ENDOVASCULAR TREATMENT OF COMPLEX ABDOMINAL AND THORACOABDOMINAL ANEURYSMS
This book is dedicated to Roy K. Greenberg, who continues to inspire us to push the limits of endovascular treatment of aortic pathologies.
Until a few years ago, open surgery was the only form of treatment for patients with aortic pathologies. However, less invasive methods such as endografting with chimney, branched and fenestrated stent grafts have been increasing in importance in recent years. The demographic changes and the increasing number of high-risk patients have led to a shift toward endovascular techniques. This book focuses on illustrating the alternative techniques to open surgery for treatment of complex aortic diseases in high-risk patients.

Some of the techniques, e.g. the use of fenestrated grafts, were introduced more than ten years ago. Accordingly, long-term results of this technique are available; benefits as well as limitations of this technique are well-known.

Other procedures such as the chimney technique are relatively new and not yet standardized. Mid- and long-term follow up results are still not available. Initially used as a bail-out procedure, the technique is now discussed as an alternative treatment of patients with extremely short or no aneurysm neck.

As thoracoabdominal aortic aneurysms still represent one of the most demanding pathologies with high morbidity and mortality, even in specialized cardiovascular centers, the description of the complete endovascular approach with branched endografts and the hybrid techniques will have a central role in this book.

All possible approaches at the present day are described in a step-by-step manner, including complications and trouble shooting procedures. I would like to point out that the informations presented in this book are based on our many years of clinical experience, and may not entirely align with recommendations of the device manufacturers. Refer to the manufacturer’s instructions for use for specific information on a device.

I thank the authors for their contribution and Priya Bharadwaj, Ph. D., Jennifer McCann-Brown, Ph.D., and Jarin Kratzberg, Ph.D., for technical review.

I hope the book is helpful in your practice to choose a tailored strategy in sense of a case-to-case oriented treatment of complex aortic diseases.

Giovanni Torsello
List of Contributors

EDITORS

GIOVANNI TORSELLO, MD
Department of Vascular Surgery, Münster University Hospital and St. Franziskus Hospital
Münster, Münster, Germany

KONSTANTINOS P. DONAS, MD
Department of Vascular Surgery, Münster University Hospital and St. Franziskus Hospital
Münster, Münster, Germany

CONTRIBUTORS

MARTIN AUSTERMANN, MD
Department of Vascular Surgery, St. Franziskus Hospital Münster, Münster, Germany

MARIO LACHAT, MD
Clinic of Cardiovascular Surgery, Zurich University Hospital, Zurich, Switzerland

THEODOSIOS BISDAS, MD
Department of Vascular Surgery, Münster University Hospital, Münster, Germany

GIUSEPPE PANUCCIO, MD
Department of Vascular Surgery, Münster University Hospital, Münster, Germany

BÄRBEL BEREKOVEN
Department of Vascular Surgery, St. Franziskus Hospital Münster, Münster, Germany

FRANCISCO MARQUES DE AZEVEDO
Department of Vascular Surgery, St. Franziskus Hospital Münster, Münster, Germany
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Abbreviations

BECS: balloon expandable covered stent
CIA: common iliac artery
CSF: cerebro spinal fluid
CT: celiac trunk
EIA: external iliac artery
F: French
IBD: iliac branch device
IIA: internal iliac artery
LRA: left renal artery
LSA: left subclavian artery
RRA: right renal artery
SMA: superior mesenteric artery
SECS: self expandable covered stent
Endovascular aortic aneurysm repair of challenging anatomies is technically demanding and potentially hazardous. The main concern is inadequate endograft sealing, especially in short necks. The chimney endovascular technique has been primarily suggested as a rescue procedure for over-stented aortic side branches during endovascular treatment; however, it has also been used to increase the sealing zone in cases of an insufficient neck for endovascular approach.

There is no consensus or recommendation in the current literature about the suitable type of chimney grafts. Generally, balloon expandable covered stents (BECS), such as the Advanta/i-Cast, are characterized by high radial force and good fluoroscopic visibility, which allows for precise placement of the bridging devices in the target vessels. The Advanta stent-graft shows advanced conformability and adaptability of the device in the target vessel. Additional placement of a self-expanding bare stent increases the flexibility of the BECS, but placing the additional component in the small diameter target vessels may provoke significant reduction of the patent lumen and subsequent occlusion. In this context, the new generation of the Advanta/i-Cast (Atrium) covered stents, characterized by an open cell design (Figure 1.1), aims to improve the flexibility of the Advanta/i-Cast stent-grafts without reducing the radial force.

Figure 1.1 The new generation of the Advanta/i-Cast balloon-expandable covered stent with open-cell design.
Importantly, the chimney technique is feasible with the majority of available abdominal endografts. This fact allows urgent endovascular treatment of symptomatic or ruptured aneurysms with abdominal endoprostheses available in stock at any vascular center. Flexible devices with low profiles, such as the Endurant stent graft (Medtronic), perform very well in combination with BECS also in case with severe calcification and tortuosity in the iliacs, which may be very hazardous for fenestrated endografting.

Coscas et al. reported extensively on the issue of the “gutters”, also known as perigraft channels, located between the aorta, the chimneys and the abdominal endograft. The “gutters” might be the origin of type Ia endoleaks. However, the current published literature showed that occurrence of type Ia endoleak is rare. They can also be treated by cuff implantation or glue embolization (Onyx; ev3).

**Indications and limitations**

Anatomical preconditions for the use of chimney technique are the presence of at least a 15 mm neck distance between the target vessel which needs chimney graft implantation and the first aortic side branch above the covered stent. Other important prerequisites are patent subclavian artery and absence of extensive thrombus in the aortic arch and suprarenal segment. In cases where more than two branches of the pararenal aortic pathology are involved, fenestrated endografts should also be considered.

**Procedure**

– Cut down or puncture of the brachial artery and device/graft/stent introduction over a 0.035 Terumo wire (Terumo) and a 5 F catheter (MPA or Headhunter). In case of multiple chimneys, contralateral access is additionally required. Alternatively, cut down of the subclavian artery can be performed. Suturing of a large external conduit facilitates access, avoiding trauma to the subclavian artery.
– Catheterization of the target vessel. Withdrawal of the guide wire and application of contrast medium to exclude dissection and to identify side branches of the target vessel (Figure 1.2 A).
Introduction of the Rosen wire (Cook), which has a tight less traumatic J tip over a 6 F or 7 F shuttle sheath (Cook) into the target vessel. The sheath is placed into the target vessel. After this, the main body of the abdominal endograft can be partially deployed at the origin of the left renal artery (Figure 1.2 B).

Figure 1.3 A shows a juxtarenal aortic aneurysm with the SMA and left renal artery origins at the same level. The right renal artery has a chronic occlusion. In planning the implantation of two chimney grafts in two different target vessels, as in this case, bilateral puncture or cut down of the brachial artery is necessary. In a similar manner to that previously described for one chimney graft, two 7 F sheaths are placed in the SMA and left renal artery over the Rosen wire. This allows for advancement and partial deployment of the abdominal stent-graft with covering of the origin of the target vessels (Figure 1.3 B). The goal is to create a minimum neck length of 10 mm.

Abdominal endograft placement follows the insertion of the chimney graft (Advanta V12, Atrium) in the target vessel. After retraction of the sheath, the chimney graft can be deployed (Figure 1.4). We recommend at least a 2 cm landing zone for the chimney graft into the target vessel. The end of the chimney graft has to be between the covered part of the abdominal endograft and the anchor pins or hooks.

Figure 1.3 A) Juxtarenal aortic aneurysm with origin of the superior mesenteric artery and left renal artery at the same level. The right renal artery is chronic occluded. B) Successful placement of the 7 sheaths over Rosen wires in the SMA and left renal artery. The abdominal stent-graft is partially deployed at the origin of the target vessels.

Figure 1.4 The placement and full expansion of the abdominal endograft follows the deployment of the chimney graft in the target vessel (left renal artery).
TIP: in cases of an unstable positioning of the sheath, we suggest to have the covered stent already in the estimated location within the target vessel at the end of the sheath. Disadvantage of this maneuver may be that the length of the covered stent has to be previously determined.

TIP: in cases of chimney graft implantation, an oblique angiography in the renal arteries is helpful to document the origin of the SMA. This can prevent an inadvertent over-stenting of the SMA.

- Placement of bare stents in order to “reline” the chimney graft is optional.
- Kissing PTA of chimney graft and abdominal endograft: the chimney graft has to be inflated first, then the abdominal endograft; otherwise, fracture or collapse of the chimney graft is possible, especially when balloon expandable covered stents are used. Figure 1.5 illustrates the kissing PTA maneuver in one case with multiple chimneys (i.e. SMA and left renal artery) between the aortic endograft and the chimney grafts. Figure 1.6 demonstrates the final result of a single chimney graft deployed in the left renal artery with synchronous placement of the abdominal endograft at the origin of the target vessel. In this case, a bare stent (SMART, Cordis) for relining of the chimney graft was also implanted within the covered stent providing flexibility.

TIP: additional placement of bare stents within the chimney grafts may lead to significant narrow of the patent lumen of small target vessels with consecutive occlusion.
Persistent type I endoleak

The chimney endovascular technique can be also used in cases of a rapidly growing abdominal aortic aneurysm caused by dislocation of a previously implanted abdominal endograft.

The case presented in Figure 1.7 A demonstrates a 10 cm abdominal aortic aneurysm after previous implantation of a Talent endoprosthesis in a patient with severe iliac and neck angulation. The Talent endograft migrated, resulting in type IA (proximal) and IB (distal) endoleaks. The patient was treated by implantation of Endurant cuffs and a chimney stent-graft for the right renal artery (extending the proximal fixation of the endograft) and an Endurant limb (for distal extension of the right Talent limb) (Figure 1.7 B).

References