The heart as access to the aorta†
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Abstract
Thoracic endovascular aortic repair (TEVAR) is an accepted treatment option for patients with thoracic aortic pathologies regarded as unfit for open surgery. Nevertheless, a subgroup of these patients is ineligible for classic TEVAR due to the lack of access vessels. We describe the transapical TEVAR technique enabling surgeons to perform TEVAR even in these patients.

Keywords: Transapical access • Aortic aneurysm • Thoracic endovascular aortic repair • Transventricular TEVAR • Transapical TEVAR

INTRODUCTION
Thoracic endovascular aortic repair (TEVAR) is an emerging technique yielding excellent results [1]. Due to its minimal invasiveness, TEVAR offers safe treatment even in high-risk patients denied conventional surgery [2]. Femoral or iliac arteries are typically used as access vessels for stent-graft insertion. Whenever this is made impossible for varying reasons, other access paths like the ascending or infrarenal aorta could be used. In cases where the transfemoral/transiliac and aortic access are ruled out because of severe atherosclerotic disease, transapical stent-graft implantation is an appealing alternative [3]. Here, we describe the technical aspects in transapical TEVAR.

MATERIALS AND METHODS
Transapical TEVAR should be performed in a hybrid operation room guaranteeing the best imaging quality in an optimal setting. General anaesthesia combined with extended monitoring including transoesophageal echocardiography (TEE) and cerebral oxygen saturation should be implemented [4]. Furthermore, the patient should be equipped with a transvenous or epicardial pacemaker. After systemic heparinisation (100 IU of heparin/kg body weight), both common femoral arteries (if possible, or alternatively, the left brachial artery) should be punctured and cannulated with catheter sheaths using the Seldinger technique over a soft guide wire. Then a 4–5-cm skin incision between the fifth intercostal space, directly in the sub-mammary fold, should be made, followed by a left anterolateral minithoracotomy. Double-tube intubation with the opportunity for single-lung ventilation may simplify this step. Subsequently, optimized apex exposure is achieved by a star-shaped opening of the pericardium and the placement of traction sutures. Then, two Teflonfelt-pledged-reinforced purse-string 3-0 polypropylene sutures should be made in the centre of the left ventricular apex to ensure safe haemostasis during and after the procedure (Supplementary Video 1). An arterial needle puncture enables placement of a 5F-catheter sheath over a soft guide wire using the Seldinger technique in the middle of the purse-string sutures. Via femoral or brachial access, an angiography catheter should be placed in the proximal aortic landing zone. A second sheath with a snare catheter should be introduced via the other femoral artery into the common iliac artery or infrarenal aorta. The soft guide wire from the apex should then pass the aortic valve under fluoroscopic and TEE control, advancing to the infra-renal aorta or iliac artery. There, it is captured using the snare catheter and changed to a super-stiff guide wire. To dilate the hole in the left ventricular apex, the 5F-catheter sheath should be replaced with a 12F-catheter sheath. Finally, a stent-graft (we used the Relay NBS plus thoracic stent-graft from Bolton Medical) is chosen according to the preoperative computed-tomographic measurements (Fig. 1).

The stent-graft should be inserted via the left ventricular apex and the super-stiff guide wire, carefully bypassing the aortic valve and aortic arch (Supplementary Video 2). For blood-pressure control, rapid pacing is recommended to achieve a blood pressure below 50 mmHg and laminar blood flow monitored by using the aortic angiocatheter as an arterial line. Under these optimized conditions, the stent-graft can be delivered in an inverted manner, beginning from the distal aortic segment to the proximal aortic segment against minimal aortic residual flow under fluoroscopic control (Fig. 2).

The introducer device is carefully removed after stent-graft deployment. At the end of the procedure, the stent-graft’s position should be documented in a final angiography, ensuring the technical success of the procedure [1]. After withdrawing the guide wire, the purse-string sutures are tightened at the left ventricular apex to control bleeding. A chest tube is placed in the left thoracic cavity, followed by layer-wise wound closure of the minithoracotomy. All femoral and brachial puncture sites can be
closed by a closure device. At the end of the procedure, aortic-valve function should be monitored by TEE.

COMMENT

TEVAR via a femoral or iliac approach is standard treatment for many descending aortic pathologies. However, TEVAR is not feasible in patients with severe atherosclerotic anomalies in the ascending and infrarenal aorta, or in the iliac vessels, due to the lack of access for stent-graft introduction. Transapical access for TEVAR via the left ventricular apex is a potential alternative for these patients [5].

However, the technique entails certain risks due to the fragile tissue of the left ventricle and aortic arch that one often encounters, and any tension must be avoided. Furthermore, the risk of injuring the aortic valve and of thromboembolism and stroke must not be disregarded.

We, hereby, rely heavily on our knowledge and experience in conducting transapical aortic valve implantation (TAVI) and TEVAR in the ascending aorta and aortic arch when planning and performing such an intervention. Our experience provides additional evidence of the feasibility of precisely implanting a stent-graft using an antegrade transapical approach [6].

Many promising surgical developments in the past have taken off via a new access to the operating field. The question now is, will transapical access affect our treatment options in the future and if so, will that open new treatment horizons for cardiac surgeons? The heart is no longer our sole therapy target—it may also provide minimally invasive access for the treatment of other organs.

SUPPLEMENTARY MATERIAL

Supplementary material (Videos 1 and 2) is available at EJCTS online.

Video 1: Two Teflon felt-pledget-reinforced purse-string sutures in the centre of the left ventricular apex.

Video 2: Stent-graft insertion via the left ventricle.

Conflict of interest: none declared.
REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr C. Mestres (Barcelona, Spain): Dr Weigang and his colleagues from Mainz present to us this technical note that sounds conceptually and practically easy. At this point in time, it is an attractive and provocative proposal in a very dynamic field. They have used the apex of the heart to gain access to the ascending aorta and the aortic arch to deploy a stent-graft for endovascular treatment of aortic disease. They stress the fact that transapical access is an elegant alternative in cases of poor or non-existent peripheral vascular access for stenting. I agree with this statement, although this must be modulated in a way that prevents the dissemination of a message that might be taken wrongly by the community.

In their presentation, Dr Weigang and colleagues described a way to perform aortic stenting through the transapical route. They have taken extreme care in looking for safety, as in any other transapical procedure, like transcatheter aortic valve deployment. They have also used the femoral and brachial arteries for secondary cannulations, like angiographic or snare catheters. Stenting of the aorta is therefore treated in the same way as the stenting of the aortic valve, and the authors advocate this approach as an alternative in patients with advanced peripheral vascular disease.

In this brief manuscript, the authors do not refer to actual clinical experience other than this case, and it would be worth knowing how and what they have done up to now. I am talking about the manuscript that I had the chance to review.

The apex of the heart has been used in surgery for at least 80 years. It has been used in mitral stenosis to perform valvotomies with a Tubbs dilator, for left ventricular venting, as an inflow port in the case of apico-aortic conduit or left ventricular assist device implantation, to name just a few procedures that have been out there for more than four decades. Therefore, there is nothing new in using this approach, although the younger generations are discovering it due to the introduction of transcatheter valve implantations. This is another example that makes clear that history has to be reviewed on a periodic basis.

I have some questions for you. First, what organs do you believe will benefit from such an approach? You mentioned that in your manuscript.

Dr Weigang: By organ, I mean the aorta here. I personally understand the aorta as an organ. Therefore that would be the first organ (after the heart itself) that could be also treated from a transapical approach.

Dr Mestres: That is a matter of definition. Second, the risk of stroke continues to be a matter of concern, possibly more than in TAVI cases. As you are going to navigate the aortic arch and the downstream aorta, the risks of embolization are there. How would you address cerebral protection? Do you think we have to make some progress with these issues?

Dr Weigang: I do not think there is a difference between the retrograde approach (from the groin) and the antegrade approach (from the ascending aorta or even the apex of the heart), in terms of cerebral embolism when you place your stent-graft into the arch. Thus I don’t believe that there is a higher risk for cerebral embolism with an antegrade approach.

Dr Mestres: Yes, but at the moment we don’t have this evidence.

Dr Weigang: Yes, I agree that we don’t have evidence of this so far. Only similar case series have been published to date and 50% of the procedures have so far failed. Therefore I thought it would be a good idea to write an article on how to do this kind of procedure successfully.

Dr Mestres: Number three, if the patient had severe peripheral disease, why did you guide wires through the groin? We know that sometimes guide wires, when trying to place balloon pumps and all these things, they don’t cross in patients with peripheral vascular disease and there might also be some risk.

Dr Weigang: A pull-through manoeuvre with the guide wire was planned, but I found it quite difficult to pass the femoral and iliac arteries because the iliac arteries measured less than 6 mm and the femoral arteries were under 5 mm. So there was no way to access that entry site with the stent-graft device. Even when I tried to use a conduit on these vessels, the patient also had a high-grade, stenosed aortic bifurcation and a previous thoracoabdominal replacement. But to succeed in this operation, it was extremely important to carry out a pull-through manoeuvre with the guide wire. That means that the guide wire goes from the apex into the heart and all the way down through the femoral artery and I was able to change it into a stiff guide wire which enabled me to navigate the entire stent-graft system in the arch.

Dr Mestres: Fourth, if, as expected, this approach becomes popular among the non-surgical community, who will be taking care of the intra-procedural and post-procedural complications of the apex, which have been well described in the literature for years? Although I may know the answer, I would love you to comment on this.

Dr Weigang: This is a very important question. I know that some vascular surgeons have already tried this access and some have failed. This access should only be used by cardiac surgeons; no one else should treat patients via transapical access.

Dr Mestres: Finally, would you address a patient with peripheral vascular disease for aortic stenting and concomitant aortic stenosis?

Dr Weigang: Very difficult to say.

Dr Mestres: I can imagine. I congratulate you and your group for renovating the interest in such an old approach for this particular indication, which surely will bring benefit to some of our patients.

Dr T. Schachner (Innsbruck, Austria): I also think that the transapical approach via a small thoracotomy is a good one. The knowledge among the cardiac surgeons has definitely increased since the introduction of transapical TAVI. So we should keep this in mind as an alternative.

Dr Weigang: But it is not an easy procedure.

Dr D. Hori (Saitama, Japan): Another approach for this case, I believe, is by having a laparotomy and delivering the device from the abdominal aorta. You chose to treat this patient from the apex by a retrograde approach. I think it is very difficult to position the distal end precisely at the subclavian artery. I think there is a risk of occluding the arch branches. Which one do you think is more risky, opening the heart apex and putting it retrogradely or by having a laparotomy and putting it through the abdominal aorta?

Dr Weigang: As I stated, this patient had already undergone a thoracoabdominal replacement and presented severe comorbidities with a history of stroke and just one insufficient renal kidney. Those are the reasons why we chose the minimally-invasive transapical access to the aorta here. Inserting the stent-graft via retrograde fashion, and placing it extremely close to the supra-aortic vessels is much easier than doing it the other way around via an antegrade approach when the stent-graft must be deployed from the distal to proximal aspect. To then be exact with the distal end of the stent-graft in the arch is even more complicated. You are absolutely right!

Dr D. Dougenis (Patras, Greece): I have a quick technical question. Why did you use pacing? If we normally put it the other way around, we don’t use pacing. Was it just to reduce the cardiac output?

Dr Weigang: I always use rapid pacing when I perform an endovascular procedure in the aortic arch, and in the ascending aorta. It is even more important when you’re dealing with a very short landing zone, and when you have to deploy the stent-graft very precisely close to one of the supra-aortic branches. In those circumstances, I would strongly recommend using rapid pacing for stent-graft deployment. Correct, in our case we deployed the stent-graft the other way around. The reason why I used it in this case as well was that I wanted to make sure that there was practically no blood flow in the aorta or blood pressure amplitude during stent-graft deployment that could cause stent-graft migration.

Dr K. Shimamura (Osaka, Japan): I agree with you that the transapical approach is a very good option to treat the aortic arch, but still there is a limitation in the selection of the device. Most of the devices are designed to deliver retrogradely. For example, the Relay NBS you showed in your presentation has the strongest radial force in the most proximal stent. I would like to know why you selected the Relay NBS for this case.

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Dr Weigang: I have quite a lot of experience with the Bolton device. I use most of the available devices on the market. But I personally feel that the Relay NBS from Bolton is a very good device for curved anatomies because it is very flexible, especially for the aortic arch and ascending aorta, and Bolton provides you with a huge custom-made programme. That means that this stent-graft I used in this particular case was a custom-made device, made exactly to fit the anatomy of the patient. The proximal fixation that you mentioned is also very important. Bolton designed the proximal and the distal stent-graft ends exactly the same. So the fixation of the stent-graft was on both ends, like it is normally for the proximal stent-graft part. Those are the reasons why I feel quite safe with this stent-graft.