Endovascular treatment of acute Type A aortic dissection—the Endo Bentall approach

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Abstract: Outcome after classical surgical repair of acute Type A aortic dissection has steadily improved over the years and several modifications in cannulation and perfusion added to this achievement. However, subgroups remain where results of classical surgical repair still have room for improvement, particularly patients with severe preoperative malperfusion as well as elderly patients with a limited physiological reserve. So far, only small case series or case reports have been published on the endovascular treatment of dissected ascending aortas. However, a tube alone is not sufficient to fix the entire complex underlying problem in the vast majority of patients with acute Type A aortic dissection. In addition, these published reports are either due to a favorable anatomy or due to very localized disease processes, which are the exception and not the rule. The concept of an endovascular valve-carrying conduit may significantly increase the number of patients suitable for endovascular therapy and it may soon be common practice.

Keywords: Type A aortic dissection; ascending thoracic endovascular aortic repair (TEVAR); endovascular valve-carrying conduit

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Introduction

Acute Type A aortic dissection is still a deadly disease: Conservative treatment remains highly ineffective with up to 60% mortality (1) and even with surgical intervention the perioperative mortality remains stagnant between 10% and 20% in most centers (1-3). In addition, even with surgical repair, mortality rates for specific subpopulations have been reported to be as high as 75% (4) and up to 8% of all patients with an acute Type A aortic dissection are deemed inoperable even in high volume centers (5).

Thoracic endovascular aortic repair (TEVAR) has significantly broadened the therapeutic armamentarium for diseases of the aorta and has significantly reduced early mortality and morbidity in patients presenting with diseases of the descending thoracic aorta (6). However, the use of TEVAR in the ascending aorta particularly in the setting of acute aortic dissection remains experimental (7). In fact, since the first successful endovascular ascending aortic repair in 2000, the largest case series consists of 45 patients that were treated with ascending aortic TEVAR and most reports consist only of few patients in high volume centers (4,8-19). Also, reports are either due to a favorable anatomy or due to very localized disease processes, which are the exception and not the rule. Nevertheless, some authors have called for a TEVAR first strategy in specific subpopulations of patients with acute Type A aortic dissection (4).

Endovascular treatment of the ascending aorta is often prevented by anatomic limitations including the short length of the ascending aorta, the location of the coronary arteries as well as supra-aortic vessels, and the location of the entry tear (19). Moreover, in patients with acute Type A aortic dissection, successful TEVAR may be insufficient because of the frequent comorbidities of the dissection itself. In fact, an average of one third of all patients with an

acute Type A aortic dissection may present with progressive tamponade or moderate to severe aortic regurgitation (20). Lastly, in order to select the correct stent-graft size and guarantee sufficient long term durability, one needs to understand the dissection induced geometry changes of the ascending aorta.

Hence, in order to offer an endovascular therapeutic option particularly to patients deemed unfit for open surgery there are three main considerations that require further illumination: geometrical, anatomical, and clinical.

Geometrical considerations

Technical success of TEVAR in the setting of acute aortic dissection is defined as closure of the primary entry tear, induction of false lumen thrombosis, and true lumen expansion—thereby resolving the issue of distal malperfusion (21). Thus the TEVAR stent-graft diameter has to sufficiently expand the true lumen, but must not result in the formation of new entries or even cause aortic rupture. When treating the acutely dissected aorta, there is general consensus to limit oversizing to 5% (21). From previous work, performed by Rylski and colleagues (22), three important lessons were learned on the geometry changes of the acutely dissected ascending aorta:

(I) There is an induced average increase in the mid ascending aortic diameter of 32%. Of note, the diameter increase is different at the level of the sinotubular junction and the distal ascending aorta at the level of the offspring of the brachiocephalic trunk;
(II) The length of the aorta does not change when it dissects even though it may be a predictor of ascending aortic dissection (23);
(III) The increase in diameter of the ascending aorta is independent of patients' age, height, or weight.

Therefore, we are able to adequately calculate the pre-dissection aortic diameter from post-dissection computed tomography imaging in order to effectively determine the adequate stent-graft size that corresponds to the original media diameter of the aorta (22,24). To date, it is unclear whether we can achieve technical success with short straight stent-grafts or whether the different diameter increase in the proximal and distal aorta may require tapered stent-grafts.

Anatomical considerations

Compared to the descending aorta or the abdominal aortic bifurcation, the ascending aorta is significantly shorter and therefore ascending aortic stent-grafts have to be significantly shorter too. The covered area of the ascending aorta is limited proximally by the coronary arteries or the aortic sinus respectively and distally by the offspring of the brachiocephalic trunk. Moreover, the length of the stent-graft is limited by the available proximal and distal landing zones. There is general consensus that at least 20 mm are necessary for the safe deployment and durable fixation of a stent-graft, especially in case of short stent-grafts, and the entry tear should not be in the landing zone (21).

The average distance from the sinotubular junction to the offspring of the brachiocephalic trunk in dissected aorta has previously been measured and was found to be between 70 and 80 mm in average (5,25,26). Requiring 20 mm proximal landing zone and 20 mm distal landing zone would require the entry tear to be within an average length of 30 to 40 mm in the mid ascending aorta to be coverable by a stent-graft. Thus, with currently available stent-grafts, it is not possible to cover entries close to the aortic root or the coronary arteries, while entries in the distal ascending aorta would require highly complex fenestration or branching techniques. Therefore, the potential candidates for ascending TEVAR are highly limited by the length of the ascending aorta and the location of the entry tear. In fact, two high quality anatomical feasibility studies for ascending aortic TEVAR in patients with Type A aortic dissection identified just 31.5% (26) and 36.2% (27) of patients as potential candidates for an endovascular approach. The most common criteria contradicting an endovascular treatment was the lack of a sufficient proximal landing zone and the distance between the more distal coronary artery and the entry tear has been measured to be less than 20 mm in average (14). Thus, in order to treat more patients, it seems inevitable to reduce the length of the stent-grafts' landing zones. However, without additional anchorage this may increase the risk for stent migration and endoleak development.

Clinical considerations

Up to one third of all patients with acute Type A aortic dissection present with cardiac tamponade or moderate to severe aortic regurgitation and both conditions require prompt treatment (20). However, cardiac tamponade may not be a limiting factor for endovascular treatment when considering a transapical approach for stent-graft deployment. In fact, a transapical approach would not

only resolve the issue of cardiac tamponade but would also simplify true lumen wire placement while avoiding the steep aortic curvature at the aortic arch. The transapical approach is a routinely used option by cardiac surgeons. Accurate and correct deployment of the stent-graft in the short ascending aorta must be guaranteed because of the proximity to the coronary arteries and because of the short length of the stent-graft itself. In fact, a transapical approach is the shortest possible approach to the ascending aorta and it may therefore increase the accuracy during coaxial deployment of the stent-graft. The approach may therefore reduce the likelihood of endoleak formation. Nevertheless, significant aortic regurgitation will most likely not be treated by simple stent-graft deployment.

The Endo Bentall approach

Rylski *et al*. have first introduced the concept of an endovascular treatment of ascending aortic pathologies with valve-carrying conduits in 2014 (28). The concept consists of a proximal transcatheter aortic valve that is connected to an uncovered portion of a stent-graft. The uncovered portion allows free diastolic coronary blood flow. The distal portion of the stent graft is covered in order to sufficiently treat an ascending aneurysm or close an entry tear. Individualization is one cornerstone of the concept: the size of the catheter valve and the stent graft portion can be chosen individually and therefore allows complete individualization of the valve-carrying conduit. The two devices can be connected shortly before the implantation by a simple clip or a suture (*Figure S1*).

An endovascular valve-carrying conduit would add a third landing zone compared to the two landing zones of a conventional stent-graft. Using a catheter aortic valve not only resolves the problem of aortic regurgitation, but also effectively results in sufficient anchorage of the device. In consequence, the proximal and the distal landing zones of the stent-graft no longer need to prevent stent-graft migration but rather guarantee adequate sealing and false lumen perfusion. This may result in shorter landing zones and may therefore increase the number of patients that may be suitable for endovascular treatment by itself because the entry tear may now be more distal or proximal. Additionally, oversizing can potentially be limited and the risk for aortic rupture or new entry development would decrease. Consequently, the three landing zones of the valve-carrying conduit are defined as the aortic annulus, the sinotubular junction, and the distal ascending aorta proximally to the offspring of the brachiocephalic trunk.

Lastly, the valve-carrying conduit would not be limited to patients without aortic regurgitation, instead it would be able to treat the valvar pathology at the same time. Thus, the potential number of patients that may be candidates for endovascular treatment increases even more.

Conclusions

The treatment for acute Type A aortic dissection will remain a surgical domain and the treatment of choice will be conventional surgery in most cases for a long period particularly in the case of coronary artery involvement, large entry tears involving the ascending aorta and the aortic arch, or in case of previous coronary artery bypass grafting. However, there is growing recognition of endovascular therapy as a player in the treatment of ascending aortic pathologies particularly in patients that are unfit for open surgical repair (5). A single endovascular valve-carrying conduit may significantly increase the potential number of patients that may be treated and a tube alone may not be sufficient to treat the majority of patients. The rapid development and establishment of catheter based therapies for the treatment of cardiac and vascular diseases has shown us that a new era has begun. Endovascular treatment has successfully moved from the abdominal aorta to the proximal descending aorta and beyond. It will only be a matter of time until endovascular treatment will be routine practice for diseases of the ascending aorta too (29). The concept of a single endovascular valve-carrying conduit is already reality. Combining knowledge and technology will further pave the way.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Supplementary

Figure S1 The transapical implantation of an endovascular valve-carrying conduit into the ascending aorta of a pig (30). The transcatheter aortic valve and the ascending aortic stent-graft are connected shortly before the implantation with sutures and the two devices can be chosen individually (depending on the aortic annulus size and the ascending aortic length and diameter). The connected device is prepared for transapical access and successfully deployed. Three landing zones are used: the aortic annulus, the sinotubular junction and the distal ascending aorta proximal to the offspring of the brachiocephalic trunk. The uncovered portion between the transcatheter valve and the covered stent graft allows coronary perfusion. Correct deployment was confirmed after animal euthanasia.
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