Thieme

Initial Experience with the Transapical Access for TEVAR

Erste Erfahrungen mit dem transapikalen Zugang für das Stenting der thorakalen Aorta

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ZUSAMMENFASSUNG

Ziel Die Therapie des Aortenaneurysmas erfolgt zunehmend interventionell. Der Zugangsweg stellt dabei eine wichtige Limitation dar; so ist beispielsweise der transfemorale Zugang oftmals aufgrund von Gefäßpathologien wie erheblichem Kinking oder Okklusionen nicht nutzbar. Hier kann der transapikale Zugang eine elegante Alternative bieten. Ziel ist es die Machbarkeit eines transapikalen Zuganges zur endovaskulären Therapie des thorakalen Aortenaneurysma (TEVAR) zu beschreiben.

Material and Methoden Bei drei Patienten mit thorakalem Aortenaneurysma bei denen ein transfemoraler Zugang nicht möglich war (2 × chronisches Leriche-Syndrom; 1 × massives Kinking aller Gefäßabschnitte) wurde ein transpikaler Zugangsweg für die TEVAR gewählt. Über eine Mini-Thorakotomie wurde der Herzapex freigelegt und nach Direktpunktion ein Führungsdraht über die Aortenklappe in die A. thorakalis descendens gelegt. Hierüber erfolgt die TEVAR Prozedur unter angiografischer-Führung.

Ergebnisse Der Eingriff war bei allen Patienten technisch erfolgreich mit kompletter Ausschaltung des Aneurysmas ohne Endoleckage. Ein Patient erlitt am Tag 4 nach der Intervention eine spinale Ischämie mit nachfolgender Paraplegie. Dieser Patient verstarb 43 Tage nach dem Eingriff an einer Ösophagusruptur. Die Nachuntersuchungen der beiden anderen Patienten zeigten einen unauffälligen postinterventionellen Befund.

Schlussfolgerung Der transapikale Zugang bietet in ausgewählten Fällen eine mögliche und sichere Alternative zum transfemoralen Zugang für die TEVAR.

Kernaussagen

- Der transapikale Zugang sollte bei TEVAR bedacht werden, sofern die transfermorale Route nicht möglich ist.
- Die umgekehrte Positionierung des Stents muss bei der Planung der Prozedur und der Stentplatzierung bedacht werden.
- Im Fall von Vegetationen der Aortenklappe ist besondere Vorsicht geboten, um das Risiko eines Schlaganfalls und peripherer Embolien zu reduzieren.

ABSTRACT

Background The endovascular approach has become a mainstay in the treatment of aortic aneurysms. While the transfemoral approach is most commonly used, it is often inaccessible due to a vascular pathology, such as occlusion, tortuosity or heavy calcifications. The transapical access provides an alternative approach. The goal of this study is to report the feasibility of the transapical approach for total endovascular repair of thoracic aortic aneurysms (TEVAR).

Methods Three patients with thoracic aortic aneurysms with inaccessible femoral arteries underwent TEVAR via the transapical approach. For access, the apex of the left ventricle was exposed by a mini-thoracotomy. After left ventricular puncture, a stiff guidewire was placed through the aortic valve into the descending thoracic aorta. All stent grafts were delivered under fluoroscopic guidance.

Results All three procedures were technically successful with complete exclusion of the aneurysm without endoleak. One patient suffered spinal ischemia with subsequent paraplegia on day 4 after the procedure. The same patient died on day 43 after the procedure due to esophageal rupture. The two remaining patients did not present procedure-related problems. **Conclusion** The transapical access is a feasible and safe alternative to the transfemoral route in selected cases scheduled for TEVAR.

Key Points

- Transapical TEVAR is a feasible option if the transfemoral route is not accessible.
- Reversed orientation of the stent graft has to be taken into account for procedure planning and graft deployment.
- Care has to be taken in the case of aortic valve vegetation in order to avoid stroke due to downstream embolism.

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Introduction

First reported in 1994, total endovascular repair for thoracic aneurysms (TEVAR) has become a mainstay of therapy, particularly for treating high-risk patients [1]. TEVAR provides several advantages over open surgical repair, including fewer complications, less blood loss and shorter hospital stay. Early problems such as durability of the devices have been greatly improved over the years. Problems caused by the size and limited flexibility of the delivery systems were mostly overcome by the introduction of low-profile delivery systems and routine use of hydrophilic coatings. Moreover, advanced access techniques, such as crack-and-pave or application of one or more buddy wires, have been described [2]. Thereby access vessel-related limitations of TEVAR were reduced. Nevertheless, access-related limitations and complications are still to be considered, particularly in patients with small vessel size or complex anatomy of the access vessels. This may eventually lead to devastating sequelae.

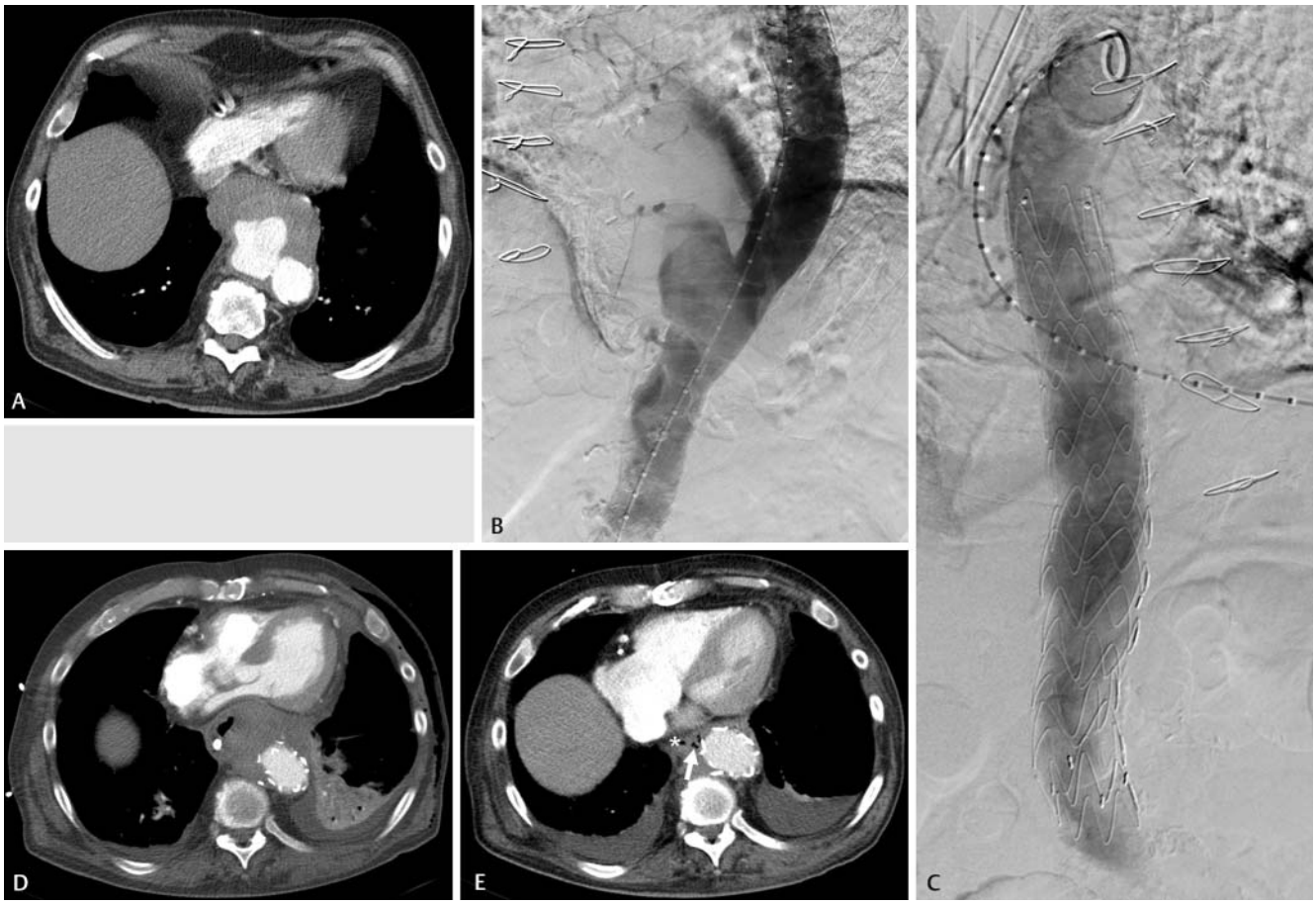
In these patients alternative access routes need to be considered. The transapical access has proven feasible in transcatheter aortic valve implantation (TAVI) [3]. First published in 2009 for treating an aortic arch aneurysm, TEVAR as an antegrade approach towards the descending thoracic aorta also proved feasible [4]. In this technical report we describe the transapical access technique, our early results using this approach for treating aneurysms in the descending aorta and provide a review on the available literature for this approach.

Technique

Informed consent was obtained from all patients prior to the procedure. All procedures were performed in a hybrid operating room with a fixed C-arm fluoroscopy unit (Artis Zee, Siemens, Erlangen, G) under general anesthesia. First an i. v. antibiotic (Cefuroxim 1.5 g, Actavis, Hafnarfjördur, IS) was administered and systemic heparinization (100 U/kg) with a target-activated coagulation time of 250 seconds was achieved. Thereafter, the left ventricular apex was surgically exposed by means of a left thoracic mini-thoracotomy at the level of the sixth intercostal space. Prior to puncture of the left-ventricular apex, two-paired felt-pledgeted purse-string sutures were applied at the left ventricular apex and secured by tourniquets. Thereafter, the left ventricle was punctured with an 18G needle (Surflo, Terumo, Leuven, BE) and a hydrophilic guidewire was advanced through the aortic valve into the ascending aorta. In Seldinger's technique a short 6F introducer sheath (Pinnacle, Terumo, Leuven, BE) was then placed distal to the aortic valve. Via a pigtail catheter an arteriogram of the aorta and the supra-aortic arteries was obtained in the left anterior oblique position (LAO 40°) in order to depict the aneurysm anatomy and to have an orthogonal view on the origin of the left subclavian artery. The pathology was crossed by means of a hydrophilic guidewire and exchanged for a stiff Lunderquist guidewire (Cook, Bloomington, IN) which was placed deep in the abdominal aorta far beyond the intended distal landing zone. A 24F introducer sheath (Extra Large Check-Flo Introducer, Cook, Bloomington, IN) was advanced into the left ventricle without crossing the aortic valve and manually stabilized throughout the procedure. A standard thoracic stent graft, sized to meet the individual patient's pathology, was introduced and advanced under fluoroscopic control. After the target position was reached, the blood pressure was lowered medically aiming for a target mean pressure of about 55 mmHg and the stent graft was released under fluoroscopic control. Care was taken not to cover the left subclavian or left carotid artery, as in the reversed position there were no bare springs through which the supra-aortic perfusion could be maintained. After the deployment system was removed, a 40-mm Coda balloon (Cook, Bloomington, IN) was introduced and the proximal and distal landing zones were carefully molded to the aortic wall. A final angiogram was obtained and the wire and sheaths were removed while the purse-string sutures were tightened, thus closing the left ventricular apex. A chest tube was placed in the left thoracic cavity. The thoracic incision was closed using a standard surgical technique. Finally the patients were transferred to the intensive care unit (ICU).

Case 1

A 79-year-old male presented with chest pain and a known thoracoabdominal aortic aneurysm (TAAA). He had undergone endovascular treatment of an infrarenal abdominal aneurysm 13 years before. Contrast-enhanced computed tomography (CT) revealed progression of his known TAAA with a progression in diameter of 1 cm within 9 months and a maximum diameter of 6.7 cm. There were also two new penetrating aortic ulcers present. He was diagnosed with symptomatic TAAA and stent graft placement was considered the treatment of choice. As CT showed a tortuous anatomy of the iliac arteries with stenosis and severe double curve kinking of the thoracic aorta, a flexible low-profile stent graft (Zenith alpha, Cook, Bloomington, IN) was chosen. The procedure commenced in standard fashion via a left common femoral artery approach. The femoral artery was surgically exposed. After a Lunderquist wire was placed in the ascending aorta, the stent graft was advanced into the aorta, but it proved



▶ **Fig. 1** CT depicts the contained aortic rupture directly dorsal to the left atrium in this 66-year-old male **A**. Transfemoral angiografy illustrates the position of the rupture **B**. As transfemoral stenting was not feasible, a transapical access was used and the stent was deployed in the reverse position. Transapical completion angiogram shows correct stent position **C**. The CT angiography 2 days after the procedure shows complete exclusion of the rupture and the hematoma dorsal of the left atrium **D**. Four weeks later the patient came back with chest pain. While the stent is in the correct position, the hematoma is completely gone and there is some air close to the stent graft (arrow), separate from the esophagus (asterisk). This finding is indicative of esophageal rupture **E**.

▶ **Abb. 1** Die CT zeigt eine gedeckte Ruptur der Aorta thorakalis descendens direkt dorsal des linken Atrium bei einem 66-jährigen Patienten **A**. Die transfemorale Angiografie identifiziert die exakte Position der Ruptur **B**. Eine transfemorale Positionierung eines Stent-Grafts war nicht möglich, so dass ein transapikaler Zugang gewählt wurde. Der Stent-Graft wurde in dieser Situation verkehrt herum platziert. Die Abschlußangiographie bestätigt die korrekte Platzierung des Stent-Grafts **C** Die Kontroll-CT zwei Tage nach der Intervention zeigt das komplett ausgeschaltete Aneurysma und das entsprechende Hämatom dorsal des linken Atriums **D**. Vier Wochen später wurde der Patient mit starken Rückenschmerzen erneut aufgenommen. Die CT zeigt hier den Stent-Graft weiterhin in der korrekten Position, jedoch ist kein Hämatom mehr nachweisbar. Weiterhin ist wenig Luft (Pfeil) nahe des Stent-Grafts, aber distant vom Ösophagus (Sternchen) sichtbar. Dieser Befund weist auf eine Ösophagusruptur hin **E**.

impossible to properly place the stent across the proximal part of the double kinking of the thoracic aorta. An attempt to straighten the access with 3 additional Lunderquist wires inserted in parallel failed. Therefore, it was decided to change access to a transapical approach as described above. A 46 – 46 – 233 mm Zenith alpha aortic stent graft (Cook, Bloomington, IN) and a 46 – 46 – 150 mm Valiant Captivia stent graft (Medtronic, Santa Rosa, CA) were implanted with a 4 cm overlap. Contrast-enhanced CT obtained the following day confirmed complete exclusion of the aneurysm. He was discharged from hospital 11 days after the procedure. His follow-up was unremarkable and there were no signs of stent migration or failure on a CT scan 6 months after the procedure. Eventually the patient died 9 months after the procedure from acute pneumonia.

Case 2

A 66-year-old patient presented with acute chest pain. He had a history of myocardial infarction treated by coronary artery bypass graft surgery and coronary stenting with subsequent double antiplatelet medication. Contrast-enhanced CT revealed a contained rupture of the thoracic aorta with compression of the left atrium (▶ **Fig. 1**). Furthermore, severe iliac artery stenoses were diagnosed. Urgent aortic stent graft placement was indicated. The procedure commenced via the left common femoral artery as the left iliac arteries appeared to be more suited for endovascular treatment. First “cracking-and-paving” of the left iliac axis with placement of a 10 mm bare metal stent (SMART Flex, Cordis, Fremont, CA) was performed. However, preparation of the iliac arteries proved insufficient for advancing the 24F deployment

▶ **Table 1** Summary of current reports on transapical access for stent graft placement in aortic arch or descending aortic aneurysms.

▶ **Tab. 1** Zusammenfassung der bisherigen Literatur zum transapikalen Stenting von Aneurysmen des Aortenbogens und der A. thorakalis descendens.

author/year	patients [n]	pathology	location	adjunct procedures	results (follow-up)
MacDonald 2009 [4]	1	false aneurysm	aortic arch	femoral-to-carotid artery bypass	died day 10, respiratory failure
Kölbel 2011 [10]	1	true aneurysm	aortic arch	bilateral iliac-to-subclavian artery bypass & left carotid-to-subclavian artery bypass	died 2 h after procedure, myocardial infarction
Kappert 2012 [11]	1	true aneurysm	descending aorta	none	technical success (n.a.)
Weigang 2013 [12]	1	n.a.	n.a	n.a.	n.a.
Saouti 2015 [13]	3	true aneurysm	distal aortic arch	left carotid-to-subclavian artery bypass	technical success (3 months)
		true aneurysm	descending aorta	none	technical success (n.a.)
		ruptured true aneurysm	descending aorta	none	died week 3, multiorgan failure

system of the 38 – 38 – 200 mm Valiant Captivia endoprosthesis (Medtronic, Santa Rosa, CA). Therefore, the transfemoral procedure was abandoned and a transapical approach was chosen. The same 38 – 38 – 200 mm endoprosthesis was successfully deployed and the procedure was completed uneventfully. The day after the procedure, he presented with incomplete paraplegia, which was considered to be due to overstenting of the artery of Adamkievicz without protective liquor drainage. The latter was considered too risky due to the double antiplatelet medication. Contrast-enhanced CT two days after the procedure showed complete exclusion of the rupture with regular perfusion of the aorta and excellent run-off. The patient was transferred to a neurologic rehabilitation center on day 16 after the procedure. On day 38 after the procedure, he was re-admitted with improved neurologic function, but a new episode of chest pain. Contrast-enhanced CT showed no device migration, but the perigraft hematoma at the level of the left atrium was completely gone. Subsequent endoscopy revealed a 6 cm long tear of the esophagus at the same level. It was assumed to be secondary to the pressure from the extensive hematoma with rupture of the hematoma into the esophagus. The patient refused any kind of treatment and died 43 days after the initial procedure from mediastinitis due to the esophageal rupture.

Case 3

A 60-year-old man under treatment for mantle-cell lymphoma was newly diagnosed with a penetrating aortic ulcer directly distal to the left subclavian artery. The ulcer was diagnosed on the basis of contrast-enhanced CT performed as a regularly scheduled staging examination. Based on this diagnosis, endovascular treatment was deemed the therapy of choice. As the patient showed only small iliac arteries with a diameter of 5.5 mm for both common iliac arteries, a transfemoral access was deemed inappropriate and elective transapical stent graft placement was considered. The procedure was performed as described above and a 32 – 32 – 200 mm Valiant Captivia endoprosthesis (Medtronic, Santa Rosa, CA) was successfully placed. The procedure was completed without complications and the patient was transferred to the ICU. His further course was uneventful and follow-up CT prior to discharge showed a correct stent position with preserved perfusion of all supra-aortic vessels. He was discharged 10 days after the procedure and oncologic therapy was continued. During a 24-month follow-up period, no further events occurred and the patient is doing well.

Discussion

TEVAR in patients without sufficient peripheral vascular access or a very tortuous aortic anatomy poses a challenge, despite major improvements in the design of both stent grafts and deployment systems. While adjunctive techniques such as “crack-and-pave”, iliac conduits and direct aortic access have been described [2], these options may not provide the anticipated success or are quite invasive. Access to the target lesion is a relevant issue in patients with iliofemoral diseases such as stenosis, severe calcification, and tortuosity precluding delivery of an aortic stent graft in about 10 – 25 % of patients [5]. Therefore, an alternative approach, avoiding the iliac segment and providing more direct access with only a short distance towards the target is appealing.

With the introduction of TAVI in the clinical routine, the transapical approach became a routinely used option [3]. Thus, the use of the transapical access for stenting of the thoracic aorta seems an obvious approach. Consequently initial animal data on this technique proving the feasibility and safety of this novel approach

was published in 2008 [6]. The same group reported their first patient treated with this technique only one year later [4]. Nowadays this technique is discussed as a potentially ideal access for treating the ascending aorta. For treating the aortic arch and descending aorta, this approach has remained a niche technique and so far only few reports describe the use of transapical TEVAR (▶ **Table 1**). Only 7 patients with distal aortic arch or descending aortic pathology requiring stent graft placement using the transapical approach have been reported. In all patients heavily calcified, stenotic or tortuous iliac arteries were reported as the reason for choosing the transapical access. Our data adds to previous experience, indicating the transapical approach to be a safe and effective alternative to the femoral access. However, one has to be aware that the transapical access comes at the price of at least transient regional left ventricular dysfunction in about one-third of patients [7].

There are several technical aspects of the procedure that need to be discussed. Firstly the guidewire should be placed deep down to the abdominal aorta to provide sufficient stability. It is of particular importance to consider the reversed graft position. With the antegrade approach the stent graft is deployed in a reversed position, i. e. the bare springs of the graft are at the distal end of the target pathology. This needs to be considered in order to make sure that the distal part of an aneurysm is sufficiently excluded from perfusion. Conversely, the proximal end of the stent graft usually does not have bare springs and needs to be placed carefully in order to avoid overstenting of the supra-aortic vessels. Moreover, the stent is not designed for reversed positioning and the long term effects on the aortic wall need to be observed closely. With this approach the aortic valve has to be crossed. This may affect left-ventricular function and regularly causes regurgitation. While this effect is limited with only one wire crossing the valve, it becomes relevant if the deployment system of the stent graft crosses the aortic valve. In order to minimize the duration of regurgitation, we did not place the sheath across the valve and tried to keep the time of a large volume device crossing the valve as short as possible. Nevertheless, monitoring of left-ventricular function may be required in complex procedures. Moreover, aortic valve passage is associated with a risk of stroke, independent of whether an antegrade or retrograde approach is used [8]. In the case of aortic stenosis and calcifications or vegetation of the valve, one has to be aware of its role as a potential source of embolism. In such patients the indication for transapical stent placement needs to be very strict. Finally, the transapical approach requires multidisciplinary teams, such as in our setting where cardiac surgeons and interventional radiologists are working closely together. The effect of upcoming apical closure devices, which are currently under investigation, on these treatments remains to be seen [9].

The transapical approach for TEVAR is feasible and safe. It should be considered as an alternative in patients with severe aorto-iliac atherosclerotic disease and severe kinking of the access vessels.

Conflict of Interest

The authors declare that they have no conflict of interest.

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