Chapter

18 Surgical Treatment of Chronic Descending Aortic Dissection

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18.1 Introduction

The definition of descending aortic dissection is clear, indicating a dissected descending thoracic or thoracoabdominal aorta following an acute onset of an intimal tear. More debatable is the term "chronic," which in general is used if the dissection is older than 2 weeks. It seems more appropriate to apply the term "early chronic-phase," for the first 2–4 weeks following the acute phase of 2 weeks, on the basis of the instability of the patient and the friable quality of the aorta in these weeks. In this chapter only the chronic phase is addressed, indicating more than 6 weeks after the dissection. Descending aortic dissection can be limited to the descending thoracic aorta but most often extends to the abdominal aorta and even the iliac and femoral arteries. Currently available techniques for open surgery and adjunctive protective measures will be described.

18.2 Indications for Surgery

In patients with uncomplicated chronic type B dissection there is no need for surgical intervention and adequate blood pressure management and regular anatomic assessment by means of computed tomography or magnetic resonance are performed. "Uncomplicated" basically means that the aorta is not dilated or growing in time. It rarely occurs that in chronic, not dilated dissected aortas, the patient develops acute ischemic events like intestinal ischemia, renal failure or paraplegia.

The main concern in chronic type B dissection is aortic dilatation, which will ultimately determine the indication for surgery. The initial aortic diameter at the time of the dissection and the fate of the false lumen have an important influence on the development of aneurysm formation. It has been shown that the predominant predictors for aortic enlargement in the chronic phase are the existence of a maximum aortic diameter of or greater than 40 mm during the acute phase and a patent primary entry site in the thoracic aorta [1]. Others [2] also showed that a patent false lumen and an initial diameter of 40 mm or more were independent predictors for chronic phase enlargement (larger than 60 mm) and aortic rupture.

Table 18.1 summarizes the different morphologic features at the time of the acute intimal tear. The nondilated aorta with a thrombosed false lumen will have the best prognosis, whereas the dilated aorta with a patent false lumen will likely develop an aneurysm. It is obvious that dissected aortic aneurysms carry a higher risk compared with aortic dissections.

In summary, the indication for surgical repair of chronic descending aortic dissection depends on the diameter of the aorta. Subsequently, from a surgical point of view, the dissected aorta becomes a thoracic aortic aneurysm (TAA) or a thoracoabdominal aortic

Table 18.1. Possible morphologic features of the aorta at the time of acute type B aortic dissection

Aortic dissection	Fate of lumen	Remarks
Nondilated aorta	Open true and false lumens	Most common
Nondilated aorta	Thrombosed false lumen	Best prognosis
Nondilated aorta	Thrombosed true lumen	Uncommon
Dissected aortic aneurysm	**Fate of lumen**	**Remarks**
Dilated aorta	Open true and false lumens	Most common
Dilated aorta	Thrombosed false lumen	Best prognosis
Dilated aorta	Thrombosed true lumen	Uncommon

aneurysm (TAAA). In fact, 25% of descending and TAAAs are postdissection dilatations [3].

Prosthetic replacement of a TAA or a TAAA is indicated if the diameter exceeds 6 cm. In Marfan patients the threshold is accepted at 5 cm. Additional indications for surgery comprise aorta-related symptoms like back pain and rapid, progressive aortic dilatation.

18.3 Surgical Techniques

18.3.1 Access

Surgical access is dependent on the extent of the aortic replacement. Figure 18.1 schematically depicts the different TAAs and TAAAs. Table 18.2 summarizes the surgical access for the corresponding aneurysms. Figure 18.2 depicts a giant post-type B dissection thoracic aneurysm. Figure 18.3 shows a perforation of the aortic wall and only thrombus in the false lumen prevented free rupture. Figure 18.4 illustrates the implanted polyester graft.

It is obvious that the majority of type B, C and D descending thoracic aneurysms can be treated by endovascular techniques; these modalities are described elsewhere in this book. Descending thoracic aneurysms with distal arch involvement can be treated by hybrid techniques in which an endograft covers the supraaortic arteries following bypass reconstruction of these arteries.

Table 18.2. Surgical access for the corresponding aneurysms

Extent of aneurysm	Access
Descending thoracic aorta, proximal part ± distal aortic arch (Fig. 18.1 a, b)	Left thoracotomy, fourth intercostal space
Descending thoracic aorta, mid + distal parts (Fig. 18.1 c)	Fifth intercostal space
Descending thoracic aorta, entire (Fig. 18.1 d)	Fifth intercostal space
Thoracoabdominal types I, II, III according to Crawford	Thoracolaparotomy, sixth intercostal space
Thoracoabdominal type IV	Laparotomy/left anterior thoracotomy, eighth intercostal space

18.3.2 Thoracic Approach

In open repair, type A and B descending thoracic aneurysms require a surgical approach via the fourth intercostal space. If, however, the aneurysm extends to the diaphragm, the fifth intercostal space will provide adequate exposure. In some cases it is necessary to resect the rib in order to extend the surgical working field.

The left lung is intubated with a selective bronchus blocker or double lumen tube, allowing collapse of the lung. In a substantial number of cases, the left lung is adherent to the aneurysm as a result of local fibrous reaction following dissection and dilatation. It is recommended to limit the surgical dissection of the lung as much as possible and only prepare the cross-clamp positions and the area of aortotomy.

Since the intimal tear is located at the level of the left subclavian artery in the majority of patients it is necessary to prepare a cross-clamp position proximal to the left subclavian artery. Indeed, it might be possible to clamp the aorta just distal to the subclavian artery, but often this approach does not provide enough "normal," nondissected aortic tissue to perform a secure anastomosis. During dissection of the aortic arch and left subclavian and carotid arteries, careful attention is paid to the vagus and recurrent nerve. The nerve can be dissected free from the aortic wall and secured with a vessel loop. In all cases we prefer to transect the Botalli duct, allowing more access for the proximal clamp. Safe clamping between the left carotid and the subclavian arteries requires circular dissection of the transverse aortic arch. Opening of the pericardium, posterior to the phrenic nerve, not only provides access to the left atrium or pulmonary vein, but also allows easier dissection at the inner curve of the aortic arch. After the inner and outer curves have been dissected, the final clamp position between the carotid and subclavian arteries can be prepared by two fingers encircling the aortic arch. During preparation of the distal clamp posi-

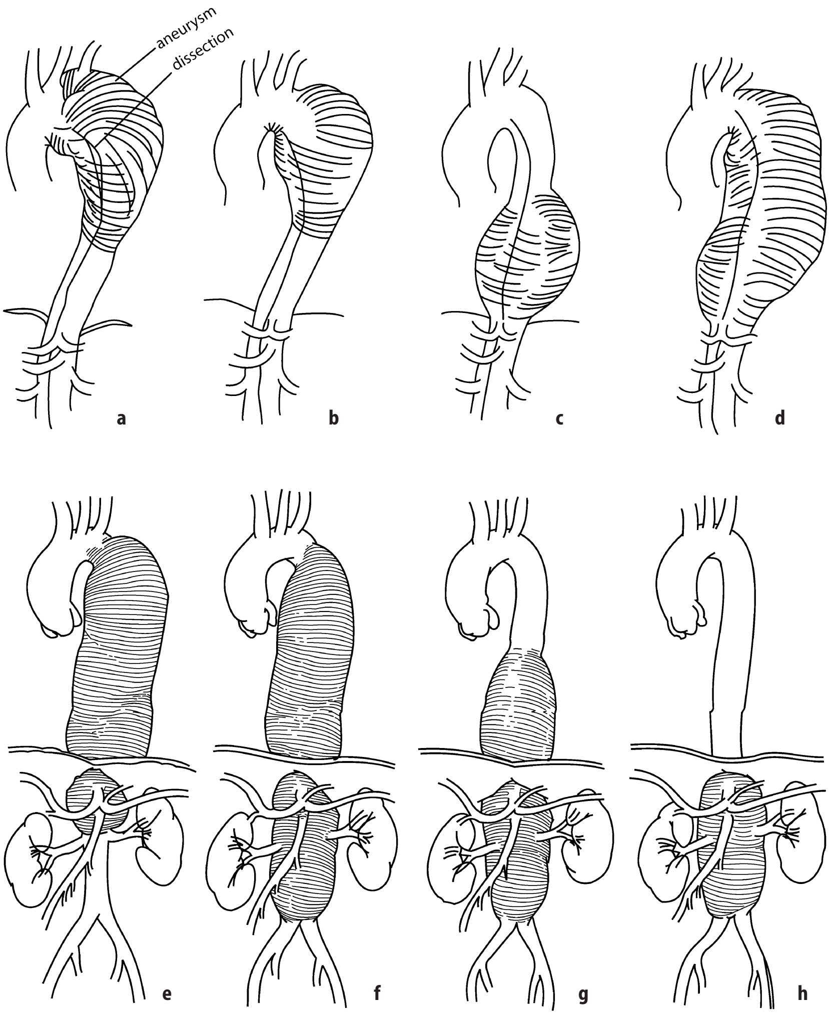

Fig. 18.1. Extent of descending thoracic aortic aneurysms (**a–d**) and thoracoabdominal aortic aneurysms (*TAAA*) (**e–h**) according to Crawford. **a** Distal arch and proximal descending thoracic aneurysm. **b** Proximal descending thoracic aneurysm. **c** Distal descending thoracic aneurysm. **d** Descending thoracic aneurysm involving the entire descending thoracic aorta. **e** TAAA from the left subclavian artery to the visceral arteries. **f** TAAA from the left subclavian artery to below the renal arteries. **g** TAAA from Th6 to below the renal arteries. **h** TAAA from the diaphragm to below the renal arteries

tion, the esophagus has to be identified and freed from the aorta. In some cases the esophagus might be adjacent to the aneurysm wall and accidental lesions caused by the clamp or anastomosis can lead to leakage in the early postoperative period or aorto-esophageal fistula in the late phase.

If the repair is performed under left heart bypass, the left atrium or pulmonary vein is used for venous cannulation. We prefer the use of the left upper or common pulmonary vein: following a double perstring with Prolene with pladgets the hooked cannula can be easily introduced. Only limited heparinization is required (0.5 mg/kg).

Fig. 18.2. Left thoracotomy via the fifth intercostal space and giant descending thoracic aortic aneurysm

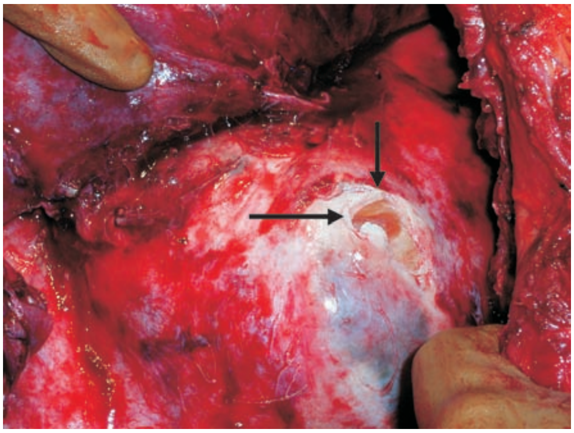

Fig. 18.3. The same aneurysm with focus on lateral aortic wall perforation. Thrombus mass in the false lumen prevents free rupture (*arrows*)

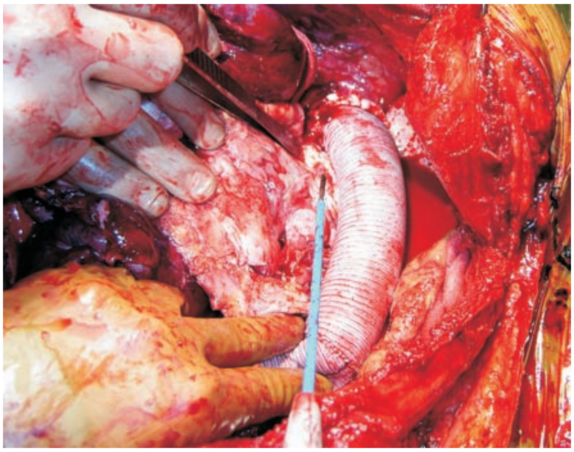

Fig. 18.4. Aortic aneurysm replacement in the same patient. Tip of electrocautery and end of forceps show the very small true lumen, whereas the rest of the giant aneurysm was dilated false lumen

18.3.3 Thoracoabdominal Approach

In type I, II and III TAAAs (according to Crawford), a left thoracolaparotomy is performed via the sixth intercostal space. The dissection of the thoracic part was described before; the abdominal part can be approached transperitoneally or retroperitoneally. We only transect the diaphragm at the anterior side (5–7 cm) and open the pillars of the crus to encircle the muscle with a loop, allowing traction and movement of the muscle. Dissection is continued laterally of the descending colon, behind the left kidney and the spleen. The left ureter has to be identified and secured with a vessel loop. The abdominal aorta is exposed following mobilization of the spleen, left kidney and colon. The soft tissue surrounding the aorta easily bleeds and adequate hemostasis is required. The large crossing veins to the hemiazygos system have to be oversewn and transected prior to aortotomy. The origin of the left renal artery is identified and the artery is secured with a vessel loop. If the aneurysm extends into the iliac arteries the surgical access has to be enlarged accordingly.

18.3.4 Abdominal Approach

Dilatation of a dissected aorta can occur in the thoracic, thoracoabdominal or abdominal aorta. If the dissected descending thoracic aorta is not or mildly dilated but the abdominal part is enlarged (more than 5–6 cm), surgical repair is limited to the abdominal aorta and the procedure is equivalent to a type IV TAAA.

Laparotomy with left subcostal extension usually provides adequate approach as described before. However, in some patients the angle at the supraceliac aorta is too narrow to perform safe dissection and repair. In these cases it is recommended to perform a limited anterior thoracotomy through the eighth or ninth intercostal space. This approach not only widens the angle but also allows clamping of the distal descending thoracic aorta.

18.4 Adjunctive Procedures

Operations on the descending and thoracoabdominal aorta have been notorious for their detrimental effects on organs supplied from these portions. Paraplegia, renal failure and visceral infarction are most feared complications of extensive aortic repair. Because of the fragile aortic quality and limited collateral networks, these complications occur even more frequently in dissected aneurysms or aneurysmatic dissections compared with degenerative aneurysmatic disease.

Spinal cord protection can be achieved by means of retrograde aortic perfusion or profound hypothermia and circulatory arrest. The latter, however, requires full heparinization with the inherent bleeding complications. We prefer left heart bypass with cannulation of the left atrium or pulmonary vein, only requiring limited heparinization. Cerebrospinal fluid drainage has extensively been evaluated and recently proven to be an important asset in the prevention of paraplegia [4].

Our surgical protocol of chronic aortic dissection with aneurysm formation is similar to our strategies in TAA and TAAA repair. Besides cerebrospinal fluid drainage (72 h) we use the technique of motor-evoked potentials. This is an accurate method for detecting cord ischemia, guiding surgical tactics to reduce neurologic deficit [5]. Unlike atherosclerotic aneurysmatic thoracoabdominal aortas, dissected aortas contain many patent intercostal and lumbar arteries. Monitoring motor-evoked potentials helps to identify those arteries which are crucial for spinal cord integrity, requiring reattachment in the aortic graft or selective grafting with small-diameter prostheses.

In descending TAA repair, distal aortic perfusion provides blood flow to the visceral organs, kidneys, lumbar arteries, pelvis and extremities. In thoracoabdominal repair, the celiac axis, superior mesenteric artery and both renal arteries are perfused by means of selective catheters which are part of the left heart bypass tubing system [6]. In patients with postdissection aneurysm, this technique allows continuous organ perfusion, offering the surgeon the opportunity to perform an optimal vascular reconstruction of the visceral and renal arteries. These arteries are always involved in the dissecting process and originate from the true or the false lumen. Dissection might even extend into the visceral and/or renal arteries. Adequate surgical repair, often including selective bypass grafts, is time-consuming. In addition, the quality of the aortic wall can require reinforcement by means of Teflon strips, adding even more time to the reconstruction. Selective organ perfusion allows these time-consuming procedures. The selective perfusion catheters contain a small-diameter channel, allowing pressure measurements. In addition, volume flow in each catheter is assessed.

In patients in whom the distal aortic arch is involved or proximal clamping is not safe, we use the selective perfusion catheters for antegrade cerebral perfusion [7]. Obviously, left heart bypass is not chosen and total extracorporeal circulation is installed. Several cannulation techniques can be applied, including femoral–femoral connection or left femoral artery and pulmonary artery. The patient is cooled to 28–30°C, the descending aorta cross-clamped, the aortic arch opened and perfusion catheters introduced in the left carotid and innominate arteries. The heart is either fibrillating with a left vent or cardioplegia is provided via a large, inflated Foley catheter in the ascending aorta. Transcranial Doppler encephalography and electroencephalography are used to assess the adequacy of antegrade perfusion. Then, the proximal anastomosis is performed and the patient rewarmed to regain normal heart activity.

18.5 General Considerations: Pitfalls During Surgery

Surgery for postdissection aneurysms differs from surgery for degenerative aneurysms. In general, blood loss in postdissection aneurysms is more profound because the majority of side branches are patent. As an example, in postdissection thoracic aneurysms, the majority of intercostal arteries are open, whereas in degenerative aneurysms the majority are occluded by plaques or thrombus [8]. A certain number of 3-French occlusion balloons should be on the sterile table to block the back-bleeding arteries. Also, a dissected aneurysm or an aneurysm of a dissected aorta is not always sufficiently cross-clamped: because of the fibrous septum and the discrepancy between tissue strength of the false and true lumens, the aortic clamp might clamp the false lumen completely and the true lumen incompletely. Therefore, it is necessary to have the aorta completely free (not necessary in a nondissected aorta), especially at the medial-posterior wall. Sometimes it is required to apply a second clamp.

In general, the diameter of the true channel is smaller than that of the false lumen. In some cases it can even be less than 5 or 10% of the total diameter. Since the true lumen is most often located at the right (medial) side, there is a potential risk that the true lumen is not identified and that repair is inadequate. Therefore, it is imperative to transect the aorta completely and open the true lumen longitudinally followed by excision of the septum. The dissected membrane is completely resected, leaving a longitudinal rim at the nondissected edges.

18.6 Additional Surgical Techniques

In addition to the techniques described in the previous sections and protective measures, some other important recommendations and variants have to be mentioned.

18.6.1 Descending Thoracic Postdissection Aortic Aneurysms

Following access and starting left heart bypass, it is technically easier to perform the distal anastomosis first. The cross-clamp has to be at least 5 cm distal to the planned area of anastomosis, because resection of the dissected membrane has to be performed, allowing distal blood flow through the true and false lumens. The quality of the aortic wall in the false lumen often requires reinforcement by means of a circumferential Teflon strip at the outer layer of the aorta. In some cases it is even necessary to apply a Teflon strip at the inner and outer layers, creating a sort of sandwiched anastomosis.

Reattachment of intercostal arteries is a challenge because in dissected, nonatherosclerotic aortas the majority are patent. Fortunately, the important intercostal arteries most often arise from the true lumen, allowing adequate anastomoses. In general, it is recommended to reattach all intercostals arteries between T8 and T12. In our experience, we rely on the information provided by motor evoked potential monitoring. In some cases it might be necessary to revascularize intercostal arteries with a separate graft, especially if the poor quality of the aorta does not allow a safe button reimplantation.

The proximal anastomosis might be hazardous, specifically if the intimal tear is located at the level of the left subclavian artery. Furthermore, in most instances this proximal part of the dissection is calcified, making a safe anastomosis even more difficult. In case of doubt we always prepare a more proximal clamp position, as described before.

18.6.2 Thoracoabdominal Aneurysms

In the majority of cases the dissection extends into the abdominal aorta and even the iliac and femoral arteries. Entries and reentries guarantee sufficient antegrade blood flow to all organs. Reversing the direction of blood flow by means of left heart bypass might cause different flow patterns and the surgeon cannot be sure about safe perfusion.

In patients with iliac dissection involvement and in whom the entire thoracoabdominal aorta has to be replaced, we prefer to reverse the direction of repair. Following exposure of the thoracoabdominal aorta, an infrarenal clamp position, if possible, is prepared. Heparin (0.5 mg/kg) is administered and the iliac arteries and infrarenal aorta are clamped. A bifurcated prosthetic graft is implanted and the body of the graft is clamped. A hooked aortic cannula is inserted in the prosthetic graft and fixated with perstrings. After cannulation of the left pulmonary vein the left heart bypass is started. The left renal artery is disconnected from the aorta and a selective perfusion catheter inserted through a 6- or 8-mm polyester graft. The end-to-end anastomosis is performed while continuous perfusion is provided. Then, the supraceliac aorta is clamped and the selective perfusion catheters positioned in the celiac axis, superior mesenteric artery and right renal artery. In general, these arteries are reattached in one aortic button. Depending on the size of the aneurysm and the possibility to cross-clamp the aorta sequentially, the descending thoracic aorta is replaced in steps. Motor-evoked potentials determine which intercostal arteries are reattached. The last step is the proximal anastomosis, according to the techniques described before.

18.7 Complications

18.7.1 Stroke

Patients with aortic dissection have a higher incidence of generalized atherosclerotic disease. Furthermore, calcification and thrombus formation at the area of the intimal tear comprise potential risks during cross-clamping, initiating turbulence and dislodging debris. No exact data on stroke rate following thoracic aortic repair are available. However, it is obvious that proximal clamping at the level of the subclavian artery or between the left carotid and subclavian arteries is prone for embolization of dislodged debris.

18.7.2 Paraplegia

Postoperative paraplegia is a dreadful event following thoracic and thoracoabdominal aortic surgery. Unlike degenerative aneurysms, in postdissection aneurysms the majority of intercostal and lumbar arteries are patent; therefore, the risk of paraplegia mainly depends on the extent of the diseased aortic segment and the adequacy of restoring blood supply to the spinal cord. In our experience of TAAA repair, approximately 25% of patients suffered from a type B dissection. Paraplegia rate is very low [8] and no differences between atherosclerotic and postdissection aneurysms existed.

If the surgical repair is limited to the descending thoracic aorta, neurologic deficit is less than 1% [9]. Obviously these excellent results are achieved by means of protective measures like left heart bypass, spinal fluid drainage and reattachment of intercostal arteries.

18.7.3 Renal Failure

The incidence of renal failure has extensively been reported in patients undergoing TAAA repair but to a much lesser extent after TAA exclusion. In patients with an initial type B dissection, one or both kidneys might have suffered from temporary or chronic renal ischemia with subsequent renal insufficiency. Furthermore, the majority of these patients suffer from severe hypertension and related renal complications.

Taking these considerations into account it is extremely important to provide adequate perfusion pressures to the kidney. If the thoracic aorta is replaced only, this can be achieved by means of left heart bypass. In TAAA surgery, pressure-guided selective perfusion can prevent renal failure in the majority of cases [6].

On the basis of the experience published in the literature, the surgical scenario mainly depends on the preoperative function of the kidneys. Furthermore, ischemic clamp times should not exceed 30 min. In patients with a normal kidney function undergoing an uncomplicated aneurysm resection, the clamp-and-sew technique without adjunctive procedures will lead to an uneventful outcome. In patients with preoperative renal insufficiency (creatinine greater than 200 μmol/l), the clamp-and-sew technique, irrespective of clamp time, will lead to temporary or permanent renal failure. In general, renal failure following extensive TAAA repair occurs in 10–18% of cases.

18.7.4 Visceral Ischemia

The incidence of gastrointestinal, biliary and hepatopancreatic ischemia following extensive TAAA repair is limited [10], but probably underestimated. Selective perfusion of the celiac axis and superior mesenteric artery has definitely improved the results; however, the immune responses of the visceral ischemia–reperfusion injury and the subsequent impact on multiple organ failure are unclear.

In thoracic aortic repair, visceral ischemia is hardly reported and therefore seems to be an irrelevant clinical problem.

18.7.5 Pulmonary Complications

Respiratory failure is the commonest complication after TAA and TAAA repair. The incidence of pulmonary complications depends on many pre-, intra- and postoperative variables. In a prospective study, Svensson et al. [11] evaluated 1,414 patients. Independent predictors for respiratory failure, defined as ventilatory support exceeding 48 h, were chronic pulmonary disease, history of smoking, and cardiac and renal complications. Pulmonary complications requiring respiratory support with tracheostomy were observed in 112 patients (8%) and 40% of these patients died. Money et al. [12] encountered 21% respiratory failure following thoracic aortic repair with a mortality rate of 42%. In patients who did not develop respiratory failure, the mortality rate was 6%. They identified age, type of aneurysm, excessive intraoperative blood transfusions, elevated creatinine and postoperative pneumonia as independent variables affecting respiratory failure. The mean number of days of intubation was 5.8. It should be emphasized that the studies of Svensson et al. and Money et al. mainly comprised patients with TAAAs. Few studies focus on respiratory failure following thoracic aneurysm repair, but it is evident that pulmonary complications occur less frequently than after thoracoabdominal aortic surgery. The main reason for this difference is transection of the diaphragm. Leaving the diaphragm intact significantly improves respiratory outcome, especially in type II aneurysms. In our own experience we reduced the incidence of respiratory failure from 61 to 45% by only transecting the first 5 cm of the diaphragm instead of complete transection, in patients with type II aneurysms.

The left lung should be handled with utmost care. Direct surgical trauma causing air leaks, subcutaneous emphysema, atelectasis or bleeding will provoke respiratory failure. For several years now we have left the left lung ventilated as much as possible, even during the thoracic part of the procedure. We feel that a continuously ventilated lung improves clinical outcome; however, not collapsing the lung increases the risk of damage (air leak, bleeding) by pushing or retracting.

18.8 Conclusion

The surgical management of chronic descending aortic dissection is actually similar to the treatment of descending and TAAAs. Stable, uncomplicated descending aortic and thoracoabdominal aortic dissections do not require surgical repair. The indication for surgical intervention is aneurysm formation, following the same criteria as in degenerative or Marfan-related TAAs and TAAAs.

Adjunctive protective measures and strategies are crucial in decreasing peri- and postoperative complications.

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