

Transapical TAVR Devices

An era of rapid evolution in transcatheter aortic valve replacement technology.

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In the past 5 years, transcatheter aortic valve replacement (TAVR) has become a relatively standard technique for the treatment of severe aortic valve stenosis in high-risk patients in Europe and Canada. Due to the avoidance of sternotomy, cardiopulmonary bypass, cardioplegic arrest, and aortic cross-clamping, TAVR is regarded as a truly minimally invasive technique and a revolutionary technology. Promising clinical results in high-risk patients and rapid acceptance from clinicians and patients have resulted in an explosion of TAVR procedures in many countries. In Germany, for example, the proportion of isolated aortic valve replacement (AVR) operations that are now being performed as a transcatheter-based procedure is approximately one-third.

The first TAVR procedures were performed using an antegrade transseptal approach via the femoral vein, which proved to be too cumbersome for most operators. The development of a retrograde approach via the femoral artery represented a major milestone for TAVR, and the transfemoral approach remains the most commonly performed TAVR access route to date. The major drawback of the transfemoral approach, however, is its limited applicability in patients with small femoral arteries or peripheral vascular disease, as well as the not insignificant rate of vascular complications.^{1,2}

One of the main limitations that was observed during the initial experience with the transfemoral approach was the large access sheath diameters of 22 to 24 F. These large sheath diameters were not only problematic in patients with small femoral arteries but

also led to major vascular complications in patients with calcification, tortuosity, or previous interventions of the femoroiliac arteries and/or aorta. In more recent years, the sheath diameter of transfemoral devices has been significantly reduced to 16 to 18 F. In addition, percutaneous vascular closure devices have been developed to further reduce invasiveness and possibly reduce vascular complication rates of transfemoral procedures. Despite these developments, a significant proportion of patients remain ineligible for transfemoral TAVR because of peripheral access issues.

The transapical approach for TAVR was first applied in humans at our center in December 2004. Several other investigators have subsequently demonstrated that transapical left ventricular access is a safe and effective approach for TAVR.³⁻⁵ It is achieved by a left anterolateral minithoracotomy in the fifth or sixth intercostal space under general anesthesia.⁶ The main advantages of the transapical approach include the short distance from the left ventricular apex to the aortic valve, allowing for improved operator maneuverability during device implantation and the large sheath diameter that can be inserted.

The main disadvantage is the performance of a minithoracotomy and the necessity of general anesthesia. Despite these limitations, the number of patients undergoing transapical TAVR has increased exponentially during the last few years.⁵ In 2010, approximately 2,000 patients underwent transapical TAVR in Germany alone.⁷ The promising results for transapical access have led to the development of many different devices that

are at the clinical and preclinical stage. We review the transapical aortic valve prostheses with the largest clinical experience to date and briefly discuss future developments in this rapidly evolving area.

TRANSAPICAL TAVR DEVICES

The transapical approach for TAVR has been well established since its clinical introduction more than 5 years ago. Several companies have designed and developed new transapical devices, which are in varying stages of clinical development.

The Sapien valve (Edwards Lifesciences, Irvine, CA) is balloon-expandable and must be deployed during rapid ventricular pacing, without specific anatomic orientation. The Sapien valve has the largest clinical experience to date and was the first to acquire regulatory approval for transapical implantation. The remaining devices that are currently in clinical use are self-expanding and anatomically oriented, which may result in a lower risk of coronary obstruction. In addition, these devices can be deployed without ventricular pacing and its associated hemodynamic alterations.

The following sections describe the currently available transapical TAVR devices in greater detail.

Edwards Sapien

The Edwards Sapien prosthesis consists of bovine pericardial tissue leaflets that are fixed within a stainless steel, balloon-expandable stent. The bovine pericardial leaflets are matched for thickness and elasticity and are treated with an anticalcification solution. The Sapien prosthesis was the first, and to date only, commercially available valve approved for both transapical and transfemoral implantation in Europe. Since its CE Mark approval, a rapidly increasing number of high-risk patients have undergone Sapien valve implantation, with current estimates of more than 25,000 implantations worldwide. Several studies have been published displaying promising results for the treatment of high-risk patients with aortic stenosis. Perioperative mortality in larger studies varies between 3% and 11%,⁸⁻¹² which is acceptable given the high-risk patient populations. The SOURCE registry of Sapien patients is particularly important, in that it is a real-world multicenter registry including data from 32 European centers.¹²

The PARTNER (Placement of Aortic Transcatheter Valve) study was a groundbreaking randomized controlled trial comparing TAVR, medical treatment, and conventional AVR.⁹ In cohort A of the PARTNER trial, transfemoral and transapical TAVR were associated with a better 30-day survival rate than conventional AVR (96.5% vs 93.5%, respectively; $P = .07$) but a comparable survival rate



Figure 1. The Edwards Sapien XT valve.

after 1 year (75.8% vs 73.2%; $P = .44$).¹¹ Vascular complications were more frequent in TAVR patients, but major bleeding and atrial fibrillation occurred more frequently in the surgical AVR group. Although the trial was not designed to compare outcomes between the transapical and transfemoral approaches, there were no differences in perioperative mortality between these two groups (3.8% vs 3.3%). The similar perioperative outcomes are of interest given that transapical patients were a higher-risk subgroup because of the “transfemoral first” approach adopted by the study investigators. Two-year results of the PARTNER cohort A trial continued to show that TAVR is a reasonable alternative to conventional AVR in high-risk aortic stenosis patients.¹³ Mortality was higher 2 years after transapical TAVR (41.1% vs 30.9%), probably because of the higher risk profile in the transapical group.

The Sapien valve was the first to receive CE Mark approval for transapical and transfemoral implantation in 2007, and US Food and Drug Administration (FDA) approval for transfemoral implantation was granted in 2011 for patients at prohibitively high risk for conventional AVR (PARTNER cohort B). It is expected that FDA approval for transapical implantation, under the umbrella of TAVR for patients at high risk for surgery (PARTNER cohort A), will be granted in the third or fourth quarter of 2012.

Edwards Sapien XT

The Edwards Sapien XT is also a balloon-expandable pericardial valve, but it contains a cobalt chromium frame that permits thinner struts without a loss of structural integrity or radial force. Lower-profile struts allow for a reduced crimped profile and smaller sheath diam-

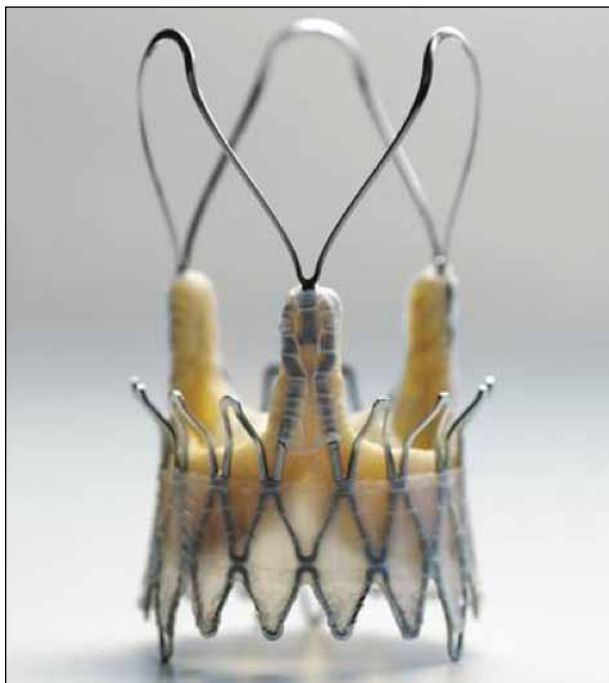


Figure 2. The Symetis Acurate valve.

eter (Figure 1). Furthermore, available valve sizes range from 20 to 29 mm and therefore allow for the treatment of patients with a wide range of aortic annular diameters (17–27 mm).¹⁴ The Sapien XT received CE Mark approval in 2011.

Symetis Acurate

The Symetis Acurate transcatheter valve (Symetis, Ecublens, Switzerland) (Figure 2) is a CE Mark-approved device consisting of a porcine valve that is mounted within a nitinol stent and is designed to achieve an intra-annular, subcoronary position. The self-expanding stent has three stabilization arms that are first deployed in the ascending aorta, and thus prevent tilting during deployment. The device design allows for anatomical rotation prior to final deployment.

The distal edge of the stent body forms the “upper crown,” which is not covered in order to minimize the risk of coronary artery obstruction. The purpose of the upper crown is to provide additional axial fixation, but more importantly, to facilitate and ease valve positioning with tactile feedback. The delivery catheter allows for sheathless transapical implantation. The device is available in three different sizes (small, medium, and large), covering aortic annular diameters ranging from 21 to 27 mm. Preliminary results with the Symetis Acurate valve have been encouraging¹⁵ and led to CE Mark approval in 2011.



Figure 3. The JenaValve device.

JenaValve

The JenaValve device (JenaValve, Munich, Germany) consists of a self-expandable nitinol stent that is designed for subcoronary implantation (Figure 3). A porcine tissue valve with a porcine pericardial skirt is mounted within the nitinol stent. A sheathless delivery system is used for antegrade transapical implantation. Three nitinol “feelers” are positioned in each sinus of the patient’s aortic root, resulting in fixation of the calcified native leaflets between the feelers and the base of the prosthesis. The stent design has a predefined implantation height and relies on axial and radial fixation. The JenaValve is available in three different sizes (23, 25, and 27 mm) allowing treatment of patients with a range of aortic annular diameters between 21 and 27 mm. Preliminary clinical results have been good,¹⁶ resulting in CE Mark approval in 2011.

Medtronic Engager

The Engager aortic valve prosthesis (Medtronic, Inc., Minneapolis, MN) is the second generation of the Ventricle Embracer valve (Ventricle Technologies Ltd., Netanya, Israel). Experience with the original Embracer valve was complicated by iatrogenic aortic dissection,¹⁷ but this problem seems to have been resolved with a redesign of the posts and delivery system. The Engager valve is composed of three leaflets cut from tissue-fixed bovine pericardium sewn to a polyester sleeve and mounted on a self-expanding nitinol frame (Figure 4). The stent assembly consists of a main frame and a sup-

port frame, which are coupled together so as to form the commissural posts of the valve.

The support frame arms are released into the aortic sinuses to achieve anatomical orientation prior to final deployment. By embracing the native aortic valve leaflets, the risk of coronary obstruction seems to be very low.¹⁸ Although the Engager valve can be repositioned after deployment of the support frame arms, no further repositioning is possible after unsheathing of the main frame. Two different sizes (23 and 26 mm) are currently under clinical investigation, with expected CE Mark approval in late 2012.

FUTURE DEVELOPMENTS

TAVR is an excellent option for high-risk aortic stenosis patients and has been performed in approximately 50,000 patients to date worldwide. Potential advantages include the avoidance of cardiopulmonary bypass, myocardial ischemia, and sternotomy.⁴ In addition, operative and patient recovery times are significantly shorter than for conventional AVR surgery.⁸ The transapical route for TAVR has the additional advantages of a very short working distance to the native aortic valve and the avoidance of device manipulation across the aortic arch.

No randomized trial has compared the transfemoral to the transapical approach thus far, but several lines of evidence point to safe and effective results for transapical TAVR. As noted above, the early (perioperative and 1-year) results were similar for transfemoral and transapical TAVR patients in the PARTNER A trial, despite the fact that a “transfemoral first” approach was employed in this study.¹¹ Although the higher risk profile for transapical patients has been associated with an increased mortality in some registries,^{19,20} others have shown very acceptable results for the transapical approach. The Canadian registry in particular revealed equally good results between transfemoral and transapical patients, despite a clearly higher risk profile in the transapical group.²¹ Furthermore, the transfemoral approach seems to be associated with a higher risk of stroke than the transapical approach and is associated with a higher risk of major vascular complications.²²

The favorable outcomes for transapical TAVR are particularly notable, given that most centers mostly employ this approach in patients with documented peripheral vascular disease, a marker for generalized atherosclerosis and a well-described risk factor for cardiac surgery.²³ Increasing comfort with the transapical approach has also led to the development of transapical mitral valve and ascending aortic procedures.^{24,25}

Further access options for TAVR procedures, other than the transapical and transfemoral routes, include



Figure 4. The Medtronic Engager valve.

the common iliac artery, subclavian artery, and ascending aorta via a hemisternotomy.^{26,27} These alternative TAVR procedures can also be performed without cardiopulmonary bypass and myocardial ischemia but require intubation, ventilation, and a separate incision, similar to the transapical technique. Although the number of patients in comparison to transfemoral and transapical procedures remains small, the transaortic route seems to be particularly safe and effective.²⁷

This article has examined the four transapical valves that have the largest clinical experience to date. The “working horse” has been the Edwards Sapien valve, which was the first to achieve regulatory approval for transapical use in Europe and is on the verge of achieving FDA approval for the same indication. The other devices have the potential benefit of being anatomically oriented, which may result in less valve malpositioning and a lower risk of coronary obstruction. Although coronary obstruction occurs in only 1% to 2% of patients,⁹ it is frequently a lethal complication. The self-expanding devices also have the advantage of not requiring rapid ventricular pacing, with the accompanying hemodynamic instability, during implantation.

Despite the rapid progress of transapical devices, further improvements are required for the next generations. In particular, future devices should be easier to deploy, repositionable, and durable. In addition, future devices need to address the problems of periprocedural stroke and paravalvular leak. Only when TAVR results in a very low rate of mortality and major complications, and durability is demonstrated, will these procedures compete with standard AVR in lower-risk patients.

CONCLUSION

The transapical approach is a safe and effective access site for TAVR. Current clinical devices include the Edwards Sapien, Symetis Acurate, JenaValve, and Medtronic Engager valves. Future devices will need to focus on improving ease of implantation and methods of minimizing the known complications of TAVR. ■

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