Strategies for Endovascular Aortic Repair in Aortobronchial and Aortoesophageal Fistulas

Bernhard Dorweiler1  Ernst Weigang1  Friedrich Duenschede1  Michael Bernhard Pitton2  Christoph Dueber2  Christian-Friedrich Vahl1

1 Division of Vascular Surgery, Department of Cardiothoracic and Vascular Surgery, University Medical Center, Johannes-Gutenberg University, Mainz, Germany
2 Department of Radiology, University Medical Center, Johannes-Gutenberg University, Mainz, Germany


Introduction

Aortobronchial fistula (ABF) and aortoesophageal fistula (AEF) are rare but potentially life-threatening complications of both treated and untreated aortic disease due to exsanguinating hemorrhage. By classification, primary fistulas occur as communications between the untreated aorta and the bronchial tree/esophagus due to aneurysm rupture, penetrating aortic ulcer, advanced esophageal or lung cancer, or ingestion of foreign body. Secondary fistulas originate from reconstructed aorta (prosthetic graft) or develop secondary to complications of a visceral surgical procedure (anastomotic insufficiency).1

Compared with results of open surgery for thoracic aortic aneurysm (TAA) with a mortality of 14%,2 open aortic surgery in ABF and AEF is endowed with a significantly increased mortality of 243 and 50%,4 respectively, clearly reflecting the complexity of those lesions. Therefore, less invasive concepts to reduce perioperative mortality have been evaluated with special attention on thoracic endovascular aortic repair (TEVAR). Since the first report of TEVAR in TAA (13 patients) in 1994,5 the technique has rapidly evolved and currently is the primary recommendation for treatment of aneurysms of the thoracic aorta.6 Although until today, no randomized trials of open versus endovascular TEVAR have been performed.

Keywords
► descending aorta
► aortobronchial fistula
► aortoesophageal fistula
► endovascular repair

Abstract

Objective To report our experience of thoracic endovascular aortic repair (TEVAR) for acute bleeding originating from the thoracic aorta in patients with aortobronchial fistula (ABF) or aortoesophageal fistula (AEF).

Patients and Methods A total of nine patients (three woman) were treated from September 1995 to March 2012 by TEVAR for ABF (n = 5) and AEF (n = 4). The implants (N = 14) were introduced with fluoroscopic guidance via the aorta (n = 1), the iliac (n = 2), or femoral (n = 11) artery, respectively.

Results All aortic lesions could be sealed successfully. Perioperative morbidity was 0% in the ABF group and 50% (2 of 4) in the AEF group and no procedure-related morbidity was noted except one patient who received aortofemoral reconstruction because of iliac occlusive disease. After an overall mean follow-up of 56 months, three patients of the ABF group are alive and well and two patients died of nonrelated cause. Of the AEF group, one patient is alive after 22 months, and one died from metastasized esophageal cancer after 7 months.

Conclusion TEVAR is a safe and reliable procedure in the management of ABF. For AEF, TEVAR provides a successful first-line treatment to seal the fistula and control bleeding. However, prognosis is limited by the esophageal lesion and by ongoing mediastinitis/sepsis.

Address for correspondence Bernhard Dorweiler, MD, PhD, Division of Vascular Surgery, Department of Cardiothoracic and Vascular Surgery, University Medical Center, Johannes-Gutenberg University, Langenbeckstr. 1, 55101 Mainz, Germany (e-mail: dorweiler@htg.klinik.uni-mainz.de).
Evidence has accumulated that there are advantages of TEVAR over open repair in terms of survival in the short term. Therefore, the objective of this study was to analyze our results of TEVAR in the treatment of ABF and AEF.

**Patients and Methods**

Between September 1995 and March 2012, nine patients (three women, six men) with a mean age of 65 ± 12 years (range, 48–80 years) were treated by endovascular stent graft placement in the thoracic aorta (TEVAR) for ABF or AEF. For the subsequent report, patients are divided into an ABF group and an AEF group. Preoperative imaging protocol consisted of high-resolution spiral computed tomography (CT) scan and additional magnetic resonance image in selected cases. Preprocedural planning was based on 3D reconstructions obtained with the Aquarius workstation (TeraRecon, Frankfurt, Germany). For postprocedural imaging analysis (2D maximum intensity projection and 3D volume rendering), the OSIRIX software (Pixmeo SARL, Geneva, Switzerland) was used. At our institution, endovascular treatment is performed by an interdisciplinary approach of vascular surgeons and interventional radiologists. Informed consent was obtained either by the patients themselves or by the relatives for the remaining cases. The implantation procedures were performed according to standard protocol in a hybrid operating room equipped with a ceiling-mounted digital subtraction angiography (Siemens Artis Zee, Erlangen, Germany). All cases were operated with standby for cardiopulmonary bypass available, in case a conversion to open procedure would be necessary. The operations were in most cases performed under general anesthesia and ABF patients were intubated with a double lumen tube to allow for selective ventilation of the nondiseased lung. In selected cases, cardiac overpacing (180 bpm) was used to reduce blood flow during deployment of the graft.

The follow-up protocol encompassed clinical visit with repetitive high-resolution contrast-enhanced spiral CT scans with early and late phase series and a chest X-ray after 1, 3, 6, and 12 months with annual repetitions thereafter.

**Results**

According to the above-described method, we have implanted 14 stent grafts in the descending aorta in a series of nine patients (Tables 1 and 2). The mean operative time for the TEVAR procedure including surgical arterial access and arterial closure was 124 ± 54 minutes (range, 65–200 min). For Patient 3, operative time was prolonged to 315 minutes because of difficult access and aortofemoral reconstruction.

Table 1 Perioperative patient data

<table>
<thead>
<tr>
<th>Pat.</th>
<th>Gender</th>
<th>Age</th>
<th>Diagnosis</th>
<th>History</th>
<th>Location of fistula</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Male</td>
<td>77</td>
<td>ABF, I</td>
<td>TAA (5 cm)</td>
<td>Left lower segment bronchus</td>
<td>Nonrelated death (age 82) at 61 months</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>61</td>
<td>ABF, I</td>
<td>PAU</td>
<td>Left bronchial mainstem</td>
<td>Alive at 151 months</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>74</td>
<td>ABF, I</td>
<td>PAU</td>
<td>Left lower segment bronchus</td>
<td>Nonrelated death (colon cancer) at 10 months</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>80</td>
<td>ABF, I</td>
<td>Postdissection TAA (6.5 cm)</td>
<td>Left lower segment bronchus</td>
<td>Alive at 3 months</td>
</tr>
<tr>
<td>6</td>
<td>Female</td>
<td>60</td>
<td>AEF, I</td>
<td>Malignant fistula of metastasized esophageal cancer, palliative treatment</td>
<td>Died after 7 months (tumor cachexia)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>71</td>
<td>AEF, II</td>
<td>Anastomotic insufficiency with aortic erosion after esophageal resection for esophageal cancer (pT2B pN1 M0)</td>
<td>Died on day of TEVAR (sepsis/multiorgan failure)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>68</td>
<td>AEF, II</td>
<td>Anastomotic insufficiency with aortic erosion after esophageal resection for esophageal cancer (pT1B pN0 M0)</td>
<td>Died after 3 months (in hospital) due to recurrent sepsis/pneumonia</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>48</td>
<td>AEF, I</td>
<td>Ruptured mycotic aneurysm of distal thoracic aorta due to Boerhaave Syndrome with esophageal perforation</td>
<td>Alive at 22 months, Re-TEVAR (prox. extension) at 3 months</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ABF, aortobronchial fistula; AEF, aortoesophageal fistula; I, primary fistula; II, secondary fistula; Pat., patient; PAU, penetrating aortic ulcer; prox., proximal; Re-TEVAR, redo-thoracic endovascular aortic repair; TAA, thoracic aortic aneurysm.
in patient 9, visceral debranching was performed immediately after TEVAR (245 minutes). All patients survived the operative procedure and sealing of the aortic lesion could be achieved in all cases resulting in a technical success rate of 100%. Proximal landing zone was located in zone 3 in the majority of cases (►Table 2), overstenting of the left subclavian artery has not been performed in this series.

For the ABF group, all five patients recovered and were discharged home from the hospital, resulting in a perioperative mortality of 0%. In the long-term follow-up, two patients are alive and well after 188 and 151 months, respectively. Two patients died after 61 and 10 months, respectively, because of nonrelated causes. In two cases,1,2 redo TEVAR had to be performed for recurrent haemoptysis at 5 and 96 months (►Fig. 1). Interestingly, both patients continued to expectorate bits of hematoma for 2 weeks, after which no further episodes of expectoration were noted. The procedure-related morbidity was found to be one of the five patients: in Patient 2, conversion from femoral to iliac and finally to aortic access had to be performed because of extensive iliac occlusive disease. For introduction of the stent device, a 10-mm polytetrafluoroethylene conduit was used and completed to an aortofemoral bypass at the end of the procedure. Thrombosis, embolization, or clinical manifestations of impeded blood flow as well as postoperative stroke or paraplegia could not be detected. Completion angiograms and postoperative CT scan confirmed satisfactory position of the implanted stent graft in each case and showed no sign of endoleak or dislocation. All patients were transferred to the intensive care unit for postoperative monitoring, and prolonged duration of mechanical ventilation (9 days) was only necessary for Patient 3 because of cardiopulmonary arrest and underlying chronic obstructive pulmonary disease. Patients were either discharged home,2 retransferred to the referring hospital,1 or discharged into rehabilitation.2 All patients with ABF received long-term oral antibiotic treatment (broad-spectrum gyrase inhibitor) for 6 weeks postoperatively. Complete resolution of the extensive periaortic hematoma was noted in Patient 3.7

For the AEF group, only one patient is alive after 22 months (►Fig. 2). This patient presented with a ruptured aortic aneurysm at the thoracoabdominal level that in retrospect was attributed to an esophageal perforation (Boerhaave Syndrome). Following emergency TEVAR and visceral debranching (superior mesenteric and splenic artery with vein graft), the esophageal lesion was sealed with a stent as bridging procedure and the mediastinal abscess was drained. After 3 months, removal of the stent and esophageal resection was performed. The patient recovered from the procedure and could be discharged home but had to be readmitted for dilatation of a stenosis of the esophagogastric anastomosis repeatedly. However, no recurrent hematemesis or aortic endoleak could be detected.

### Table 2 Stent graft details

<table>
<thead>
<tr>
<th>Graft</th>
<th>Pat.</th>
<th>Device</th>
<th>Size (mm)</th>
<th>Arterial access</th>
<th>Landing zone (0–4)</th>
<th>Anesthesia</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Stentor</td>
<td>26 × 50</td>
<td>External iliac</td>
<td>4</td>
<td>General</td>
<td>Iliac access due to shortness of introducer sheath</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Talent</td>
<td>30 × 100</td>
<td>Common femoral</td>
<td>3</td>
<td>Local</td>
<td>Proximal and distal extension for recurrent ABF at 96 months</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Talent</td>
<td>36 × 130</td>
<td>Aortofemoral graft (PTFE 10 mm)</td>
<td>3</td>
<td>General</td>
<td>Distal extension for recurrent ABF at 5 months</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Talent</td>
<td>36 × 110</td>
<td>Femoral (PTFE graft)</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>Vanguard</td>
<td>24 × 50</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Bail-out procedure in general surgery OR using plain fluoroscopy (Garm)</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Talent</td>
<td>30 × 110</td>
<td>Common femoral</td>
<td>4</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>Relay NBS plus</td>
<td>34 × 154</td>
<td>Common femoral</td>
<td>3</td>
<td>Local</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>Valiant</td>
<td>28 × 150</td>
<td>External iliac</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>Valiant</td>
<td>38 × 160</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Valiant</td>
<td>42 × 150</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Valiant</td>
<td>42 × 150</td>
<td>Common femoral</td>
<td>4</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>Valiant</td>
<td>32 × 150</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>Valiant</td>
<td>32 × 130</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Relay plus</td>
<td>28 × 215 × 20</td>
<td>Common femoral</td>
<td>3</td>
<td>General</td>
<td>Simultaneous visceral debranching</td>
</tr>
</tbody>
</table>

Abbreviations: NBS, nonbare stent; Pat., patient; PTFE, polytetrafluoroethylene.
detected at 22 months after the initial TEVAR. Two patients with secondary fistula (aortic erosion because of anastomotic insufficiency and mediastinitis following esophageal resection for esophageal cancer, Patients 7 and 8) died in hospital. One shortly after TEVAR (day 1), the other after recurrent episodes of sepsis/pneumonia due to persisting esophago-bronchial fistula despite combined esophageal and bronchial stent placement in multiorgan failure 3 months after TEVAR. In Patients 7 to 9, bronchial lavages/drainage specimen revealed multiple gram-positive bacteria and candida species. Therefore, all patients received calculated broad-spectrum antibiotics (third generation cephalosporin + gyrase inhibitor) in hospital. Patient 9 was discharged with a gyrase inhibitor until readmission for esophageal resection. The fourth patient with AEF was treated in a palliative situation of metastasized esophageal cancer (25 cm from the mouth/
Discussion

Treatment of ABF and AEF aims at two major goals: immediate control of aortic bleeding and closure of the fistula. The first, however, puts high requirements on logistics for an open operation that are often not easily met. Consequently, as TEVAR has the advantage of rapid aortic sealing at low invasiveness, attempts were undertaken to adopt TEVAR in the treatment of ABF. In 1996, the first two successful cases of TEVAR in ABF were reported by Campagna et al and Chuter et al. Since then, the technique has been used more widely, however, single center series are very limited because of the low incidence of ABF and AEF. Currently, there are two articles that focus on the outcomes of TEVAR in ABF and AEF: Jonker et al conducted a literature survey and identified 71 cases of ABF and 43 cases of AEF with an in-hospital mortality of 3% and 19%, respectively, and a mean follow-up of 10 months. Chiesa et al published a multicenter study where 25 cases of ABF, and 11 cases of AEF were pooled from 17 centers. Here, 30-day overall mortality was high (56%) and not different between ABF and AEF and follow-up was 22.6 months. From both series, it clearly emerges that ABF and AEF are distinct entities, which require different treatment modalities.

With respect to ABF, additional evidence has been accumulated, which corroborates safety and also long-term efficacy of TEVAR: Riesenman et al published their institutional series of 5 cases and added a literature survey yielding a total of 67 cases (4 reports with \( n \geq 5 \)) with an overall 30-day mortality of 1.5% and mean follow-up of 21.5 months. De Rango et al compiled a total number of 87 cases (3 reports with \( n \geq 5 \)), however, no overall analysis of mortality and follow-up was performed. Throughout the cited publications, mean/median follow-up did not exceed 42.6 months. The largest single-center series (\( n = 11 \)) of TEVAR in ABF also stated beneficial results with safe and effective management (0% mortality), however, follow-up was limited to 8.8 months. Our previously published results of patients treated by TEVAR for ABF were in line with those data and we have now expanded our series to five patients with a mean follow-up of 82.6 months, which represents the longest currently available single-center follow-up for this patient entity. All of the patients survived, and there was only minor procedure-related morbidity (aortofemoral bypass for access in severe iliac occlusive disease).

Since the first report of TEVAR in a patient with AEF by Oliva, the current series in the literature, as reviewed by Jonker et al, consists of 43 cases in total. However, institutional series is limited to a few cases, with the report by Topel et al probably being the most extensive (\( n = 5 \)). In addition, multicenter studies from European centers are available that report series of 11 patients with TEVAR in AEF. As mentioned above, prognosis of AEF differs largely from that of ABF. In-hospital mortality of TEVAR in AEF patients ranges from 19% in the meta-analysis to 31%. However, reports of open surgery in AEF are even more sparse and in one of the larger series, published by Kieffer in 2003, perioperative mortality is 50%. Therefore, TEVAR in that setting has been added to the armamentarium of vascular surgeons to serve as a “bridge” to open surgical repair and should be regarded as a first choice lifesaving procedure as it is able to control the life-threatening bleeding. Of the four AEF cases presented in the series, one is caused by an infiltration of the metastasized esophageal carcinoma into the descending aorta (malignant fistula). In that case, patient’s comorbidity was prohibitive of primary open surgical repair as well as secondary esophageal resection. TEVAR in case of primary malignancy–induced AEF has also been described before, although survival was limited to 3 months due to recurrent bleeding complication. In our case, patient was able to be discharged to nursing home and suffered death from tumor-induced cachexia after 7 months, however, without recurrent episodes of bleeding.

It has been highlighted, that key element of treatment in AEF patients is correction of esophageal lesion as survival of AEF patients without esophageal surgery is significantly limited. Placement of esophageal stents has emerged as a valuable tool, however, unlike aortic stent grafts, in our patients they were not able to seal the lesion completely and therefore cannot exclude risk of mediastinitis. Based on our results, definitive surgical correction seems vital to obtain a reasonable long-term perspective and possible techniques include esophageal resection with gastric pull-up, esophagoplasty, or the “Thal” fundoplication.

In summary, we were able to successfully control acute bleeding from the descending thoracic aorta due to ABF and AEF in a series of nine patients applying endovascular treatment techniques (TEVAR). Our results with 0% perioperative mortality for the ABF-group compare well the literature and our follow-up of 82.6 months is the longest published so far. Consequently, TEVAR can be seen as safe, reliable, and durable treatment of ABF without the actual need for secondary conversion (removal of stent graft). In our experience, even for recurrent hemoptysis (because of material fatigue), redo TEVAR seems justified. For AEF, TEVAR also provides a straightforward method to achieve bleeding control by aortic sealing. However, the accompanying esophageal lesion is limiting the long-term prognosis by recurrent sepsis and therefore, TEVAR and esophageal stenting should be considered a bridging procedure to open surgery in those patients. However, it must be subjected to further evaluation, if an aortic conversion operation (e.g., endograft replacement by homograft, or peri-cardium) indeed is necessary, or if the endograft can remain in situ and only the esophageal lesion is targeted.

Conflict of Interest
None.

References

8 Verhoeven EL, Vourliotakis G. Thoracic endovascular aortic repair for aortobronchial or aortoesophageal fistulas: permanent or temporary salvage or not an option at all? J Endovasc Ther 2009;16(4):441–442