

Problems Encountered During and After Stent-Graft Treatment of Aortic Dissection

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21.1 Introduction

Aortic dissection is one of the life-threatening diseases involving the aorta whether it is acute or chronic [7, 23]. The conventional treatment strategy depends on the extension of the dissecting process: surgical repair of the aortic replacement with prosthetic graft when it involves the ascending aorta (Stanford type A), and medical treatment when it involves the descending thoracic aorta (DTA) (Stanford type B). However, more than 20% of patients with Stanford type B aortic dissection need surgical intervention for the various indications: an expanding false lumen of dissection, branch vessel and leg ischemia, recurrent pain, or impending rupture [8, 31]. Because of high surgical morbidity and

a mortality rate around 20–60% [9, 34], endovascular stent-graft placement has emerged as a new treatment modality as a substitute for open surgery in aortic dissection with a descending aortic intimal tear and many authors have reported their encouraging results of more than 60% of complete thrombosis or resolution rate [1, 3, 5, 21, 37].

However, because of the very limited number of patient populations and the duration of follow-up, many questions are still controversial. Especially, only a few reports have concerned the various problems which can be encountered in stent-graft treatment of the aortic dissection [15, 16]. In this article, we present our experiences and review other authors' reports about these problems encountered during the procedure of stent-graft placement and the follow-up period in patients with aortic dissections.

21.2 Materials and Methods

21.2.1 Patients

Between July 1994 and December 2003, 60 patients with aortic dissections who underwent stent-graft placement in the DTA were included in this study. The protocol was approved by the Institutional Review Board, and informed consent was obtained from all patients. The 39 men and 21 women ranged in age from 37 to 88 years (mean 59 years). The inclusion criteria for the stent-graft were type A with retrograde dissection and an intimal tear located in the DTA, type B dissection with dynamic obstruction of abdominal aortic branch vessels, persistent or recurrent pain, aortic rupture, and an aortic diameter greater than 40 mm in the acute phase of dissection or greater than 60 mm in the chronic phase [22]. Five of nine patients with type A dissections had retrograde dissection with a primary entry tear located distal to the left subclavian artery (SCA). Therefore, a stent-graft was available for the treatment of this rare type of dissection. The other four

patients, including two with Marfan syndrome, with type A dissection had previously undergone surgical replacement of the ascending thoracic aorta and the aortic arch, leaving a large reentry tear in the DTA. Ten patients presented acute (less than 2 weeks) symptoms; 50 patients had chronic (2 weeks or more) symptoms [24]. The location of the primary entry tears were at the proximal DTA in 38 patients and at the mid to distal DTA in 22 patients. All aortic dissections simultaneously involved the abdominal aorta below the level of the diaphragm, with contiguous extension. The distal extents of the dissections were variable from the supraceliac abdominal aorta to both iliac arteries. All patients showed patent false lumen flows from the proximal primary entry tear to the distal several reentries in the abdominal aorta or the iliac artery.

21.2.2 Imaging

Before the procedures, all patients underwent contrast-enhanced spiral computed tomography (CT) scans and digital subtraction aortograms in order to measure the dimension of the aorta and to evaluate entry and reentry tears. Conventional spiral CT scans of the aorta were evaluated using the following parameters: collimation of 7 mm with a table feed of 7 mm/s, 2-mm reconstruction, 120 kV, and 220 mA s. The patients received 120–150 ml of contrast medium at a rate of 3.0 ml/s. Recently, we used a 16-channel multidetector row CT scan (Somatom Sensation 16, Siemens, Forchheim, Germany) with the following parameter: table feed of 15 mm, gantry rotation time of 0.5 s, tube voltage of 120 kV, amperage of 150 mA m, 2-mm reconstruction. Between 10 and 15 s after the end of the arterial phase acquisition, a second acquisition was performed. The aortography was performed with the use of a calibrated marker catheter (Cordis, Roden, The Netherlands). We injected 25–30 ml of contrast medium at a rate of 15 ml/s and obtained six to ten images per second for the thoracic aorta and two to six images per second for the abdominal aorta. Angiographies of the femoral, external iliac, and common iliac arteries allowed accurate sizing of these arteries and evaluation of tortuosity for the adequate vascular access.

21.2.3 Stent-Graft

We used two different kinds of stent-graft. Until the end of 1999, we implanted a homemade Z-shaped stent covered with balloon-dilated poly(tetrafluoroethylene) (Impra, Tempe, AZ, USA) material in 20 patients. Since then, we have implanted our self-designed percutaneous separated stent-graft that can be deployed percutaneously through a 12-French low-profile introducer. The

new device consists of two separate bodies: the main body with two anchoring stents at both ends connected by a Dacron graft and the second body of an inner nitinol bare stent. This unique structure enables percutaneous deployment and less resistance against blood flow during deployment, so we could implant the stent-graft without any blood pressure, lowering medication [14]. Each stent-graft was individually constructed and manufactured to be 10–15% larger than the diameter of the unaffected aorta proximal to the entry tear of dissection. The mean diameter and the mean length of the stent-graft were 33 ± 4 mm (24–40 mm) and 9.6 ± 2.0 cm (6.0–15.0 cm).

21.2.4 Procedures

The method of Z-shaped stent-graft placement was almost the same as those described in a previous report [20]. All procedures were performed in angiography units under local or epidural anesthesia and full hemodynamic monitoring while placing the patients in the supine position. Vascular access was obtained through the femoral artery following surgical cut-down. After inserting an exchange (260-cm) 0.035-in.-diameter Amplatz superstiff guidewire (Boston Scientific, Watertown, MA, USA), we advanced the 20- or 22-French stent-graft delivery sheath (Keller-Timmerman Sheath, Cook, Bloomington, IN, USA) over the guidewire. The patient was anticoagulated with intravenous heparin (5,000 IU) before the insertion of the stent-graft delivery sheath. After that, we deployed the stent-graft by rapidly withdrawing the introducer sheath. Aortography via a contralateral percutaneous femoral artery approach with a 5-French multisidehole catheter (Cook, Bloomington, IN, USA) was performed before and after the stent-graft deployment in order to confirm the exact location of the stent-graft, the absence of perigraft leakage, and the patency of adjacent branch vessels.

Deployment of the percutaneous separated stent-graft needs slightly different steps from conventional Z-shaped stent-graft. First, the main body of the stent-graft is deployed and subsequently the bare stent is deployed inside the main body. In addition, deployment of a percutaneous separated stent-graft was performed through a 12-French low-profile introducer under local anesthesia without surgical cut-down. Recently the puncture site has been closed using a Perclose device (Abbott Vascular Devices, Redwood City, CA, USA).

21.2.5 Follow-Up

Follow-up spiral CT scans were performed within 1 month of the procedures, then at 3–6-month intervals for 2 years, and annually thereafter. Each patient was

Table 21.1. List of problems encountered in stent-graft placement for aortic dissection

Problems during the procedure
Stent-graft migration
Stent-graft torsion
Complication related to the size of the stent-graft
Appearance of a hidden intimal tear in the descending thoracic aorta
Type I endoleak
Problems during follow-up
Postimplantation syndrome
Neurologic complication
Persistent type I endoleak
Type II endoleak
Progressive abdominal aortic aneurysm
New intimal tear
Mechanical failure of the stent-graft

followed for 9–103 months and the mean follow-up was 31 months. Technical success was defined as the completion of the stent-graft deployment at the target area without stent-graft failure. Clinical success was defined as complete exclusion of the primary entry tear from the circulation without a significant adverse cardiovascular event by serial CT. We assessed all technical problems during the procedure and complications which occurred during the follow-up period (Table 21.1).

21.3 Problems During the Procedure

21.3.1 Stent-Graft Migration

Migration of the stent-graft caused by the “wind sock” effect of ventricular ejection results predominantly in technical failure, particularly when proximal fixation is at or near the aortic arch [2]. To avoid this serious technical problem, lowering the blood pressure with a vasodilator or beta-blocker drugs has been done [16, 25]. Despite this effort, stent-graft migration has reported to occur with an incidence of 2–20% by many authors [29].

In our experience, we observed two cases (3%) of stent-graft migration, which occurred in two patients in our early period when we used a single stent-graft system and nitroprusside to lower the blood pressure during deployment of the stent-graft. Primary entry tears of those two patients were located at the proximal DTA, 3 and 5 cm from the left SCA. We attempted to correct the location of the stent-graft with a balloon, but failed. We deployed an additional stent-graft and successfully excluded the primary entry tear in one patient. However, in the other patient, an additional stent-graft of adequate size was not readily available. Later, the patient refused further intervention and his false lumen remained patent without demonstrable interval changes

on the follow-up CT scan. The patient is under close observation for 16 months. Since changing the device to a separated stent-graft, the migration problem has no longer happened. Many investigators are known to design their own devices which enable a better proximal fixation, using stent appendages such as hooks or barbs and a rapid deployment system using a pull-string to avoid this unfavorable complication [12, 35].

21.3.2 Complications Related to the Size of the Stent-Graft

The method of measuring the adequate size of the stent-graft in aortic disease seems to be an subject that needs general consensus, especially in aortic dissection. Investigators determine the diameter of a stent-graft in many different ways. We use the diameter of the proximal unaffected aorta as a base line and manufacture the

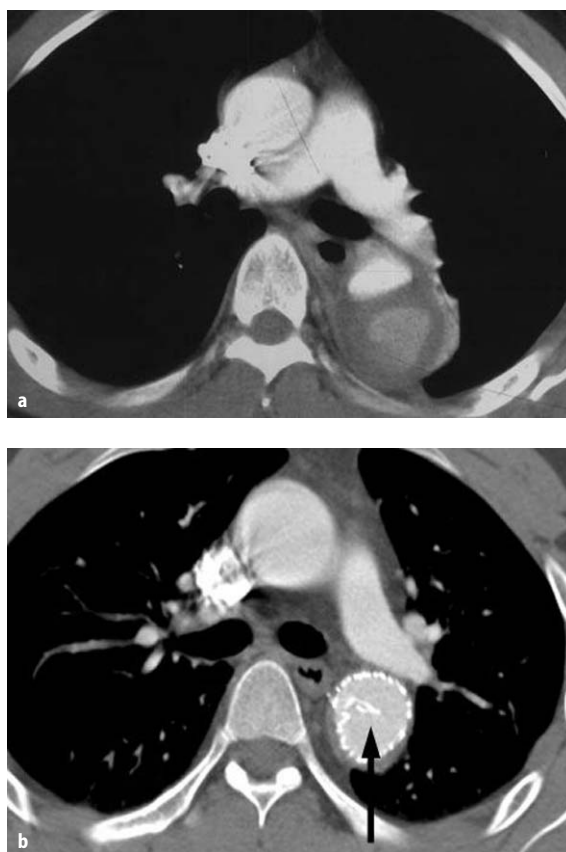


Fig. 21.1. Stent-graft folding. A 56-year-old man with De Bakey type III chronic aortic dissection. **a** Preoperative computed tomography (CT) scan shows the true lumen and the false lumen of the descending thoracic aorta. **b** Fifty-two-month follow-up CT scan after the stent-graft treatment. Despite inward folding of the stent-graft strut (arrow), complete resolution of the thoracic false lumen is achieved

stent-graft 10–15% larger. Shimono et al. [33] use a stent-graft 10% larger than the average of the maximum and minimum diameters of the thoracic true lumen in acute dissection and 20% in chronic dissection. Choosing a stent-graft diameter that is too small can cause an endoleak or migration, whereas oversizing of the prosthesis may lead to infolding of the graft. In the experimental report of Schurink et al. [32], oversizing and folding of the stent-graft were significantly related to the grade of the endoleak, and balloon expansion can not help to reduce the endoleak.

Among 60 patients of our study, two stent-grafts (3%) were infolded during deployment, which was caused by overestimation of the stent-graft size. On the follow-up CT scan, those stent-grafts were not expanded even after the aortic true lumens had been fully expanded. Fortunately, primary entry tears of these two patients were completely excluded and there was no thrombus formation around the deformed stent-graft on follow-up CT scans taken 46 and 55 months after the procedure (Fig. 21.1). We keep following these patients closely because of the possibility of blood flow disturbance inside the aorta by the protruding stent strut.

21.3.3 Appearance of a Hidden Intimal Tear in the DTA

Many authors mentioned the importance of verifying every intimal tear of the thoracic aorta on preoperative imaging. Especially in long-standing chronic dissections, it is more important owing to the possibility of multiple fenestrations in the DTA and the abdominal aorta. In chronic dissections, along with fibrosis, contraction of the myointima, and dilated outer layers, even a small intimal tear could disturb reattachment of the intima to the outer media and adventitia [17, 20]. According to our experience, every thoracic false lumen of acute dissection was decreased in size only with the exclusion of the primary entry tear. However, in chronic dissection, the size of the thoracic false lumen did not decrease until every intimal tear including the primary entry tear was excluded. In addition, the time required for complete thrombosis of the thoracic aortic false lumen was longer in the chronic dissections, as was the resolution time. Those differences might be related to the formation of the multiple thoracic reentry tears, the status of endothelialization in the false lumen, and the endotension caused by reentry tears.

In three patients (5%) with primary entry tear in the distal DTA of our series, initially undetected hidden intimal tears appeared within 2 cm of the proximal ($n=1$) and the distal ($n=2$) margins of the stent-graft which had been successfully deployed upon the primary entry tear. All of their dissections were acute. One of them underwent additional stent-graft deployment upon the hidden intimal tear. The other two patients could not

have further intervention because a suitably sized device was not readily available. Despite persistent contrast enhancement of the thoracic false lumen in these two patients, gradual decrease of the aortic diameter was seen on serial follow-up CT scans at 6 and 27 months each (Fig. 21.2).

In our institute, very thin sections of spiral CT scans of less than 2-mm slice thickness and a three-dimensional reconstruction image combined to aortograms with a high frame rate of more than 6 frame/s and oblique views perpendicular to the aortic intimal flap are obligatory for the preoperative evaluation for the aortic dissection. Recently, the multidetector CT scan became available and enables more accurate evaluation of aortic dissection by its greater spatial resolution, thinner slice thickness, and faster scan time [17]. Despite careful evaluation of the preoperative images, we lost three cases of proximal and distal hidden intimal tears which were relatively small compared with the adjacent primary entry tear. Pamler et al. [26] suggested obtaining many preoperative aortograms with the catheter tip at different levels. They also propose covering every intimal tear in the thoracic aorta with a stent-graft to prevent distal reperfusion of the false lumen.

21.3.4 Type I Endoleak

Twelve endoleaks (20%) were detected immediately after the successful deployment of the stent-graft and all of them were type I endoleaks (attachment site endoleak) at the proximal margin of the stent-graft. Ten of the twelve patients with endoleaks had a primary entry tear in the aortic arch and the proximal DTA and one of them was located in the lesser curvature side.

21.4 Problems During the Follow-Up

21.4.1 Postimplantation Syndrome

Postimplantation syndrome can be manifested in various symptoms and signs, such as fever, leukocytosis, elevated C-reactive protein level, pleural effusion, and decreased platelet count.

Fever, leukocytosis, and elevated C-reactive protein level, of which the incidence is known to be 20–60%, are suggested to be a nonspecific systemic inflammatory reaction rather than true infection. However, it has been reported to result in little prolonged complication by many authors [20, 36]. In our early experiences, we routinely medicated prophylactic antibiotics; however, this did not help to lower the incidence of postimplantation syndrome. All the patients recovered with conservative treatments in 2–10 days. Many institutes manage these



Fig. 21.2. Emergence of hidden intimal tear. A 66-year-old man with De Bakey type III acute aortic dissection. **a** Preoperative aortogram demonstrates a large entry tear located at the distal descending thoracic aorta near the diaphragm (*arrow*). No other entry tear is defined in the descending thoracic aorta. **b** Immediately after the stent-graft deployment, the completion

aortogram shows exclusion of the entry tear and nonvisualization of the false lumen. **c, d** One week after the stent-graft treatment, emergence of a hidden entry tear (*arrow*) is depicted just above the stent-graft on CT (**c**) and aortograms of 50° right anterior oblique view (**d**). Contrast enhancement of the thoracic false lumen is still noted

complications only with anti-inflammatory agents or even without any medication and recommend judicious use of antibiotics [12, 25, 30].

Pleural effusion and decreased platelet count are not well-known complications of stent-grafts in aortic dissection. In our series, 34 patients (57%) with pleural ef-

fusion and 22 patients (37%) with decreased platelet count to more than 50% of the base line were observed during the follow-up. All patients with pleural effusion, which we suggest to originate from foreign-body irritation to the adjacent pleura, showed complete resolution on 1-month ($n=25$) or 3-month ($n=9$) follow-up CT

scans without any specific treatment. In 22 of our patients, the platelet count decreased until 1–3 days after the stent-graft placement and it recovered to the initial base line in 3–13 days (mean 5.2 days) without transfusion or any other treatment. Because all cases of platelet count drop occurred in patients whose former patent false lumens had been obliterated by thrombus formation, consumptive coagulopathy is suggested to be the cause of this transient complication.

21.4.2 Neurologic Complication

Cerebral ischemic complication is reported to occur in 3–10% of stent-grafts in aortic dissection [16, 25]. A possible embolic event might be responsible for this uncommon complication. Gentle maneuver of the guide-wire and the introducer could be the only way to lower the incidence of cerebral embolic complication. In our series, transient ischemic attack developed immediately after the stent-graft treatment in one patient (2%); this patient spontaneously recovered without any sequelae.

Our own device of separated stent-grafts was deployed upon the orifice of the carotid artery and the left SCA with the bare stent portion in 13 patients. Pannus formation did not disturb the cerebral or extremity circulation during follow-up and our cases of surgical conversion proved a wide-open carotid and SCA owing to the large cell size (1×1 cm) of the bare stent portion which had covered the branch vessels of the aortic arch. Czemark et al. [3] and Quinn et al. [28] also reported that they placed the uncovered part of the stent-graft over the ostium of the left SCA without any neurologic complication.

We have not experienced any other neurologic complications such as paraparesis or paraplegia. Although spinal ischemia has been reported by some authors [18, 19], many different authors' experiences to date permit the conclusion that the usual surgical paradigm relative to intercostal artery sacrifice and aortic clamping during open repair and its resultant incidence of spinal cord ischemic complication as much as 7–35% does not pertain to stent-graft repair [27]. Furthermore, in the case of aneurysms with partial thrombosis, many intercostal branches are already occluded and the spinal cord is perfused by collaterals. The sudden deployment of the stent-graft followed by the occlusion of the intercostal branches does not produce steal syndrome in the perfusion of the spinal cord [11]. Cambria et al. [2] observed no spinal cord complication in 28 cases of thoracic aortic stent-graft treatment. Seventy patients of Palma et al. [25] were free from paraplegia with thoracic stent-grafts. Kato et al. [16] reported one case of paraplegia developed after a surgical conversion to fix an endoleak out of 38 thoracic stent-grafts.

21.4.3 Persistent Type I Endoleak

Type I endoleak (attachment site endoleak) is known to be the most frequent complication in the stent-graft treatment of aortic dissection, which could be a potential clinical failure during follow-up [10, 18]. The percentage of type I endoleak reported in the literature ranges from 0 to 44 [4]. A proximal neck less than 2 cm from the left SCA and the existence of an entry tear located at the lesser curvature of aortic arch are known as risk factor of an endoleak [26, 33].

In our series, 12 cases (20%) of endoleaks were depicted on immediate aortograms out of 60 cases. Ten of 38 patients (26%) whose entry tears were located at the aortic arch and the proximal DTA showed an endoleak, whereas two of 22 patients (9%) with entry tears at the mid and distal thoracic aorta showed an endoleak. The distance between the left SCA and the primary entry tear was 1.5–8 cm (mean 4.1 cm) in patients with an endoleak, which was significantly shorter than in patients without an endoleak (mean 12.7 cm) ($p < 0.05$).

In terms of the fate of type I endoleaks, there is still some debate between authors. However, many authors reported their experiences of the spontaneous healing of type I endoleaks. Lepore et al. [18] reported seven patients (16%) with type I endoleaks among 43 thoracic aortic stent-grafts. They treated three of them with additional stent-graft deployment and the others resolved spontaneously within 1 month. Shimono et al. [33] reported 80% spontaneous resolution of type I endoleaks in 37 stent-grafts for aortic dissection.

Also in our study, six (50%) of 12 patients who had demonstrated type I endoleaks on immediate angiograms after the deployment of stent-grafts showed spontaneous thrombosis of the thoracic false lumen without any further treatment (Fig. 21.3). The duration of self-resolution was 1 week to 8 months. The other six endoleaks remained persistent on follow-up CT scans. Among them, two patients showed progressive aneurysmal dilatation of the false lumen (Fig. 21.4). One of them underwent surgical graft replacement and the other one refused further treatment and are under close follow-up for 4 years. Four other patients did not show any remarkable changes in the size and the shape of the thoracic false lumen for 8–89 months (mean 45). In case of type I endoleaks, we suggest following the patients with repeated imaging to see if there is any change in the dissected false lumen. Surgical management could be avoided unless overt enlargement of the false lumen is detected.



Fig. 21.3. Spontaneous resolution of a type I endoleak. A 44-year-old man with De Bakey type III aortic dissection. **a** The aortogram demonstrates De Bakey type III aortic dissection. A primary entry tear is located on the greater curvature side 4 cm from the left subclavian artery. **b** After the deployment and balloon apposition of the stent-graft, contrast leakage into the false lumen at the proximal end of the stent-graft (type I endoleak) is seen (arrows). **c** The 1-month follow-up CT scan

shows persistent contrast enhancement of the thoracic false lumen around the stent-graft. **d** With the further expansion of the true lumen, remodeling of the thoracic aorta is shown on the 4-month follow-up CT scan. **e** On the 8-month follow-up CT scan, complete resolution of the previous endoleak is demonstrated. Furthermore, the thoracic false lumen disappeared completely

21.4.4 Type II Endoleak

A type II endoleak after the stent-graft treatment is not as much a concern in aortic dissection as it is in abdominal aortic aneurysm. Sometimes, type II endoleaks through the intercostal artery can occur in aortic dissection and make contrast enhancements around the intercostal attachment sites of the false lumen. Bortone et al. [1] also reported two cases of type II endoleaks among 43 stent-grafts for type B dissection, associated with a complete thrombosis of the thoracic false lumen and an insignificant retrograde flow. Palmer et al. [26] found open and retrogradely perfused intercostal arteries in the region of the stent-graft in a patient whose thoracic false lumen was completely thrombosed. They assumed that collateral perfusion through the intercostal artery enables good residual blood flow to the spinal cord rather than a harmful effect such as endotension.

In our series, two cases of type II endoleaks (3%) through the intercostal arteries were demonstrated by follow-up CT scans taken 1 month after the stent-graft treatment. Those endoleaks did not affect the remodeling and the thrombosis in the thoracic false lumen. They resolved spontaneously after 5 and 6 months (Fig. 21.5).

21.4.5 Progressive Abdominal Aortic Aneurysm

Despite an adequate sealing of the primary entry tears in the DTA after stent-graft placement, the lack of remodeling of the abdominal aorta has been a constant problem observed by many authors. The preliminary results of Kato et al. [15] dealing with 15 chronic type B dissections showed there was no significant difference in the size of the abdominal true and false lumens even after the successful remodeling of thoracic dissection.

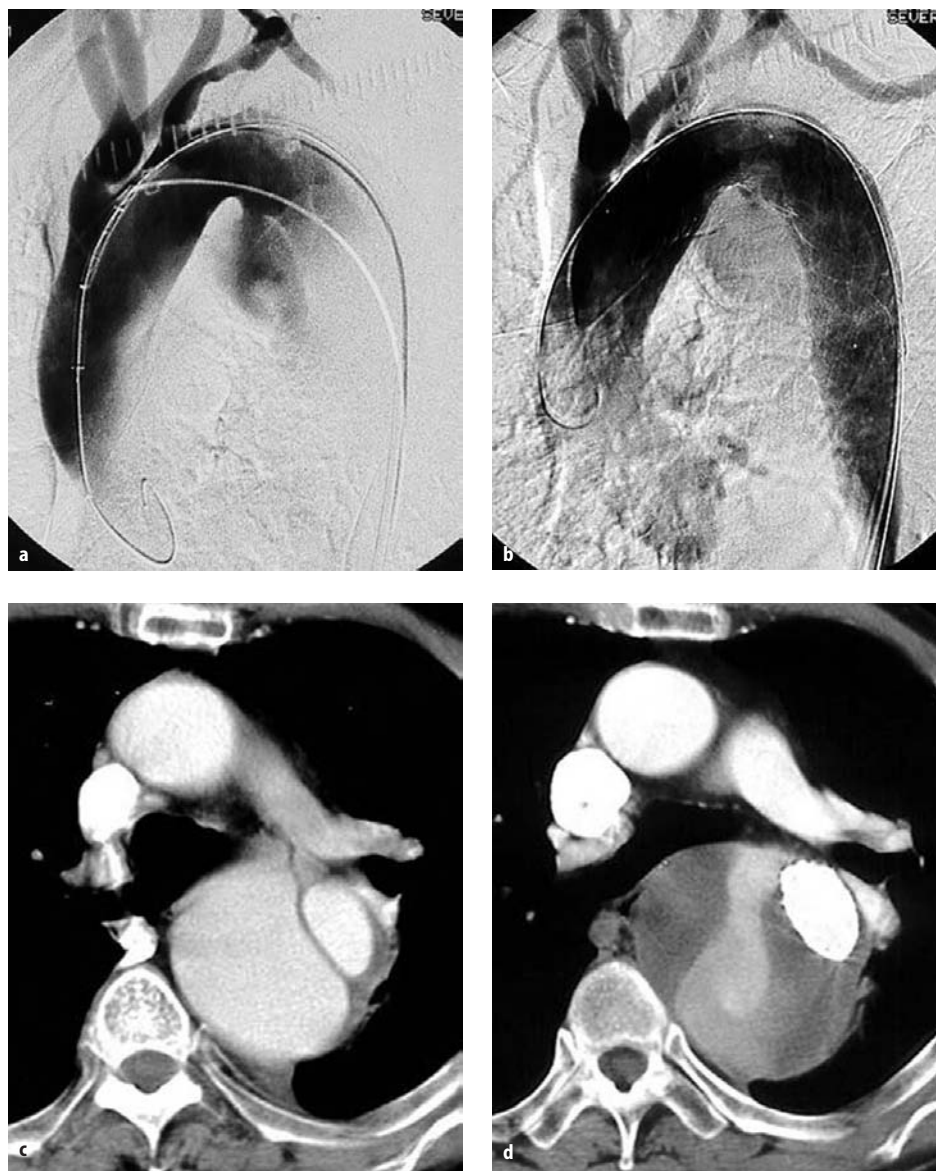


Fig. 21.4. Progression of the endoleak. A 70-year-old man with De Bakey type III aortic dissection. **a** The aortogram shows an entry tear located at the lesser curvature distal from the left subclavian artery. **b** After the placement of the stent-graft, an endoleak of contrast material at the proximal end of the stent-graft is detected. Balloon apposition turned out to be a failure.

c,d Comparison of CT scans before stent-graft treatment (**c**) and at 1-year follow-up (**d**), enlargement of the descending thoracic aorta from 6.3 to 8.0 cm can be seen. This patient refused any further treatment and is under close observation for 46 months

Quinn et al. [28] reported a case of progressive aneurysmal dilatation of the infrarenal abdominal aorta after placing a stent-graft in the DTA; the aneurysms were treated by surgical repair. Lopera et al. [20] placed stent-grafts in four acute and six chronic type B dissections. Among them, two cases of abdominal false lumen rupture occurred 9 and 13 months after the procedure and all of their dissections were chronic.

Although 47 of 60 patients (78.3%) in our study achieved complete thrombosis or resolution of the tho-

racic aortic false lumen, complete thrombosis or resolution of dissected abdominal aortic false lumens was achieved in only five patients. During the follow-up, four patients (7%) with technical success showed progressive dilatation of the abdominal false lumen in our study and all of their dissections were chronic. The maximal diameter of their abdominal aorta was increased after the procedure from 3.9 to 4.8 cm during the mean follow-up period of 35 months. We could not find any predicting factors for this problem except the

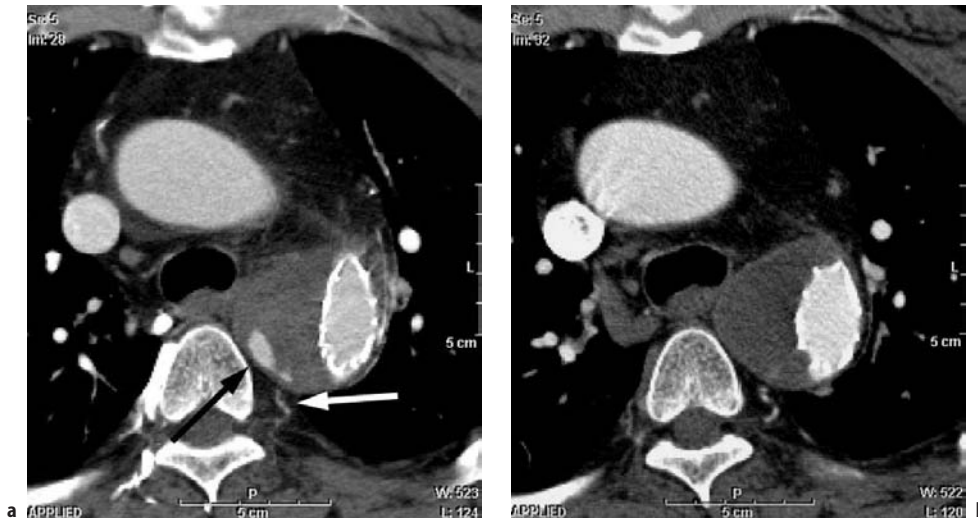


Fig. 21.5. Type II endoleak. A 55-year-old man with De Bakey type III chronic aortic dissection. **a** Follow-up CT scan taken 1 week after the complete exclusion of the entry tear with a stent-graft shows focal contrast enhancement in the false lu-

men representing a type II endoleak (*black arrow*) through the nearby intercostal artery (*white arrow*). **b** Five-month follow-up CT scan shows resolution of the endoleak despite the persistent enhancement of the intercostal artery

chronicity of the dissection that might be related to the number of reentry tears in abdominal aorta. A patent abdominal false lumen originated from the persistent false lumen flow through multiple reentry tears of the abdominal aorta. Because reentry tears in the abdominal aorta tend to be located near the exit sites of branch vessels, it is mostly impossible to exclude those reentry tears [25]. Fortunately, because of the favorable location of the reentry site, two patients were eligible for further intervention in our study; one with three more stent-graft placements upon the reentry tears in the proximal abdominal aorta, the infrarenal abdominal aorta, and the common iliac artery 53 months after the initial stent-graft treatment (Fig. 21.6); the other one with coil embolization of reentry in the renal artery and the stent-graft over the reentry in the common iliac artery.

21.4.6 New Intimal Tear

Recently, many authors reported the formation of a new intimal tear resulting in pseudoaneurysm or dissection at the margin of the stent-graft from intimal injury as one of the most frequent complications in aortic stent-graft treatment [15, 20, 26].

In our study, we identified six cases (10%) with a new intimal tear complicating saccular aneurysms ($n=3$) (Fig. 21.7) or new dissections ($n=3$) developed on both ends ($n=1$) or either end ($n=5$) of the stent-graft. Two patients had acute dissection and four had chronic dissection. The delay between the stent-graft implantation and identification of a complicating intimal tear

was 1–5 months (mean 3.2 months). Three of six patients (50%) underwent surgical conversion: one with newly developed pseudoaneurysms at both ends of the stent-graft, another with dissection due to the new intimal tear at the distal end of the stent-graft, and the other with retrograde type A dissection due to the intimal tear 6 cm above the proximal end of the stent-graft in a patient with Marfan syndrome; these were confirmed on open repair. In one patient whose previous entry tear had been located at the mid-DTA, a new intimal tear developed at the distal margin of the stent-graft at the level of the diaphragm. He presented acute collapse of the abdominal aortic true lumen and mesenteric ischemia from dynamic occlusion. We deployed another stent-graft upon the new intimal tear (Fig. 21.8). The other two patients have been under close observation for 24 and 41 months.

One case of complicating type A dissection in a patient with Marfan syndrome is suggested to be related not to irritation from the stent-graft itself but to guide-wire manipulation according to the retrospective review of intraprocedural films and the surgical findings. Care should be taken in stent-graft treatment for Marfan syndrome because of its well-known instability of the aortic wall [6].

Lopera et al. [20] also reported two cases (20%) of aneurysm formation at the ends of the stent-graft in ten patients with type B aortic dissection. Both cases were successfully managed with placement of additional stent-grafts. Lepore et al. [18] reported two cases of sudden death from aortic rupture 34 and 139 days after stent-graft treatment for acute aortic dissection. Autopsy revealed perforation of the aortic wall by the

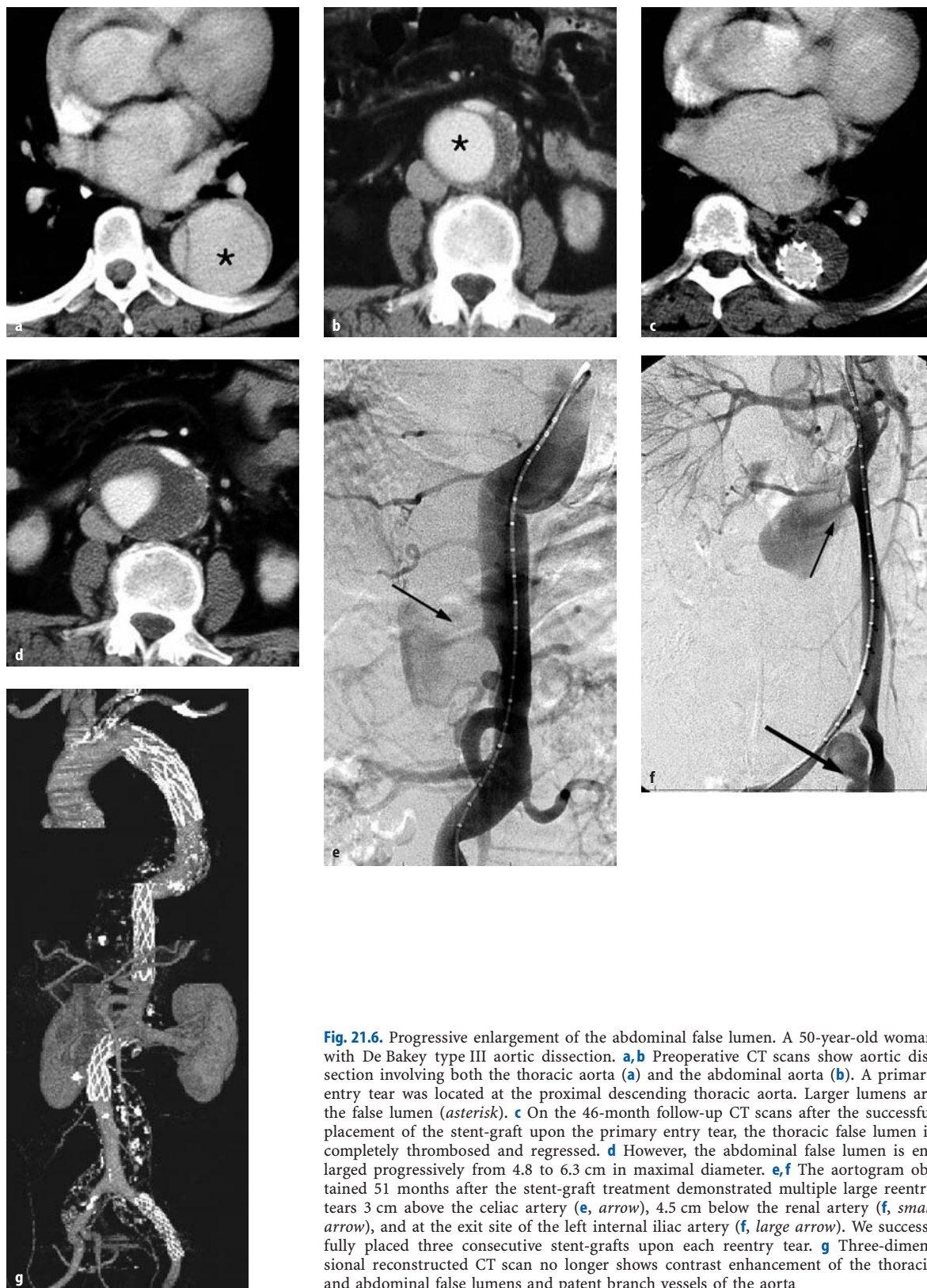


Fig. 21.6. Progressive enlargement of the abdominal false lumen. A 50-year-old woman with De Bakey type III aortic dissection. **a,b** Preoperative CT scans show aortic dissection involving both the thoracic aorta (**a**) and the abdominal aorta (**b**). A primary entry tear was located at the proximal descending thoracic aorta. Larger lumens are the false lumen (*asterisk*). **c** On the 46-month follow-up CT scans after the successful placement of the stent-graft upon the primary entry tear, the thoracic false lumen is completely thrombosed and regressed. **d** However, the abdominal false lumen is enlarged progressively from 4.8 to 6.3 cm in maximal diameter. **e,f** The aortogram obtained 51 months after the stent-graft treatment demonstrated multiple large reentry tears 3 cm above the celiac artery (**e**, *arrow*), 4.5 cm below the renal artery (**f**, *small arrow*), and at the exit site of the left internal iliac artery (**f**, *large arrow*). We successfully placed three consecutive stent-grafts upon each reentry tear. **g** Three-dimensional reconstructed CT scan no longer shows contrast enhancement of the thoracic and abdominal false lumens and patent branch vessels of the aorta



Fig. 21.7. Complicating saccular aneurysm at the proximal end of the stent-graft. A 56-year-old woman with De Bakey type III chronic aortic dissection. **a** The initial CT scan taken 3 months after the onset of the patient's symptom shows aortic dissection involving the descending thoracic aorta. Partial thrombosis of the false lumen is noted (arrow). Five days after the

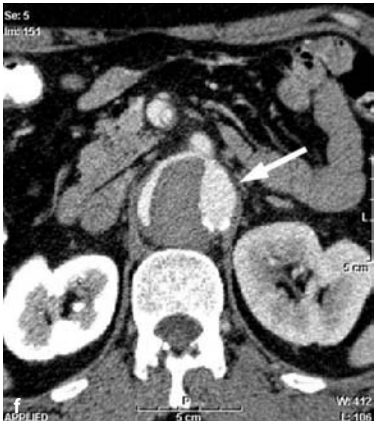
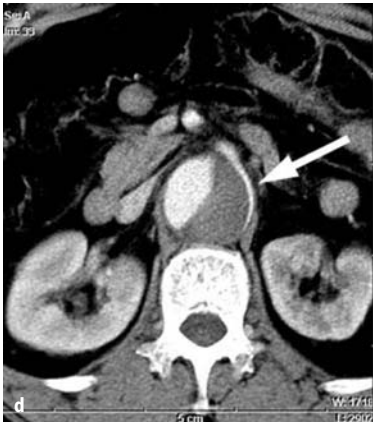
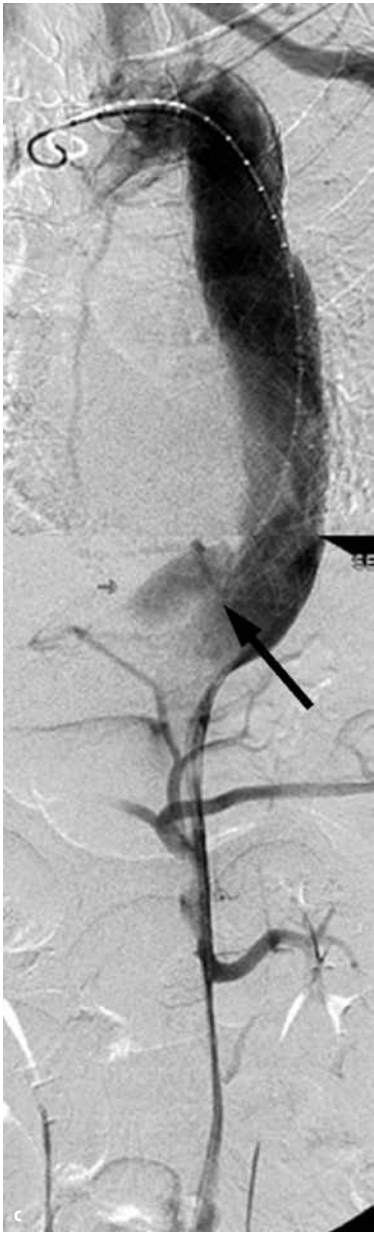
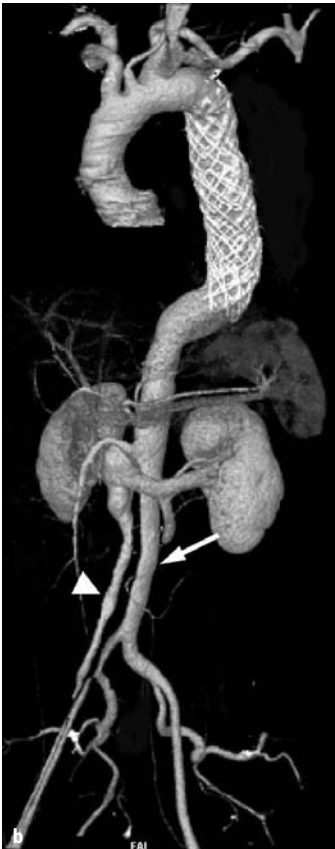
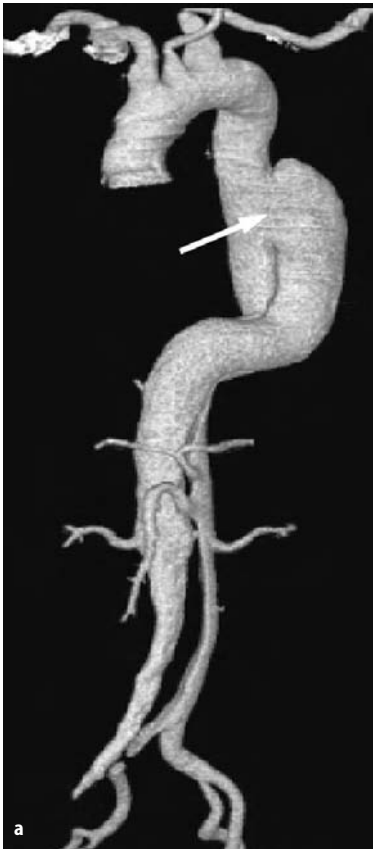
stent-graft treatment, the false lumen is excluded. **c** On the 2-month follow-up CT scan, a saccular aneurysm is newly developed near the proximal end of the stent-graft (arrow). This saccular aneurysm shows no demonstrable interval change on the 15-month follow-up CT scan

proximal end of the stent-graft. Also in our three surgical converted cases, intimal tears were clearly depicted. Kato et al. [16] reported five cases (13.2%) of new aneurysm formation after the stent-graft repair for 38 aortic dissections. The intervals between the diagnosis and notification of the aneurysms ranged from 17 to 99 days (mean 63 days). Additional stent-graft placement and surgical graft replacement were performed for the management of these patients. All of their five patients were admitted owing to acute dissection and all of the newly developed aneurysms were located at the curved portion of the DTA that attached the stent-graft at an angle. Similarly, five of our six intimal tears developed at the curved portion of aorta where the stent-graft and the intima meet at an angle. Many articles dealing with stent-graft treatment suggest that the causes of the development of intimal tears are mechanical intimal injury, stent-graft migration, and weakened aortic wall. They also suggest several methods to avoid these complications; first, the stent-graft should cover longer portions of the descending aorta until it fits the parallel portion of the aortic wall or intima; second, development of stent-grafts with smoother edges and more flexible bodies [16]. During our early phase of study, we assumed that acute dissection should be more vulnerable in the formation of complicating pseudoaneurysm rather than chronic dissection because of the unstable and fragile intima. However, four of six patients with this complication were managed from chronic dissection and there was no relationship between the duration of the aortic dissection and the development of complicating pseudoaneurysm or dissection. We consider the mechanical stress by the sharp stent tip, the in-

flexibility of the stent-graft, and the pulsatile force of the aorta have as much adverse effect as the instability of acutely dissected intima. Another possible reason we assume is diaphragmatic motion in the fixed aorta because two of these six intimal tears were located near the diaphragmatic portion of the descending aorta. We also consider ballooning for the purpose of stent-graft apposition as one of the possible etiologic factors of the complicating intimal tear and we do not routinely perform the balloon apposition in stent-graft treatment of aortic dissection. As demonstrated, it is imperative to be aware of the possibility of an intimal tear on both ends of the stent-graft during follow-up.

21.4.7 Mechanical Failure of the Stent-Graft

Since the first stent-graft was placed for the treatment of aortic disease, this technique has improved remarkably with growing understanding of metallurgic and fabric sciences. However, mechanical failure from stent-graft materials of metal and graft continues to be a potential problem in aortic stent-graft treatment. The inherent properties of the resistance of the materials (strength and corrosion) combined with extrinsic forces contribute significantly to the risk of device fatigue. Before deployment, the metallic stent may experience increased risk for failure as a result of damage during loading and subsequent confinement in the delivery catheter. Once implanted, the device is then subjected to additional extrinsic forces imposed by the geometry of the tortuous aorta and the impact of continuous,



high-pressure blood flow. Mechanical failure of the stent-graft can occur in the form of metallic fracture, fabric wear, and suture breakage. Recent large series by Jacobs et al. [13] identified 60 patients (9%) with mechanical failure of the stent-graft out of 618 patients who underwent aortic stent-graft placement. Forty-three of them had metallic stent fracture, 14 suture disruption, and three graft wear. The average time to the recognition of mechanical failure of the prosthesis was 19 months. Six of them resulted in surgical conversion and the other ones have been asymptomatic and have not needed interventions for device fatigue. They recommend that if a patient is asymptomatic and there is no evidence of disease progress or a type I or type III endoleak, observation of the stent graft fatigue is acceptable in the setting of increased graft surveillance.

In our series, two cases (3%) with mechanical failure were identified: one with metallic fracture and the other with fabric wear. Metallic fracture was found 36 months after the initial stent-graft placement. Fabric wear occurred at the proximal portion of the graft and made an endoleak around the tear site. However, they have had further complications such as false lumen enlargement or rupture for 56 and 69 months.

21.5 Conclusion

In conclusion, a stent-graft is a more efficient and safer modality for the treatment of aortic dissection than any other current treatment modality, having 87% success rate and 0% mortality. However, various problems and complications could occur during the procedure and the follow-up period. Careful design of the stent-graft, the procedure itself and close follow-up are mandatory for the avoidance and prompt management of such problems.

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Fig. 21.8. Complicating new intimal tear at the distal end of the stent-graft. A 46-year-old man with De Bakey type III chronic aortic dissection. **a** Three-dimensional reconstructed CT angiography shows aortic dissection with a large intimal tear in the distal descending thoracic aorta (arrow). Simultaneous involvement of the abdominal aorta and the right iliac artery is seen. **b** After placement of the stent-graft upon the primary entry tear, complete exclusion of the thoracic false lumen is demonstrated. Expansion of the abdominal true lumen (arrow) and decreased size of the false lumen (arrowhead) is seen.

c Four months after the stent-graft placement, the patient complained of abdominal and leg pain. The aortogram shows a new intimal tear at the distal margin of the stent-graft (arrow). **d** Collapse of the abdominal true lumen (arrow) from the dynamic obstruction is seen on the contrast-enhanced CT scan. **e** After consecutive deployment of a bare stent in the collapsed true lumen and another stent-graft upon the new intimal tear, dynamic obstruction subsided. **f** The abdominal true lumen restores its blood flow (arrow). The patient's symptoms were improved.

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Thoracic Aortic Diseases

Rousseau, H.; Verhoye, J.-P.; Heautot, J.-F. (Eds.)

2006, XVII, 387 p., Hardcover

ISBN: 978-3-540-25734-9