

Review Article

Medtronic CoreValve: Achieving Optimal Outcomes

KONSTANTINOS STATHOGIANNIS, ANDREAS SYNETOS, KONSTANTINOS TOUTOUZAS, GEORGE LATSIOS, ANTONIOS MASTROKOSTOPOULOS, GEORGE TRANTALIS, CHRISTODOULOS STEFANADIS, DIMITRIOS TOUSOULIS

First Department of Cardiology, Hippokraton Hospital, Athens Medical School

Key words:

Self-expanding, CoreValve, TAVI, aortic stenosis.

Address:

Konstantinos Spargias

Department of
Transcatheter Heart
Valves Hygeia Hospital
kspargias@hygeia.gr

Trascatheter aortic valve implantation (TAVI) has seen an unprecedented rise in implantations performed since the first TAVI in a human more than a decade ago.¹ An astonishing number of more than 100,000 valves have been implanted in over 60 countries in the past years and these numbers steadily grow.

TAVI is considered the mainstay of therapy for high-risk patients with severe aortic valve stenosis and the number of available valves, from the two that existed at the beginning of the TAVI era (Medtronic CoreValve and Edwards Sapien), has now increased to more than ten.² In addition, the VARC criteria (Valve Academic Research Consortium) have been adopted in order to enable a uniform presentation of results and complications.³

In this paper we will focus on one of the available valves, the Medtronic CoreValve system (MCV), which was the first prosthetic valve to be granted the CE mark (May 2007), in order to take a closer look at its advantages and disadvantages and the ideal conditions that need to be fulfilled for a successful implantation.

Medtronic CoreValve systems

The third generation of MCV is a self-expanding mechanical valve consisting of

a nickel-titanium frame with a tri-leaflet valve created out of porcine pericardium. The part of the valve that is in the left ventricular outflow tract (LVOT) provides high radial force in the aortic annulus, so the valve is stabilized and secured. In addition, a 12 mm “skirt” of porcine pericardium plays a major role in preventing regurgitation and paravalvular leakage. The central part of the skeleton has the tri-leaflet valve, which is designed in such a way as to avoid blocking the coronary ostia (Figure 1A).

Initially, the available valves were 26 mm and 29 mm, so they covered aortic annuli of 20-26 mm. The 31 mm CoreValve is implanted in patients with aortic annuli 26-29 mm, while with the addition of the CoreValve Evolut (23 mm), which is 10% less in length, aortic annuli of 18-20 mm were covered (Figure 1B). The CoreValve is the only available TAVI valve that covers aortic annuli of 18-29 mm. Table 1 presents the evolution of the MCV systems.

The new system by Medtronic (EnVeo R) and the new prosthetic valve (Evolut R) are ergonomically designed in such a way as to minimise complications and achieve better outcomes during TAVI. The length of the valve is 10% less than that of the original CoreValve and allows the implantation of the valve in anatomi-

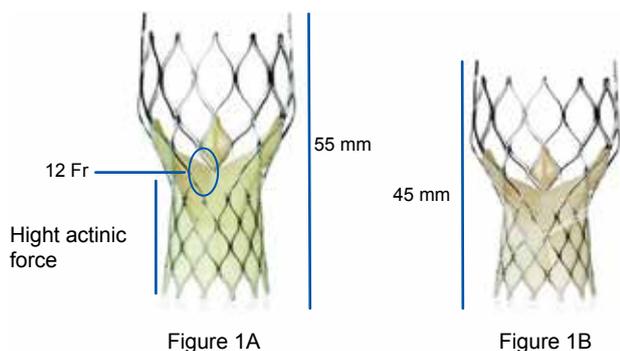


Figure 1. The CoreValve allows implantation in aortic annuli with sizes ranging from 20-29 mm (A). With the CoreValve Evolut (23 mm) aortic annuli ranging 18-20 mm are covered (B).

cal areas with increased angulation and in non-circular or asymmetric calcified aortic annuli.⁴ The “skirt” of this valve has been elongated towards the part of the valve within the LVOT, in order to achieve less regurgitation after implantation (Figure 2). The Enveo R catheter has a smaller internal diameter (14 Fr), aiming at fewer vascular complications.

Studies including the CoreValve

There is a plethora of studies involving the CoreValve, but the basic studies are the ADVANCE, SURTAVI, and Extreme Risk US Pivotal Trial.

The ADVANCE trial included patients who could not undergo surgery (n=1015). At 1 year, the mortality rate was 17.9%, while patients with logEuroSCORE >20% had lower rates of survival compared to patients with logEuroSCORE 10-20% and logEuroSCORE <10% (76.4% vs. 83.5% vs. 88.9%, p<0.05).⁵ At 2 years, the mortality rate was 25.6%, while the incidence of cardiovascular events was 2.9%.⁶ In a sub-analysis that compared patients dichotomised using an age limit of 75 years of age, there was no difference in mortality at 2 years (23.6% vs. 26%, p=0.448), showing the benefit of TAVI in both groups of patients (older and younger than 75 years).

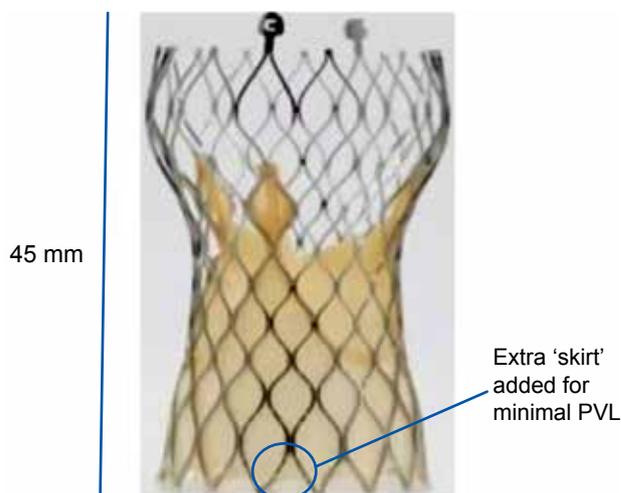


Figure 2. The new Evolut R has an extra “skirt”, in order to further decrease paravalvular leakage (PVL) after transcatheter aortic valve implantation.

In the SURTAVI trial, 910 patients of intermediate surgical risk were randomized to CoreValve (n=405) or surgical aortic valve replacement (SAVR; n=405). At one year and in patients with an STS score 3-8%, the mortality rate in both groups was similar (16.5% in TAVI patients and 16.9% in SAVR patients, p=0.64).⁷

In the second leg of the Extreme Risk US Pivotal Trial, 790 patients were randomized to either TAVI or SAVR; at 1 year, patients who underwent TAVI had lower mortality (14.2% vs. 19.1%, p<0.04), fewer cerebrovascular events, and lower bleeding rates (p<0.03). However, TAVI patients had more complications (6.2% vs. 2%, p<0.004) and permanent pacemaker implantations (22.3% vs. 11.3%, p<0.001) compared to SAVR patients.⁸ The first leg of this trial included patients at very high surgical risk (n=687) who were randomized to either TAVI or active surveillance. At one year the mortality rate was 24.3% and the rate of vascular events was 7%, while patients with severe aortic regurgitation post TAVI had higher rates of late mortality.⁹

Table 1. Evolution of the Medtronic CoreValve systems.

Generation of valve	First	Second	Third
Sheath size	25 Fr	21 Fr	18 Fr
Pericardium	Bovine	Porcine	Porcine
Mode	Surgical	Transcatheter	Transcatheter
Aortic annulus size	20-23 mm	20-23 mm	18-29 mm

Advantages and disadvantages of the CoreValve

TAVI is still in the early stages of its development and there are constant trials and studies investigating available and future devices.

One of the main advantages of the CoreValve is the ability to choose an appropriate valve size for a large range of aortic valve annuli, whereas the lower profile of the entrance devices leads to fewer vascular events. An important disadvantage of the CoreValve is the rate of permanent pacemaker implantation, an issue that is addressed with the newer valves.¹⁰ Table 2 lists the advantages and disadvantages of the MCV systems.

Successful implantation of the CoreValve

The importance of the Heart Team has been stressed ever since the beginning of the TAVI procedures. Before the procedure, there is a meticulous screening protocol that needs to be followed in order to achieve the best possible outcomes. This protocol involves a transthoracic or transoesophageal cardiac echo, angiography of the coronary arteries, aortic arch and iliofemoral vessels, as well as computed tomography of the heart structure, the iliofemoral and subclavian vessels. With computed tomography we can measure the dimensions of the aortic annulus precisely and calculate the calcium deposition in a semi-quantitative manner (Figure 3 shows a heavily calcified aortic annulus). This protocol allows the Heart Team to make the right choice of suitable patients for TAVI and to form a plan so that the right entrance route is selected and the correct prosthetic aortic valve size is chosen in order to minimise the risk of paravalvular leakage and valve dislocation. A few anatomical criteria must be met for a proper and safe TAVI procedure. The iliofemoral vessels' diameter should be at least 6 mm for the 18 Fr entrance sheath and they must be free of

Table 2. Advantages and disadvantages of the CoreValve.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Implantation in a large range of aortic annuli • Partially repositionable • No need for rapid ventricular pacing • Less trauma in aortic annulus and aorta, with low risk of rupture • Multiple entrance points (femoral, subclavian, trans-aortic) 	<ul style="list-style-type: none"> • Permanent pacemaker implantation

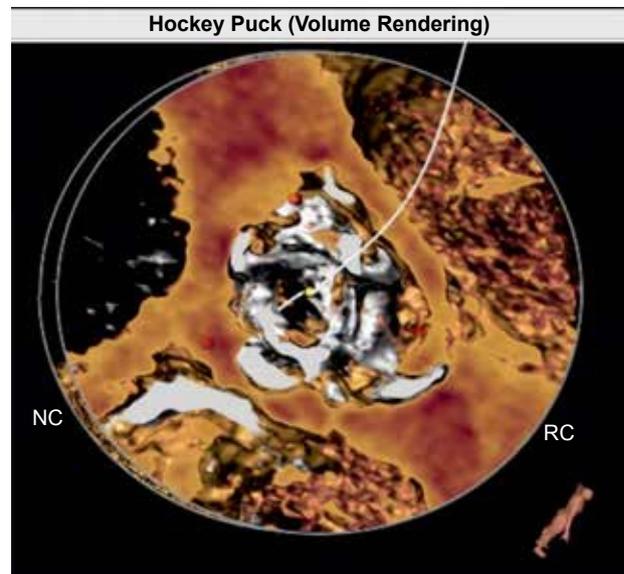


Figure 3. Three-dimensional imaging of a heavily calcified aortic annulus by CT scan.

severe calcification or intense tortuosity. Computed tomography measurements provide details about the best possible angiographic angles and views that can be used during the actual TAVI procedure, allowing us to perform the implantation with the minimum usage of contrast material and radiation, making the procedure safer, simpler and faster.

The primary target for the implantation is the device success and procedural success, according to the aforementioned VARC criteria. Device success is defined as a mean pressure gradient <20 mmHg or maximal flow velocity <3 m/s, implantation of one valve only, and no or mild aortic regurgitation. Procedural success is defined as an absence of cerebrovascular accidents, renal failure, or major vascular complications, no need for post-TAVI balloon dilatation, no implantation of a second prosthetic valve, no need for immediate surgical procedure, and no death.

The entry route is important in order to have a successful implantation. The most common is the transfemoral route, and it is usually the primary choice for TAVI procedures. In vessels with severe calcification or tortuosity an alternative route must be sought, such as the subclavian or direct aortic. For these routes, careful and meticulous surgical planning before the operation is required, since they are more demanding and the operators lack the necessary experience, so it is possible for serious complications to arise.

During the TAVI procedure, transoesophageal

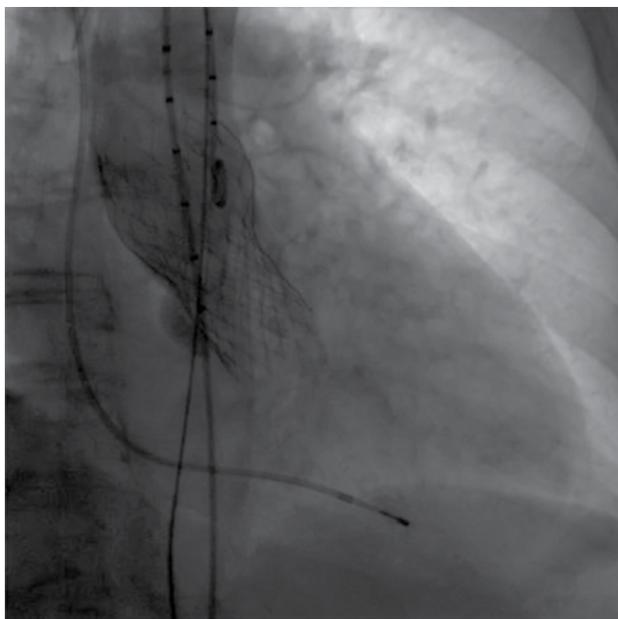


Figure 4. Optimal CoreValve implantation in a patient with a heavily calcified aortic valve.

echo is used only in patients who are intubated, since it does not appear to provide useful information about precise valve placement. Intraoperative success may be checked using rapid ventricular pacing during balloon aortic predilatation, if performed, and by high implantation of the valve, with a limit of 4-6 mm below the aortic valve annulus (Figure 4) for an implantation to be considered successful, in order to minimise the need for permanent pacemaker implantation. It seems that with the CoreValve predilatation before TAVI is not necessary and experienced operators avoid doing it.

The risk of atrioventricular block and permanent pacemaker implantation post TAVI with a CoreValve is relatively high, because of the injury to the conduction pathway of the heart.¹¹⁻¹³ The CoreValve keeps expanding after the implantation and there is local oedema in the area, making it necessary to maintain the temporary pacing for at least 72 hours, while conduction abnormalities have been known to appear even nine days post TAVI.¹⁴

Special echocardiographic indexes may be used in order to predict pacemaker implantation. Such an index is the ratio of the left ventricular outflow tract to the aortic annulus diameter (LVOT/annulus).¹⁵ The difference between the LVOT and the aortic annulus causes increased tension and oedema in the interventricular septum, at the level of the CoreValve skeleton. For this reason the conduction abnormalities last

longer. The condition seems to be exacerbated when the depth of implantation is low. This index is independent of the thickness of the interventricular septum. Patients with optimal CoreValve depth and high LVOT/annulus index (≥ 0.89) have a lower incidence of pacemaker implantation ($n=4/49$, 8.16%). Patients with optimal CoreValve depth and a low LVOT/annulus index have the same rate of pacemaker implantation ($n=18/34$, 52.94%) as patients without optimal valve depth and a high LVOT/annulus index ($n=8/14$, 57.14%). The highest rate of pacemaker implantation is in patients without optimal valve depth and low LVOT/annulus index ($n=14/16$, 87.5%, $p \leq 0.05$).

The newer CoreValve Evolut is 10% shorter than the previous CoreValve and has less angulation; thus, it causes less injury to the surrounding area and concomitantly is associated with a lower rate of pacemaker implantation.

After the temporary pacemaker has been implanted in the right ventricle and the 18 Fr sheath has been introduced, the Amplatz-1 catheter is advanced through the ascending aorta and the Valsalva sinus. The catheter is then advanced to the left ventricle with the assistance of a guiding wire. The catheter is then exchanged for a pigtail, so that the aortic valve gradients can be calculated. A Super-Stiff wire is used in order to advance the bioprosthesis over the aortic arch and through the stenotic aortic valve in a “push-and-pull” manner, while the correct position of the bioprosthesis is constantly confirmed by aortography performed during the valve deployment. The aortography is recorded by the pigtail, which is in the non-coronary cusp at such an angle that all three cusps are lined up and visible. In cases where the bioprosthesis is implanted either too low or too high and has not fully deployed (maximum 2/3 of the deployment), there is the possibility to fully retrieve the valve and reposition it. This procedure demands stable and smooth tension of the wire until there is a change in the positioning of the valve.¹⁶ There are case reports in which the valve was deployed but failed to anchor in the aortic valve orifice and native aortic valve and even using special wires (gooseneck snare, ev3) the valve could not be retrieved.¹⁷ In these rare circumstances, surgical bailout must be considered in order to prevent further vascular damage. In addition, there are plenty of other alternative approaches that can be used in emergency situations with a good result.¹⁸

Repositioning the valve with a snare wire, balloon post-dilatation, or the valve-in-valve method can be used to further decrease the paravalvular leakage, in

case the operators consider it to be necessary. Based on current large trials, even mild paravalvular leakage is considered a risk factor for increased mortality after TAVI.¹⁹

At the end of the procedure, the 18 Fr sheath is removed. With the crossover method, a wire from the contralateral side is advanced to the proximal part of the femoral artery where the sheath is and dilates a balloon, in order to decrease the pressure and allow the sheath to be removed.

Under normal conditions the patient remains in the ICU for at least 48 hours and is then transported to a regular room. The patient will be on dual anti-platelet therapy for 6 months, while high-risk patients should be checked for possible gastrointestinal bleeding. The patient will undergo a transthoracic echo at 1, 6, and 12 months after the procedure. Thereafter, an annual transthoracic echo and clinical exam is warranted.

Conclusions

TAVI is considered the gold standard for high-risk patients with aortic valve stenosis. TAVI has already proved its efficacy and safety in the midterm, while the long-term results (>5 years) are eagerly awaited.

The CoreValve was the first TAVI valve to be granted a CE mark and can be implanted in a wide range of aortic valve annuli. The newer generation valves and their systems will have a smaller and safer profile, an advance that will benefit patients at intermediate risk.

Acknowledgment

Dr. Toutouzas is a proctor for Medtronic.

References

1. Cribier A, Eltchaninoff H, Bash A, et al. Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description. *Circulation*. 2002; 106: 3006-3008.
2. Toutouzas KP, Stathogiannis KE, Latsios GS, Synetos AG, Stefanadis CI. Recent valves used for transluminal implantation in patients with aortic valve stenosis. *Recent Pat Cardiovasc Drug Discov*. 2012; 7: 206-215.
3. Kappetein AP, Head SJ, Génèreux P, et al. Updated standardized endpoint definitions for transcatheter aortic valve implantation: the Valve Academic Research Consortium-2 consensus document. *J Am Coll Cardiol*. 2012; 60: 1438-1454.
4. Sinning JM, Werner N, Nickenig G, Grube E. Medtronic CoreValve Evolut R with EnVeo R. *EuroIntervention*. 2013; 9 Suppl: S95-96.
5. Linke A. One year results of CoreValve advance. *EuroPCR*. 2013.
6. Linke A. Two year advance date for Medtronic's CoreValve. *EuroPCR*. 2014.
7. Piazza N, Kalesan B, van Mieghem N, et al. A 3-center comparison of 1-year mortality outcomes between transcatheter aortic valve implantation and surgical aortic valve replacement on the basis of propensity score matching among intermediate-risk surgical patients. *JACC Cardiovasc Interv*. 2013; 6: 443-451.
8. Adams DH, Popma JJ, Reardon MJ, et al. Transcatheter aortic-valve replacement with a self-expanding prosthesis. *N Engl J Med*. 2014; 370: 1790-1798.
9. Popma JJ, Adams DH, Reardon MJ, et al. Transcatheter aortic valve replacement using a self-expanding bioprosthesis in patients with severe aortic stenosis at extreme risk for surgery. *J Am Coll Cardiol*. 2014; 63: 1972-1981.
10. Spargias K, Toutouzas K, Chrissoheris M, et al. The Athens TAVR Registry of newer generation transfemoral aortic valves: 30-day outcomes. *Hellenic J Cardiol*. 2013; 54: 18-24.
11. Gilard M, Eltchaninoff H, Iung B, et al. Registry of transcatheter aortic-valve implantation in high-risk patients. *N Engl J Med*. 2012; 366: 1705-1715.
12. Moat NE, Ludman P, de Belder MA. Long-term outcomes after transcatheter aortic valve implantation in high-risk patients with severe aortic stenosis: the U.K. TAVI (United Kingdom Transcatheter Aortic Valve Implantation) Registry. *J Am Coll Cardiol*. 2011; 58: 2130-2138.
13. Ussia GP, Barbanti M, Petronio AS, et al. Transcatheter aortic valve implantation: 3-year outcomes of self-expanding CoreValve prosthesis. *Eur Heart J*. 2012; 33: 969-976.
14. Toutouzas K, Michelongona A, Synetos A, Latsios G, Tsioufis C, Stefanadis C. Atrioventricular block 9 days after transcatheter aortic valve implantation. *Int J Cardiol*. 2011; 151: 112-114.
15. Toutouzas K, Synetos A, Tousoulis D, et al. Predictors for permanent pacemaker implantation after core valve implantation in patients without preexisting ECG conduction disturbances: the role of a new echocardiographic index. *Int J Cardiol*. 2014; 172: 601-603.
16. Latib A, Michev I, Laborde JC, Montorfano M, Colombo A. Post-implantation repositioning of the CoreValve percutaneous aortic valve. *JACC Cardiovasc Interv*. 2010; 3: 119-121.
17. Latsios G, Toutouzas K, Tousoulis D, et al. Prosthetic aortic valve removal from the abdominal aorta after successful "valve-through" TAVI. *Int J Cardiol*. 2013; 164: e27-28.
18. Latsios G, Toutouzas K, Tousoulis D, et al. Case reports of bail-out maneuvers for implantation of a second core valve prosthesis during the same TAVI procedure. *Int J Cardiol*. 2013; 167: e134-136.
19. Kodali SK, Williams MR, Smith CR, et al. Two-year outcomes after transcatheter or surgical aortic-valve replacement. *N Engl J Med*. 2012; 366: 1686-1695.