting of the descending aorta has become our exclusively used form of treatment. There were no open surgical repairs during this period of time for these patients. In all cases diagnosis was made by computed tomography (CT).

Indications for acute intervention are summarized in Table 1 and include contained aortic rupture, hemotherax, life-threatening malperfusion affecting the kidneys, spinal cord or lower extremities. Two patients had refractory pain for a mean of 9.0 $\pm$ 4.2 h despite adequate control of blood pressure and in one patient a progressive expansion of the aorta was found.

One of the patients had Marfan's syndrome and a history of prior surgery of the ascending aorta and the proximal
aortic arch. Except for one patient, arterial hypertension as a cardiovascular risk factor was found in all patients (n=12/13, 92.3%).

In all patients the entry of the type B dissection was found in typical location just distal to the left subclavian artery.

3. Technique of stent-grafting

All procedures were carried out in the cardiac catheterization lab with the patients under general anesthesia. Technical details have been described previously [2]. Stent-graft diameters were chosen according to CT morphology. Self-expanding stent polyester-covered nitinol grafts ( Talent from 2000–2005: n=10, Valiant after January 2006: n=6 in three patients, Medtronic, Sunrise, FL; mean diameter 39.8±4.7 mm, covered length 121±29 mm) were placed into the descending aorta at the entry of dissection distal of the origin of the left subclavian artery (LSA), i.e. landing zone three according to the classification by Criado et al. [4]. In none of the patients was the origin of the LSA intentionally or unintentionally occluded by the covered portion of the stent-graft. The average number of stents per patient was 1.2±0.4. Three patients received two stents (mean entire length 283±45 mm) each for closure of initial type I B endoleaks. The location of the stent as well as the perfusion of the aorta and its branches (e.g. left subclavian, mesenteric, renal) were visualized by angiography (Fig. 1) at the end of the procedure in all patients. One or 2 days after ESG, before discharge and at follow-up, computed tomography was used for imaging of the aorta.

4. Results

In all patients the stent-grafts were successfully deployed in the intended position. There were no primary conversions to open surgery. In 12 out of 13 patients (92.3%) the primary entry could be occluded with the endovascular stent. Only one stent was used in the first 10 patients. In the last three patients initial type I B endoleaks were successfully treated by placement of an additional stent-graft. None of the patients had vascular problems at the arterial site of access for endovascular stent grafting. There was one minor wound infection in the groin after surgical exposure.

Complications of emergency stent-grafting and secondary surgical interventions are summarized in Table 1. Early mortality was 15.4% (2/13 patients).

In one patient visceral ischemia persisted despite the successful occlusion of the proximal entry of the dissection by stent-grafting. Surgical fenestration of the abdominal aorta was performed as rescue surgery but the patient died due to massive intraabdominal bleeding.

One patient had a complete disruption of the intimal layer distal to the stent. No flow could be demonstrated in any of the visceral arteries. Despite surgical fenestration of the abdominal aorta, the patient died of multi-organ failure.

Three patients (23%) required consecutive surgical treatment of the thoracic aorta: two complications occurred early after aortic stent-grafting, one late. Indications for secondary open surgery as an emergency procedure included the development of retrograde type A aortic dissection (n=1, 7.7%).
This patient developed left-sided hemiplegia one day after initially uncomplicated ESG. Acute retrograde type A aortic dissection with involvement of the aortic arch and occlusion of the right common carotid artery (CCA) was demonstrated in addition to severe aortic regurgitation. During the emergency operation a new entry tear (Fig. 2) was found between the brachiocephalic trunk and the left CCA [4]. The former entry site of the dissection in the proximal descending aorta was occluded by the stent. An aortic valve reconstruction (modified Yacoub procedure) was performed; the ascending aorta and proximal aortic arch were replaced. The right CCA was revascularized by direct anastomosis of the dissected layers. Postoperatively symptoms of the hemiplegia were resolving.

A second indication for open surgery early after ESG was acute stent dislocation by fractured wires resulting in a type III endoleak and an expansion of the distal descending aorta. First the descending thoracic aorta was uneventfully replaced, later the infrarenal abdominal aorta.

One patient (7.7%) needed elective aortic surgery after endoluminal therapy for acute type B aortic dissection. In this patient a minimal perfusion of the false lumen could be demonstrated at the end of ESG. The type I A endoleak did not close spontaneously and the persistent pressurization of the false lumen resulted in late formation of an aneurysm of the descending aorta (80 mm in diameter), which was replaced six months later.

Mortality of surgery of the thoracic aorta was zero. The postoperative course in these three patients after secondary surgery of the thoracic aorta for complication of ESG was uneventful.

A total of three patients (23.1%) had neurological complications peri-interventional. In one patient, as discussed earlier, left-sided hemiplegia was caused by occlusion of the carotid artery secondary to retrograde type A aortic dissection after stent-grafting. The neurological symptoms resolved completely after surgical revascularization as described earlier.

Two patients became symptomatic with signs of right-sided hemiplegia after ESG. CT scans showed ischemia in the area of the left middle cerebral artery (MCA). The etiology of these lesions remains unclear. In none of these patients did the dissection involve the aortic arch before or after stent-grafting of the descending aorta.

In the other patients no neurological dysfunction was found peri-interventional or during follow-up. Paraplegia was not observed.

Mean follow-up was 38.0±13.9 months (range 1–70 months) and complete. None of the patients died during the follow-up period.

5. Discussion

Endovascular stent-grafting, like any kind of treatment, has its potential side effects. Embolization of particles from atherosclerotic aortas and/or malperfusion of the spinal cord after ESG can result in neurological complica-
tions. Additional risks of the endoluminal approach include a secondary intimal tear due to the stent wires, stent dislocation, endoleaks, branch occlusion, vascular problems at the arterial site of access and rupture of the aorta.

Many of these complications of ESG require secondary surgical interventions.

There is little information if aortic stent-grafting in the acute setting of type B aortic dissection will increase the incidence of early or late complications that require consecutive surgery. In this institutional report we reviewed our results of secondary surgery for complications after emergency placement of aortic stents for acute type B dissection.

In a relevant number of patients, emergency stent-grafting for acute type B aortic dissection resulted in complications that required secondary surgical treatment.

Two patients underwent unsuccessful emergency surgery of the abdominal aorta after development of complications of stent-grafting for acute type B aortic dissection. In one patient the disruption of the aortic intimal layer at the distal end of the stent-graft resulted in a complete visceral ischemia. The distal bare springs were probably responsible for the damage of the intima. This complication in our early experience of ESG is less likely to occur nowadays since stent-grafts without distal bare springs are available.

Another patient died after surgical fenestration of the abdominal aorta for persistent visceral malperfusion. Today we would try to manage this complication by application of additional endovascular stents or interventional fenestration.

Visceral malperfusion remains a major challenge and has an important impact on outcome. Early recognition is crucial since delayed treatment has an extremely high mortality.

In-hospital mortality was 15.4% (2/13) in our series. This is comparable with the 16% early mortality in 19 acute symptomatic dissections reported by Dake and associates [1]. It is also in line with the 20% mortality reported recently by Kaya and associates [5].

Three patients required surgery of the thoracic aorta after emergency stent-grafting for acute type B aortic dissection.

One of the adverse effects of endovascular stent-grafting is the creation of a secondary intimal tear by bare springs at the proximal end of the stent. This is the most likely explanation for development of retrograde type A aortic dissection in one of our patients after ESG for acute type B aortic dissection. Other groups also reported this complication [6]. In our experience the retrograde dissection of the aortic arch and the ascending aorta developed 12 h after ESG for acute type B dissection. Other authors also reported delayed development of retrograde type A aortic dissection up to several months after ESG [7]. The relatively strong radial forces by the proximal bare springs of the early generation of stent-grafts might be responsible for this complication.

Fracture of stent wires leading to dislocation of the stent and secondary leakage is another device-related complication that should decrease with recent refinements in stent design.

Stent-grafts were placed for complicated acute type B aortic dissection in one patient with Marfan’s syndrome. Stent placement was without adverse events. It is known that in these patients often surgical replacement of dilated parts of the aorta is necessary in the mid- or long-term [8]. However, emergency stent-grafting of the descending aorta in Marfan patients can serve as a bridge to elective surgery with better results compared to open emergency repair of the thoracic aorta.

6. Summary

Our study indicates that stent-grafting of the descending aorta is a feasible, relatively safe and effective approach even in the emergency treatment of patients with complicated acute type B dissection. Nevertheless, in a relevant number of patients emergency stent-grafting for acute type B aortic dissection results in complications that require secondary surgical treatment.

References


Conference discussion

Dr. V. Karri (Hyderabad, India): How do you make sure when the procedure is done whether you are in the false lumen or the true lumen?

Dr. Duebener: The so-called kissing technique was used with one catheter in the femoral artery and another in the brachial artery. When these catheters were meeting it was believed that they are in the true lumen, and fortunately there were no problems entering the false lumen so far.

Dr. M. Irarrazaval (Santiago, Chile): How do you size your graft here, because you want to anchor it safely but at the same time you don’t want to overstent the pathologic aorta.

Dr. Duebener: That is a very important and difficult topic, especially in aortic dissection because the membranes are so fragile, so that a significant oversizing of the stent-grafts can lead to a high incidence of retrograde
dissection. We did oversizing of about 10% and then a gentle ballooning of the proximal end. I guess if you oversize more, the complication rate might increase.

Dr. Irarrazaval: And in your follow-up you did not see any dilatation of the stented area or the anchoring site?

Dr. Duebener: Not so far, but the follow-up is limited.

Dr. G. Ziemer (Tuebingen, Germany): Emergency stenting of acute type B dissections in rupture is a life-saving procedure. We know the poor results of surgery. My question is that recently we had to reoperate one of our emergency stent cases for acute type B dissection. Intraoperatively I could see the free-standing endovascular prosthesis, and I saw blood pouring out of many stitches where the stent was mounted to the tissue. Did you ever have a chance to look at these free-standing grafts when they were perfused under pressure. I, however, was very surprised. We operated because the aneurysm had gone up to 12 or 14 cm, so after four or five months we reoperated on the patient. But to me it is questionable whether these little leaks could still maintain the growth of the aneurysm, which obviously has then to be operated. The distal graft could be easily pulled out of the aorta without any adherence.

Dr. Duebener: Unfortunately I was not participating in any of these rescue operations, so I don’t have personal experience, but from what I read in the OR reports there were no major endoleaks through the prosthesis. The reasons for reoperations were that the entry site of the dissection was not completely occluded or there was a stent dislocation. There were stent-related complications, but the polyester material of the covered part of the stent seems not to be a problem.

Dr. Ziemer: I cannot claim that this was the reason but it was striking to me that there was suddenly this sprinkler-like pouring out of the blood. It may be rare, however, to have a look at the pressurized endovascular graft after removal of the aneurysm as had in just one case.

Dr. P. Ghosn (Montreal, Canada): I have two questions. The first one is, with your stent grafts you were able to restore blood flow without adding any operation to the visceral artery and to the renal artery? And the second one is, did you have any case where both iliac arteries were perfused by the false lumen of the dissection? Because I had recently a case where both iliac arteries were perfused by the false lumen, and if this is the case, what would you do?

Dr. Duebener: To answer your first question, in the majority of patients we saw that the visceral ischemia improved, but I mentioned this one patient who had persistent visceral ischemia, but this also can occur after open repair, because the dissection membranes have a very complex form and there can be local flaps occluding the mesenteric arteries. So even with open repair you can have persistent visceral ischemia. In one patient this happened, and actually our colleagues from general surgery tried to rescue this patient, but it was unsuccessful.

Dr. Ghosn: And the second question for the iliac arteries?

Dr. Duebener: Fortunately so far it did not happen. More commonly we use the femoral arteries. We only use the iliac arteries if femoral access was impossible, and so far we did not enter the false lumen.

Dr. Grabenwoger: I have one recommendation. In this case you can go antegrade via the aortic arch.