

# Management of aorto-esophageal fistula secondary after thoracic endovascular aortic repair: a review of literature

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**Abstract** Aorto-esophageal fistula (AEF) is a rare and lethal entity, and the difficulty of making diagnosis of AEF is well-known. As promising results in the short-term effectiveness of thoracic endovascular aortic repair (TEVAR) promote its usage, the occurrence of AEF after TEVAR (post-TEVAR AEF) increases as one of the major complications. Therefore, we provide a review concerning the management strategy of post-TEVAR AEF. Although its representative symptom was reported as the triad of mid-thoracic pain and sentinel hematemesis followed by massive hematemesis, the symptom-free interval between sentinel hemorrhage and massive exsanguination is unpredictable. However, the physiological condition represents a surgical contraindication. Accordingly, early diagnosis is important, but either CT or esophago-gastro-duodenoscopy rarely depicts a typical image. The formation of post-TEVAR AEF might be associated with the infection of micro-organisms, which is uncontrollable with anti-biotic administration. The current first-line strategy is combination therapy as follows, (1) to control bleeding by TEVAR in the urgent phase, and (2) radical debridement and aortic/esophageal re-construction in the semi-urgent phase. In view of the high mortality and morbidity rate, it is proposed that the choice in treatment strategies might be affected by patient's condition, size of the wall defects and the etiology of AEF. Practically, we should keep in mind

the importance of making an early diagnosis and, once a suspicious symptom has occurred in a patient with a history of TEVAR, the existence of post-TEVAR AEF should be suspected. A prospective registry together with more developed technologies will be needed to establish a future strategy.

**Keywords** Aorto-esophageal fistula · Thoracic endovascular aortic repair · Thoracic aortic aneurysm · Endoscopy · Surgery

## Abbreviations

AEF	Aorto-esophageal fistula
TEVAR	Thoracic endovascular aortic repair
post-TEVAR AEF	AEF after TEVAR
TAA	Thoracic aortic aneurysm
CT	Computed tomography
EGD	Esophago-gastro-duodenoscopy
HR-CT	High-resolution CT
CTA	CT angiography
UGIS	Upper gastrointestinal series
CPB	Cardio-pulmonary bypass
PEG	Percutaneous gastrostomy
SEMS	Self-expanding metallic stents
OTSC	Over-the-scope clip

## Introduction

Aorto-esophageal fistula (AEF) is a rare entity representing about 10% of aorto-enteric fistulas [1], but it is a life-threatening condition that can cause massive bleeding and sepsis. A previous study estimated that 60% of patients suffering from AEF might die within 6 months after the onset of their symptoms [2]. In addition, the difficulty of

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making a pre-operative diagnosis of AEF has been emphasized [3], as Carter et al. demonstrated in the past that, in all 24 of their patients, a definitive diagnosis of its presence could be made at the post-mortem [4]. Here, we provide a review of the diagnostic and therapeutic strategies for AEF after thoracic endovascular aortic repair (TEVAR, post-TEVAR AEF), in order to increase awareness and improve the outcome.

### Etiologies of aorto-esophageal fistula

Previously, Hollander and Quick reviewed 500 AEF cases in 1991 and demonstrated that untreated thoracic aortic aneurysm (TAA; 54.2%), foreign body ingestion (19.2%) and invasion of malignant esophageal tumor (17%) were three major causes of AEF, despite the fact that prosthetic graft-associated complications were present in only a small proportion of such cases (1.4%). Further studies described other causes including esophageal reflux, tuberculosis, congenital abnormalities and traumatic injuries [2, 5–7]. Among traumatic injuries, the numbers of iatrogenic complications, such as failure of the sutures for esophagectomy, esophageal stent placement, nasogastric tube insertion, endoscopic esophageal biopsies and (chemo) radiation therapy for lung/esophageal cancer, have been increasing [2, 8–13]. Accordingly, the etiology of AEF has changed together with gradual improvements in diagnostic/treatment technologies.

From the point of view of the etiology of AEF, there are two groups. While secondary AEF is defined as AEF that occurs after aortic reconstructive surgery with prosthetic grafts, others are assumed to represent the primary AEF. The incidence of the former was reported to be as high as 1.6%, while those of the latter were much rarer [14, 15].

As for the secondary AEF, the recent increase in the occurrence of post-TEVAR AEF is striking. In the past, TEVAR was positioned as the main treatment strategy for TAA or traumatic aortic transection after its clinical introduction in 1994 [16]. Various studies demonstrated that the minimally invasive procedure of TEVAR might allow rapid control of blood loss even in patients with hemodynamic instability [17, 18], and that the perioperative morbidity of TEVAR during an urgent condition was significantly better than that of emergency open surgery [19]. After the usefulness of TEVAR in closing a fistula between the aorta and an adjacent organ was reported in 1996 [20], numerous promising results in its short-term effectiveness have encouraged its clinical use, and the indications of TEVAR have expanded to AEF.

However, the long-term results of TEVAR remain unknown. Several complications of TEVAR, including paraplegia, stroke, post-implantation embolisms and AEF,

have been reported [21–30]. The incidence of post-TEVAR AEF was reported to be 1.7–1.9%, comparable to the incidence after open surgery for TAA, resulting in a high rate of re-stenting for AEF recurrence [21–23]. As the clinical use of TEVAR has been widespread, a recent meta-analysis study demonstrated that primary malignant/benign esophageal disease, a prior treatment of open surgery or TEVAR of TAA, untreated TAA or a foreign body might be associated with the AEF formation in 23.6, 20.8, 20.8 or 12.5% of 72 AEF patients with the initial treatment of TEVAR, respectively [28]. Therefore, in the near future, the incidence of post-TEVAR AEF as one of the major complications of TEVAR may increase further by the widespread use of TEVAR for TAA, AEF and post-TEVAR AEF.

### Symptom of post-TEVAR AEF

Chiari's triad of mid-thoracic pain and sentinel hematemesis followed by massive hematemesis was reported as the representative symptom of AEF [31–36]. In an original study of 500 AEF cases, Hollander and Quick mentioned that hematemesis, chest pain or dysphagia were observed in 63, 58 and 42% of the subjects, respectively [2]. Steffes and O'Leary reported that massive fatal hemorrhage within 1 week after the onset of sentinel bleeding was observed in about 80% of AEF cases [37]. Amin et al. suggested that the spontaneous cessation of sentinel hemorrhage may be caused by temporary occlusion of the fistula due to spasm of the arterial wall, intra-vascular hypotension from the initial hemorrhage, or occlusion of the fistula by a peri-aortic hematoma, which may be digested later by infectious agents or digestive fluid [36].

Unfortunately, the occurrence of massive hemorrhage due to post-TEVAR AEF is not predictable. While most cases seem to occur within 1–16 months after the TEVAR procedure, Kouritas et al. reported one case of AEF that developed 6 years after TEVAR [38]. Other less frequent presentations of post-TEVAR AEF were dysphagia due to extra-luminal compression of the esophageal wall or high-grade fever due to mediastinitis, infection of the surgical/endovascular graft or sepsis [22, 34, 35]. A recent review revealed that hematemesis, hypovolemic shock or systemic infection were observed in 86.1, 60.9 or 21.7% of 72 patients with post-TEVAR AEFs, respectively [28].

### Mechanism of post-TEVAR AEF

There are some hypotheses about the pathological mechanism of post-TEVAR AEF, although it remains unknown. Previous studies suggested that the radical force of a rigid

graft expansion might cause direct erosion through the aorta into the esophagus, or pressure necrosis in the native aortic wall. As a result, the inflammation in the hematoma, mechanical compression by a large aneurysm or the force from the graft expansion might cause higher pressure in the mediastinum, resulting in further expansion of pressure necrosis due to occlusion of the aortic side branches that feed the esophagus [31, 39, 40]. Additionally, the largest risk factor for the development of its formation was reported to be infection of the implanted graft. Actually, the incidence of infection around the graft expanding to the esophagus was reported to be 0.5–5%, and has been proposed as having a central role in the development of post-TEVAR AEF [22]. In a review article, micro-organisms were reported in 43.2% of the patients after TEVAR for AEF, and, in 31.2% of the patients with inflammation, highly virulent pathogens, such as methicillin-resistant *Staphylococcus aureus*, *Streptococcus* spp., Gram-negative species, such as *Pseudomonas* and *Klebsiella*, or *Coxiella burnetii* were isolated [28, 41]. These findings suggest that micro-organisms associated with the post-TEVAR AEF formation could hardly be controlled with general use of antibiotic therapy [32].

### Importance of early diagnosis of post-TEVAR AEF

Once sentinel hematemesis has occurred in any patient with a history of thoracic surgery or TEVAR, they should be highly suspected for the possibility of post-TEVAR AEF in the clinical setting.

As for the basic screening tools, laboratory tests for detecting systemic inflammation, anemia as well as blood cultures should be employed, and chest x-ray can demonstrate a widened mediastinum, tracheal deviation with a tortuous aorta, and/or calcification [42].

Many studies proposed that both computed tomography (CT) and esophago-gastro-duodenoscopy (EGD) might be powerful modalities for its diagnosis. Considering that AEF is often located on the physiologically narrowing parts due to compression of the aortic arch, the location of abnormal findings in the images may provide important cues of its existence.

As for the CT findings (Fig. 1), it rarely depicts the fistula itself, but it clearly shows some suggestive signs, such as the presence of air bubbles within the thrombus in the aorta or around the thickened esophageal/bronchial wall, persistent/expanding fluid collection around the graft, irregular density components of soft tissue more than 6 months after the TEVAR implantation, loss of the aorto-esophageal fat plane, or the extravasation of contrast outside the aortic lumen [10, 43]. High-resolution CT (HR-

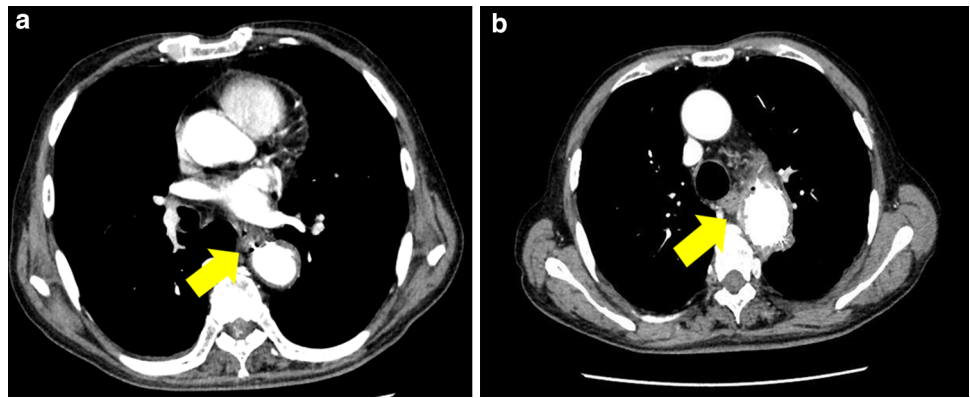
CT) provides a higher accuracy rate for AEF with its clear view of the mediastinum components, and, further, it can help to assess the condition of a pseudo-aneurysm or mediastinitis together with the extent of soft tissue involvement, so as to enable planning for aspiration or drainage of the inflamed components [44]. CT angiography (CTA) can also directly depict extravasation of the contrast material outside the aorta [31, 45–47]. Accordingly, CT is usually used for the initial investigation in cases suspicious for AEF, though such typical findings may be rarely seen.

On the other hand, it has been suggested that EGD might be the most sensitive and specific modality for making a real-time diagnosis (Fig. 2) [48]. The most common EGD finding of AEF is a sub-mucosal tumor-like protrusion with/without clots/debris due to extrinsic compression on the esophageal wall. Other reported EGD findings included ulcerative lesions, oozing from a pin-hole erosion or a pulsating protrusion with fistula, which might be related to graft exposure [35, 49, 50]. Interestingly, AEF is usually observed between the posterior to left lateral wall of the upper/middle-esophagus in the endoscopic findings. Sosnowik et al. proposed that flexible endoscopy is a valuable diagnostic modality not only from the point of view that the awareness of suggestive signs in the upper/middle of the esophagus might promote timely re-examination [51], but also because it might exclude other possible causes of upper gastrointestinal bleeding. However, some investigators pointed out its limitations in terms of its low sensitivity and risk of complications during the examination, such as rupture of the TAA as well as worsening of the co-existing cardio-pulmonary disease. Miller et al. reported that the sensitivity of even conventional endoscopy was only 38% [52]. Furthermore, Chiba et al. suggested that the intubation of a trans-nasal small caliber endoscopy might be safer than a trans-oral conventional endoscopy for AEF patients in poor condition in an urgent situation, but the sensitivity of the former is much lower than that of the latter [35, 53].

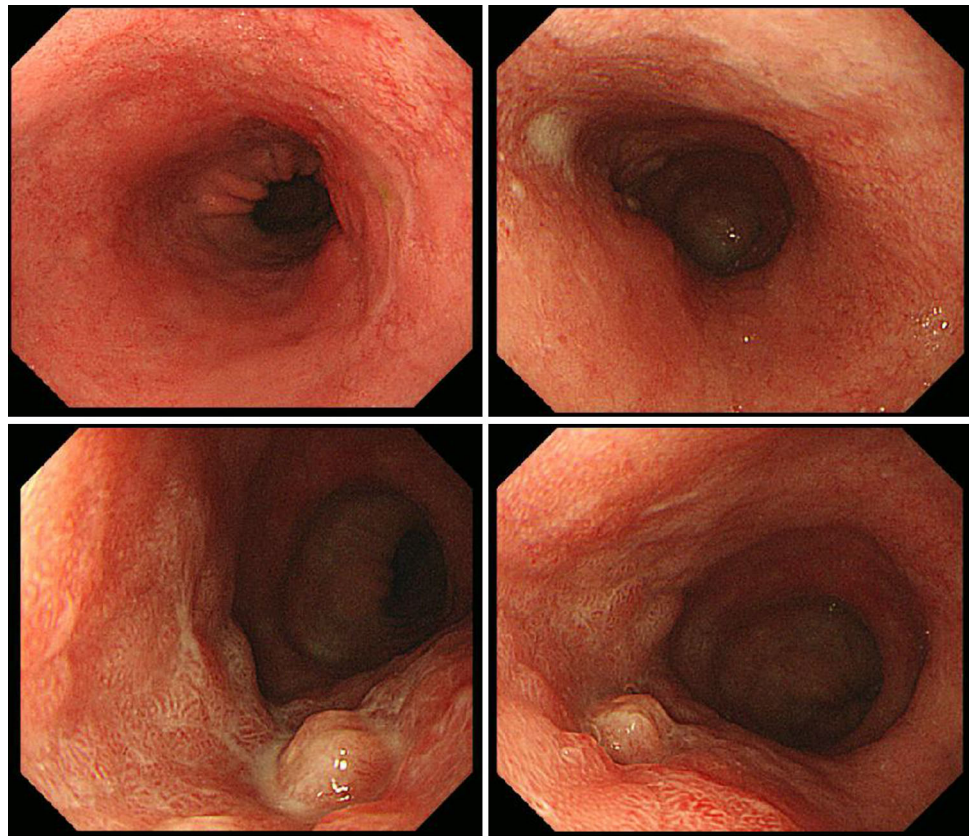
As another luminal examination, an upper gastrointestinal series (UGIS) is also generally used to make an easy diagnosis of AEF, when it visualizes extravasation of the contrast through the fistula or luminal irregularities due to hematoma or external compression [54]. However, its sensitivity is much lower than those of CT or EGD.

Accordingly, we should be mindful of the limitations of these modalities to demonstrate the presence of AEF. There was a case report in which the diagnosis was confirmed retrospectively after the second session of the TEVAR procedure, despite the fact that the initial examination of UGIS and CTA missed the presence of post-TEVAR AEF due to the lack of typical findings [47]. Therefore, for early diagnosis prior to the occurrence of lethal complications, it is important to keep in mind that once suspicious symptoms have occurred in any patient with a history of TEVAR, we should not rule out the

**Fig. 1** **a** An enhanced CT on admission showed a soft tissue density mass with air bubbles around the graft (*arrow*). **b** On post-admission day 5, the laboratory data had improved by anti-biotic administration, but the re-examined CT presented a high-density spot (*arrow*) in contact with the esophagus around the graft



**Fig. 2** EGD revealed a white pus discharge from a small ulcerative lesion without any signs of acute bleeding in the mid-esophagus, and the background mucosa was long-segment Barrett's esophagus (C8M10) with no suspicion of dysplastic Barrett's esophagus



possibilities of AEF, in spite of its rare occurrence as well as occult findings in several pre-operative examinations.

### Principle treatment strategy of post-TEVAR AEF

Once an AEF has developed, it can rapidly cause lethal complications. Because of the poor condition of their basal physiology, in most AEF patients in an urgent condition, surgical intervention is contraindicated. Therefore, there remain many issues important for improving the effectiveness of treatment.

### Radical surgical approach

A first case report in 1980 described that a patient with AEF caused by a foreign body was successfully treated by surgical treatment, which consisted of the cross-clamping of the descending TAA followed by primary closure of the fistula [55]. The current surgical approach, such as (i) primary resection of the esophagus, (ii) debridement of the contaminated tissues followed by abundant lavage of the mediastinum and (iii) in situ reconstruction of the aorta with a prosthesis, has been established as the first-line surgical strategy for AEF [25, 56–59].

With the development of new surgical techniques and devices, primary closure of small defects of the esophageal wall has become possible only in selected cases without gross contamination in the mediastinum. However, primary repair is reported to be frequently unsuccessful, due to the weakness of the wound and refractory defects of AEF, and, as a result, the breakdown from suturing defects might induce the recurrence of AEF [56]. Instead of wall repair, esophageal resection might eliminate the risk from disruption of the sutured fistula and minimize the recurrence of contamination through the fistula (Fig. 3). Therefore, most recent studies emphasized the importance of sub-total esophagectomy and ligation of the distal esophagus with a cervical esophagostomy and concomitant gastrostomy or jejunostomy to enable enteral access to bypass the fistula [25, 56]. However, such management has a significant mortality of from 25 to 78% due to its massive invasiveness in patients in a physiologically poor condition [21, 34, 60–62]. Actually, the high rate of mortality and morbidity of this surgical approach might be associated with the nature of emergency surgery to access the damaged aorta in a contaminated field, as well as the need for an invasive procedure, such as thoracic aortic cross-clamping or cardio-pulmonary bypass (CPB). In a recent study of 47 AEF patients, the newly established surgical strategies—esophagectomy, in situ reconstruction of the aorta, and additional wrapping of the fistula with a flap—were reported to be effective in the improvement of the mid-term mortality rate after the surgery [26]. Further development of surgical strategies will be needed.

### Combination therapy

At present, the fundamental strategies involve combination therapy, as follows: (1) controlling fatal bleeding by TEVAR in the urgent phase, and (2) radical debridement of the contaminated area as well as aortic/esophageal reconstruction in the semi-urgent phase. In fact, previous studies demonstrated that emergency surgery or conventional therapy alone after TEVAR might be fatal.

#### *Controlling fatal bleeding from AEF*

AEF frequently causes sudden life-threatening hematemesis with circulatory collapse. The aim of the initial treatment of AEF in the urgent phase is to maintain hemodynamic stability in the patients who frequently suffer from co-existent cardiopulmonary disease. In the past, the insertion and inflation of a Sengstaken–Blakemore tube, or embolization with isobutyl-2-cyanoacrylate, was used to stop bleeding temporarily prior to surgery [63–66]. With recent developments in endovascular stenting techniques, TEVAR has become widespread for the initial

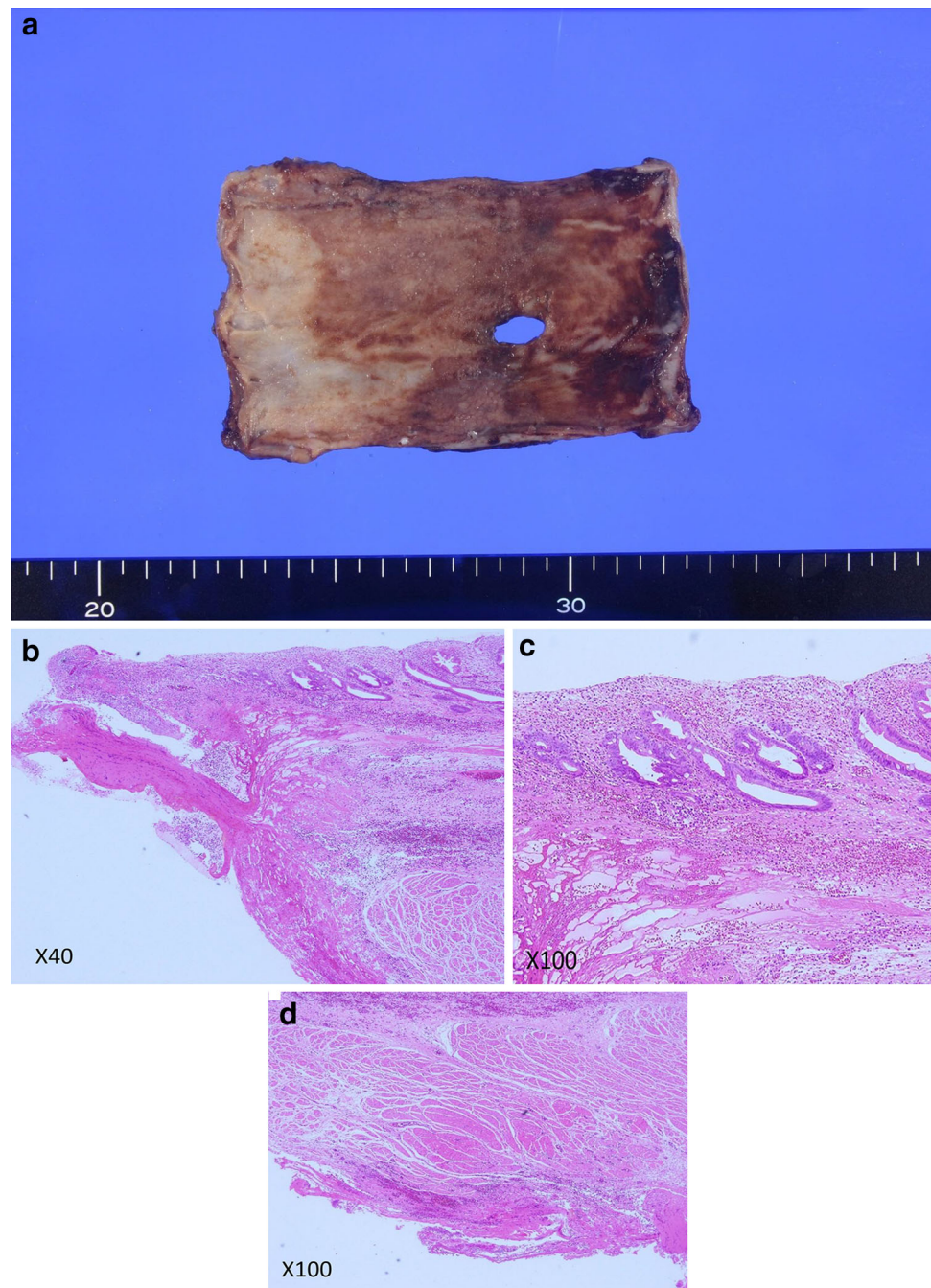
hemostasis of AEF with favorable short-term outcomes. TEVAR facilitates hemodynamic stabilization in the urgent phase of AEF, resulting in reduction of the morbidity and mortality of radical surgery during the semi-urgent phase. The outcomes of TEVAR for AEF were reported to have a high success rate of 87.3% and a favorable 30-day mortality rate of 19.7% [28, 67]. Further, Kubota et al. recommended that TEVAR should be performed at the initial step in all patients with AEF, regardless of their hemodynamic stability on admission [25]. Actually, the symptom-free interval between sentinel hemorrhage and the following massive exsanguination is unpredictable. Accordingly, TEVAR is more useful than emergency open surgery for high-risk AEF patients in an urgent situation, but there is no available data about its durability for AEF patients.

In such AEF cases, the graft is usually positioned in the contaminated area during emergency treatment, although the material is not immune to infection. There is no consensus regarding the optimal aortic substitute, including the implantation of a Dacron graft, a PTFE graft and so on [68]. In other words, TEVAR itself does nothing to control the infectious condition or to heal the esophageal wall defect, leaving the patients at risk of graft infection and/or fistula recurrence and persistent mediastinitis. When the graft replacement is performed repeatedly in such a contaminated field, the recurrence of an endo-leak within the aneurysmal sac or the persisting graft infection may become refractory [30]. A previous meta-analysis study described that the recurrence of AEF and graft infection after TEVAR occurred in 13.8 and 15.2% of the patients, respectively [28], and that prolonged ineffective administration of intra-venous anti-biotic medicine was the most significant factor associated with a lower mortality in the multi-variate analyses, despite the lack of definitive strategies for post-operative anti-biotic usage. Previous studies pointed out that the outcome of conservative management alone after TEVAR might be fatal due to recurrent hemorrhage or sepsis [26, 28, 40, 68–72]. Accordingly, TEVAR should be performed only as a bridging treatment before radical surgery is planned to treat the inflamed lesions of AEF patients [69].

#### *Perioperative management prior to radical debridement*

After the primary TEVAR, intensive medical support, such as treatment for anemia, controlling infection by long-term administration of broad-spectrum antibiotics, medical blockade of gastric acid with proton-pump inhibitor, and nutrition by total enteral feeding via percutaneous gastrostomy (PEG)/jejunostomy, are required to improve the general condition. It is widely believed that once the physical condition has thereby improved, the patient should be referred to undergo radical surgery as soon as possible.

**Fig. 3** Post-operative specimens of the esophagus with AEF: the specimen obtained by esophagectomy (**a**), and the histological examination (**b**:  $\times 40$ , **c**, **d**:  $\times 100$ ) showed fistula formation with abundant inflammatory cell infiltration in non-malignant metaplastic Barrett's epithelium



Despite the lack of consensus about the appropriate interval from TEVAR to radical surgery, Okita et al. proposed that the optimal timing was within 1 week; otherwise, the graft infection might progress [68].

#### *Surgical strategy after TEVAR*

Recent studies have emphasized that the combination therapy should be mandatory to cure post-TEVAR AEF [68, 69, 73]. A multi-center study of patients with post-TEVAR AEF demonstrated no survivors at 1 year after

TEVAR alone [73]. Another study revealed that extensive debridement with simultaneous resection of the esophagus and in situ reconstruction of the aorta using CPB provided better outcomes than TEVAR alone in terms of no recurrence [68].

However, there is no established surgical method. A Japanese study of 16 patients with AEF (11 patients with TAA, 5 with esophageal cancer and 1 with fish bone penetration) described that after the initial treatment (8 patients treated by TEVAR, 2 by a bridge TEVAR to surgery, 2 by extra-anatomical bypass and 5 by in situ

aortic reconstruction), there were 8 cases treated by esophagectomy, 7 cases by repair with an omental flap and 4 cases by simultaneous resection of the esophagus and in situ aortic reconstruction reinforced with a flap, and that there was a significant difference in the mortality rate not among the various surgical strategies, but among the AEF etiologies [68]. Additionally, in a meta-analysis, Canaud et al. described that only 11.1% of the 72 patients treated by TEVAR for AEFs were according to the scheduled strategy, and, finally, a total of 44.4% of the patients were treated by 1 or 2-staged surgical procedures, resulting in 11 patients with post-operative death due to graft infection and 10 patients from AEF recurrence. They suggested that poor control of the inflamed lesions even with prolonged antibiotic treatment and/or incomplete surgical management might have caused the significantly higher rates of mortality and morbidity (Fig. 4) [28, 74].

### Palliative treatment for AEF

Although TEVAR is usually performed as a bridging treatment, its successful use as a definitive treatment for limited cases has been reported [73, 75]. Some patients whose conditions made them unlikely to tolerate surgical intervention were reported to survive with conservative treatment, consisting of anti-biotic therapy and percutaneous drainage/aspiration with/without TEVAR, during a limited period, when they had only a small fistula with a small amount of fluid collection around the fistula, and with no evidence of sepsis [31, 42]. Kasai et al. reported a case of post-TEVAR AEF with advanced hepatocellular carcinoma that survived after conservative management alone without TEVAR for 14 months after the initial bleeding event [76]. Numan et al. described a case of post-TEVAR AEF related to an infected aneurysm that was treated by CT-guided insertion of a

drainage catheter [77]. Burks Jr. et al. suggested in their seven-case series that the combination therapy of TEVAR followed by long-term anti-biotic treatment and percutaneous drainage might be a safe method [42, 78].

Other groups demonstrated the usefulness of self-expanding metallic stents (SEMS) to cover the fistula from the esophageal side. Eggebrecht et al. reported that two of three patients with post-TEVAR AEF survived for 2–6 months after the insertion of SEMS [30]. Onodera et al. and Tao et al. reported that the implantation of covered SEMS followed by the life-long use of broad-spectrum antibiotics prohibited re-bleeding and controlled inflammation in post-TEVAR AEF patients [24, 42]. However, stent migration due to incomplete sealing on the smooth surface of a non-tumorous esophagus may require repositioning or replacement of the stent. A previous study demonstrated that 17% of 187 esophageal stent insertions required repositioning or replacement [23]. But, the development of a new-generation SEMS with anchors, such as the Niti-S esophageal stent and Double Niti-S™ esophageal stent (Taewoong Medical, Seoul, South Korea), may be able to reduce risk of such migration. Moreover, considering that the over-the-scope clip (OTSC) system was developed for closing esophageal fistulas or for anchoring SEMS under direct view of endoscopic examination [80], it may be assumed that SEMS anchored with the OTSC system can be used as an alternative strategy for SEMS together with endoscopic ultrasound-fine needle aspiration techniques for drainage [81, 82].

Accordingly, TEVAR and/or esophageal stenting followed by anti-biotic treatment and/or percutaneous drainage could be an option for a palliative strategy for a substantial period [47]. Further developments of endoscopic technologies can be expected to contribute to the improving the outcome of palliative strategies.



**Fig. 4** Broncho-mediastinum fistula formation (*arrow*) after surgical intervention followed by conventional treatment with broad-spectrum antibiotics and enteral nutrition therapy

### Summary of current treatment strategy

After TEVAR is performed as an urgent treatment, complete eradication by debridement of all contaminated tissues followed by abundant lavage of the mediastinum is recommended as radical surgery. In contrast, conservative treatment alone after TEVAR is controversial, because endo-leakage after stent placement on the weakened wall of the aorta might promote the continuation of inflammatory changes. However, previous studies demonstrated that the rate of mortality after surgery for secondary AEF (78%) was higher than that for primary AEF (61%) [21]. Therefore, some investigators proposed that the appropriate choice in treatment strategies might be depend on the patient's condition, size of the wall defects and the etiology of AEF [47, 79].

## Perspectives

Due to the low incidence of post-TEVAR AEF, previous studies presented relatively favorable outcomes for the current strategy during a limited period, despite their poor prognosis [60]. However, there is a lack of uniformity in the patients' demographics, etiologies of AEF as well as treatment strategies, such as antibiotic usage, TEVAR device or surgical method. Furthermore, most of the data obtained from case reports and case series may include some bias. Therefore, it is hard for us to determine the most suitable management strategy for post-TEVAR AEF, the incidence of which will likely increase in the near future. Accordingly, a prospective registry with a large number of post-TEVAR AEF patients will help to determine the precise results of the combination treatment, and to establish an ideal strategy.

## Conclusions

Although AEF is a fatal entity, the feasibility of ongoing strategies has not been fully elucidated because of its small incidence. As post-TEVAR AEF can be one of the major iatrogenic complications, early diagnosis prior to the onset of lethal symptoms is critically important. Although various diagnostic modalities have been used to make an early diagnosis, none of them seems to have enough sensitivity or specificity to achieve accuracy [45]. Therefore, to provide promising treatment for post-TEVAR AEF patients in the current setting, we should be aware of the possibility for any patient with a treatment history of TEVAR to require urgent TEVAR followed by radical surgery. Further developments in diagnostic imaging and treatment technologies for post-TEVAR AEF are needed.

**Figure legends:** Representative photos of a post-TEVAR AEF case in our institution.

A 77-year-old man presented with nausea and high-grade fever. He had a history of a TEVAR for thoracic aortic aneurysm at the age of 75, and, with regular use of anti-thrombotic drugs, he underwent regular surveillance after TEVAR every 6 months. From the age of 76, he took on-demand proton pump inhibitor for gastro-esophageal reflux disease. On admission, he was hemodynamically stable without any sign of active bleeding, and presented elevated laboratory markers of systemic inflammation with a high value of procalcitonin, despite negative results at several sessions of blood culture. With intra-venous administration of ceftriaxone followed by oral administration of cefcapene pivoxil hydrochloride, several examinations were performed during starvation to investigate the infectious focus. We concluded that his symptom was

caused by mediastinitis due to post-TEVAR AEF, which might be induced by the rupture of an inflamed TAA. Although his condition was relatively poor, we performed esophagectomy with a cervical esophagostomy and concomitant gastrostomy and jejunostomy on post-admission day 19. Thereafter, it was not possible to perform the planned aortic/esophageal re-construction. Instead, his condition gradually got worse, resulting in sepsis due to the formation of broncho-mediastinum fistula.

## Compliance with ethical standards

**Conflict of interest** Kaname Uno, Seiichi Takahashi, Daisuke Komazawa, Tomoyuki Koike and Tooru Shimosegawa declare that they have no conflicts of interest.

**Human rights** All procedures followed have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

**Informed consent** Informed consent was obtained from the patients whose images were used as a representative case of aorto-esophageal fistula in the manuscript.

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