

# Procedural and Mid-Term Results in Patients With Aortic Stenosis Treated With Implantation of 2 (In-Series) CoreValve Prostheses in 1 Procedure

Ulrich Gerckens, MD,\* George Latsios, MD,\* Ralf Mueller, MD,\* Lutz Buellesfeld, MD,\* Daniel John, MD,\* Seyrani Yuceel, MD,\* Barthel Sauren, MD,† Thomas Felderhof, MD,‡ Stein Iversen, MD,‡ Eberhard Grube, MD\*

*Siegburg, Germany*

---

**Objectives** This study sought to assess post-procedural and mid-term outcome of patients, in which a second “in-series” CoreValve prosthesis (Medtronic, Minneapolis, Minnesota) was implanted during the same procedure.

**Background** Because of the increasing number of patients implanted with CoreValves, the need for management of special complications has emerged. A misplaced prosthesis can be corrected by various maneuvers. An option is to pull the valve out of the aortic annulus into the ascending aorta or beyond and position a second one (in series).

**Methods** Out of 277 patients who underwent CoreValve implantation with the 18-F device in our institution, we had to implant a second prosthesis (due to severe aortic regurgitation or dislocation of the first one) in 9 (3.2%). Immediate post-procedural as well as mid-term follow-up data (5 to 20 months, mean  $10.6 \pm 6$  months, total 95 patient-months) were collected for analysis.

**Results** All implantations of the second device were successful, resulting in elimination of the gradient (mean gradient  $43.1 \pm 4.0$  mm Hg before to  $7.0 \pm 1.1$  mm Hg after implantation). There was no final aortic regurgitation grade  $\geq 2+$ . The extra-anatomically placed first prosthesis (ascending aorta,  $n = 8$ ; abdominal aorta,  $n = 1$ ) did not cause any clinical sequelae or gradients. During mid-term follow-up, none of the 18 prostheses showed any sign of malfunction. Specifically, there were no signs of valve migration or of worsening paravalvular regurgitation. No case of valve thrombosis was documented.

**Conclusions** A second CoreValve can be safely and effectively implanted in an in-series manner, without periprocedural complications. No problems arose on mid-term follow-up, ranging up to 20 months. (J Am Coll Cardiol Intv 2010;3:244–50) © 2010 by the American College of Cardiology Foundation

---

From the \*Department of Cardiology/Angiology, †Department of Anesthesiology, and the ‡Department of Cardiothoracic Surgery, “Helios” Heart Center, Siegburg, Germany. Study devices provided by CoreValve. Drs. Grube and Gerckens are clinical proctors for Medtronic.

Manuscript received August 17, 2009; revised manuscript received November 2, 2009, accepted November 13, 2009.

Since 2005 (1,2), transcatheter aortic valve implantation (TAVI) has gained acceptance as a therapeutic option for patients with severe, symptomatic aortic stenosis and high risk for conventional open heart surgery. Studies in multiple centers have shown TAVI to be an effective and safe procedure in selected high-risk patients (3,4). The self-expandable CoreValve ReValving system (Medtronic, Minneapolis, Minnesota) is a Conformité Européenne–approved device and among the most widely used techniques for transcatheter aortic valve implantation (>6,000 implantations worldwide, data on file).

Because of this increasing number of patients treated with a CoreValve device, the need for management of specific problems has emerged. One of these problems is device misplacement: too deep in the ventricle or too high within the annulus. However, there are various correction maneuvers that can be used to optimize the device position including partial device retraction using a snare catheter or implantation of a second prosthesis either within the first device, or within the native annulus after retraction and placement of the first prosthesis within the ascending aorta (“in-series”) or even more distal segments such as the abdominal aorta.

Out of 277 patients who underwent CoreValve implantation (Medtronic) with the 18-F device in our institution, in 9 (3.2%), we pulled the fully deployed CoreValve prosthesis out of its proper “anatomic” position, which is inside the native calcified aortic valve, for correction of a suboptimal initial device placement followed by successful implantation of a second device.

In this report, we discuss the feasibility of this maneuver and on the immediate and mid-term (up to 2 years) follow-up of these 9 patients.

## Methods

**Study design.** This nonrandomized observational single-center retrospective study was conducted to evaluate the safety and efficacy of implantation of a second CoreValve prosthesis as a rescue maneuver, after a first misplaced prosthesis was pulled out of the aortic annulus.

Procedural outcomes are reported and mid-term clinical, echocardiographic, and fluoroscopic follow-up was performed. **Patients and procedural details.** Between July 2007 and January 2009, 277 patients underwent elective CoreValve prosthesis implantation with the third-generation 18-F device in our institution.

Procedural details of device implantation have been described previously. In 9 of these patients (5 men, mean age 78.8 years) (Table 1), we implanted a second prosthesis in the same session, because the first one was pulled out of the aortic annulus either accidentally during the release process or intentionally to correct suboptimal placement. These 9 patients were included in this analysis.

All patients provided written informed consent to undergo the CoreValve TAVI procedure.

**Follow-up.** All patients received acetylsalicylic acid (100 mg/day) before the procedure and lifelong afterward. Also, all patients received clopidogrel (300-mg loading dose) 75 mg/day for 6 months. Platelet responsiveness to dual antiplatelet therapy was tested, and if found suboptimal, the daily dose of clopidogrel was doubled.

### Abbreviations and Acronyms

**CABG** = coronary artery bypass grafting

**TAVI** = transcatheter aortic valve implantation

**Table 1. Demographic Characteristics and Procedural Details of the Patients Implanted With a Second In-Series CoreValve Prosthesis in Our Department**

Patient #	Age (yrs)	Sex	Follow-Up	Position of CVs	Reason for 2nd CV	Comments	CV Size	Annulus Size (mm)
1	85	F	20 months	1st in asc aorta, 2nd normal	Pulling with catheter, hinges not free	Vein grafts patent	Small	22.5
2	83	M	18 months	1st in asc aorta, 2nd normal	Pulling with snare (too deep)		Large	27.0
3	81	M	13 months	1st in asc aorta, 2nd normal	Pulling with catheter, hinges not free	Vein grafts patent	Large	27.3
4	52	M	12 months	1st in asc aorta, 2nd normal	Pulling with snare (too deep)		Large	26.7
5	86	M	11 months	1st in asc aorta, 2nd normal	Pulling with snare (too deep)		Large	24.8
6	78	F	10 months	1st in asc aorta, 2nd normal	Pulling with snare (too deep)		Large	25.2
7	78	F	16 days	1st in asc aorta, 2nd normal	Pulling with snare (too deep)	Died after right iliac artery rupture and operation	Small	23.6
8	88	M	6 months	1st in abdominal aorta, 2nd normal	Pulled with catheter		Large	27.6
9	78	F	5 months	1st in asc aorta, 2nd normal	Pulling with snare (near left main ostium)		Large	24.5

asc aorta = ascending aorta; CV = Medtronic CoreValve prosthesis.

Clinical questioning and transthoracic echocardiography were performed after the procedure, at hospital discharge, and at 15 and 30 days after device implantation. Beyond this, echocardiography and fluoroscopy were performed at 3 month intervals: 3, 6, 12, and 18 months after implantation.

As adverse events, we considered death, serious arrhythmia, neurological events, myocardial infarction, and any valve structural deterioration. Deterioration was defined as changes intrinsic to the valve, such as wear, fracture, calcification, leaflet tear, stent creep, or dislocation of the whole or part of the porcine bioprosthetic tissue.

## Results

Retraction of the first prosthesis was accidental in 2 cases during device release or intentional due to suboptimal device placement in 7 cases. After retraction, the CoreValve prosthesis was placed in the ascending aorta in 8 cases and in the abdominal aorta in 1 case.

Implantation of the second device was successful in all 9 patients, resulting in a reduction of the mean gradient from  $43.1 \pm 4.0$  mm Hg before to  $7.0 \pm 1.1$  mm Hg after implantation, corresponding to an increase in calculated effective aortic valve area (Gorlin formula) from  $0.62 \pm 0.05$  cm<sup>2</sup> to  $1.64 \pm 0.09$  cm<sup>2</sup> (Table 2). Resulting aortic regurgitation was less than grade 2+ in all cases. These parameters were obtained by routine transthoracic echocardiography.

There was no hemodynamic gradient across the CoreValve that was implanted extra-anatomically in all cases measured invasively in the catheterization lab. None of the patients were at any time hemodynamically unstable, nor intubated and mechanically ventilated.

In the case of placement in the abdominal aorta, due to the unusual position of the prosthesis, this one was not accessible by echo for evaluation.

Specific details on the patients are as follows.

**Prosthesis released in aorta (Patients #1, #3, and #8).** Patient 1 was an 85-year-old woman, with a history of a former coronary artery bypass graft (CABG) procedure and 3 patent vein grafts. It was not possible to release the first CoreValve from the delivery catheter, because the hinges on its upper part continued to keep it attached. Forceful manipulation of both the delivery catheter and of the stiff wire resulted in dislocation of the CoreValve in the ascending aorta.

Subsequently, while this prosthesis was kept stable by means of a snare catheter, the second prosthesis was advanced and successfully deployed. Noteworthy to this case is the fact that all 3 vein aorto-coronary bypasses remained patent (Fig. 1).

Patient #3 was an 81-year-old man, with a history of a former CABG procedure with 2 vein grafts and a left internal mammary artery to left anterior descending artery graft. This case resembles that of Patient 1, as again the prosthesis could not be released from the delivery catheter hinges, and forceful manipulation again resulted in dislocation of the CoreValve in the ascending aorta.

We kept the prosthesis stable by means of a snare catheter, and the second prosthesis was successfully implanted. Again, both vein aorto-coronary bypasses remained patent (Fig. 2).

Patient #8 was an 88-year-old man with an aortic annulus of 27.6 mm estimated by computed tomography. In his case, the prosthesis slid back completely in the aortic root, at its left coronary cusp side, after deployment of more than two-thirds. We initially attempted to pull it with the delivery catheter backward, through the 18-F sheath, and out of the body, in order to reload and redeploy it. Again, this is a rather standard maneuver that we have performed successfully several times. However, in this specific case, as the almost completely deployed prosthesis was pulled, some of the proximal struts exited

**Table 2. Echocardiographic Evaluation of the Native Aortic Valve and of the Appropriately Placed CoreValve Prosthesis**

Patient #	P Mean (Before) (mm Hg)	AVA (Before) (cm <sup>2</sup> )	P Mean (After) (mm Hg)	AVA (After) (cm <sup>2</sup> )	AR (After) (1+ to 4+ Scale)
1	29	0.5	8	1.5	1.5
2	52	0.5	9	1.6	1.5
3	52	0.5	7	1.4	0.5
4	21	0.6	3	2.1	0.5
5	53	0.6	5	1.8	0.5
6	54	0.6	4	1.9	1.0
7*	38	0.9	5	1.8	0.0
8	52	0.7	9	1.5	0.5
9	37	0.8	14	1.2	1.0
Mean ± SD	43.1 ± 4.0	0.62 ± 0.05	7.0 ± 1.1	1.64 ± 0.09	0.7 ± 0.1

\*Patient died of vascular access complication.

AR = aortic regurgitation; AVA = aortic valve area.



**Figure 1. Patient #1 at the End of the 2 CoreValves Implantation**

Aortographic image of section just above the correctly (at the aortic annulus) positioned prosthesis. Note the 2 in-series CoreValves, the lack of dye regurgitation in the left ventricle, and the patency of the vein bypass (arrow) to the left coronary.

the delivery catheter, making its retrieval impossible. We then decided to “implant” it in the abdominal aorta, below the level of the renal arteries, and to further dilate it with a balloon (Fig. 3). Then a second CoreValve was advanced in the usual manner and deployed uneventfully in its correct position.

**Prosthesis pulled with a snare catheter (Patients #2, #4, #5, #6, #7, and #9).** This refers to Patient #2, an 83-year-old man; Patient #4, a 52-year-old man; Patient #5, an 86-year-old man; Patient #6, a 78-year-old woman; and Patient #7, also a 78-year-old woman, who share common procedural characteristics.

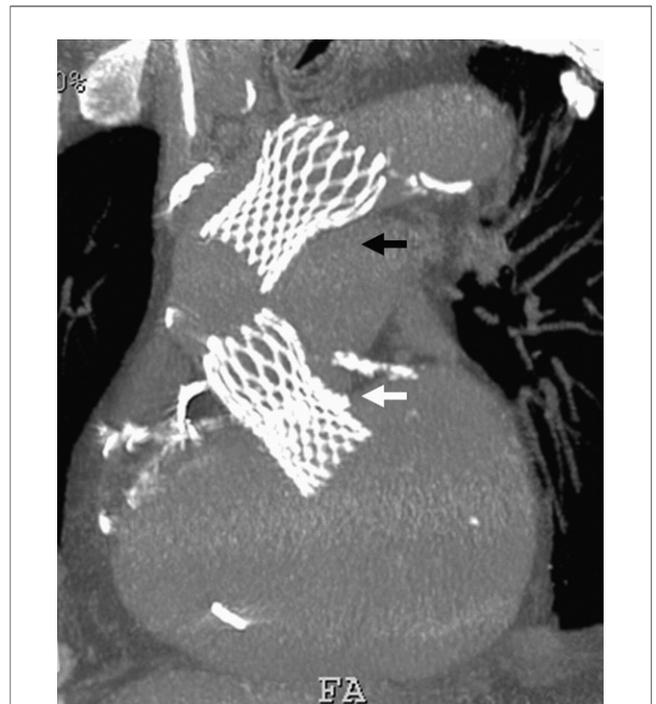
In all 5 of these patients, the CoreValve was implanted too deep, a fact that resulted in moderate-to-severe aortic regurgitation. The decision was made to pull the prosthesis by means of a snare catheter. A 15-mm loop snare catheter, 6-F compatible (Amplatz Goose Neck Snare, ev3 Endovascular, Inc., Plymouth, Minnesota), was introduced from the 6-F femoral access site. The catheter was advanced to the prosthesis hinges and was pulled under continuous hemodynamic monitoring. The target was the normalization of the diastolic aortic pressure and of the left ventricular end-diastolic pressure.

However, despite the fact that the specific maneuver had been performed numerous times in our catheterization lab, in these 5 cases, the result was the dislocation of the CoreValve prosthesis in the ascending aorta. We kept it stable by means of the snare catheter, and the second one was successfully implanted.

Patient #7 unfortunately suffered a fatal complication. After closure of the right femoral artery with the Prostar XL 10 device (Abbott Vascular, Abbott Park, Illinois), the artery was occluded. The patient was operated on by a vascular surgeon. She developed pneumonia and died of multiorgan failure 16 days later. Unfortunately, an anatomic-pathology report could not be obtained, because the relatives did not give their permission for an autopsy to be performed.

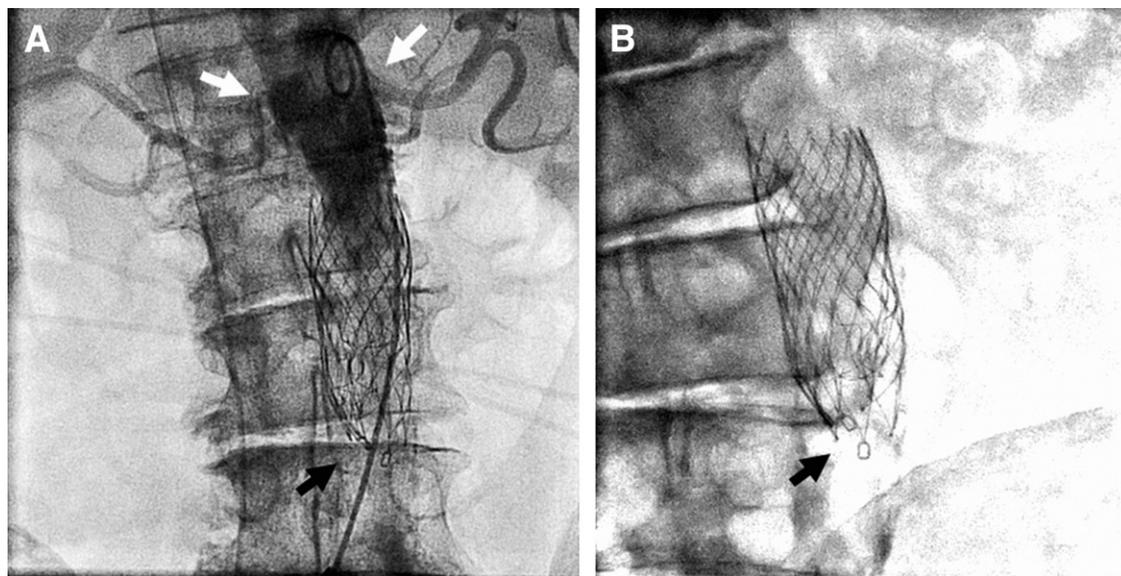
In Patient #9, a 78-year-old woman, the CoreValve prosthesis was deployed near the left main coronary artery ostium. Although the blood flow in the left system was not compromised, we decided to pull it out of this position. By means of a snare catheter, initially unsuccessfully from the femoral artery and consequently successfully from the left brachial artery, the prosthesis was pulled and stabilized in the ascending aorta, distal to the aortic arch arterial branches. Subsequently, while the first CoreValve was kept stable by means of the snare catheter, a second CoreValve was advanced and successfully deployed.

All 9 patients underwent the procedure of the second valve implantation without any significant sequelae. The procedural time was prolonged by a mean of  $35 \pm 9$  min. With the exception of Patient #7, who was operated upon by a vascular surgeon in the catheterization lab and needed transfusion of 2 U of packed red cells, all other patients



**Figure 2. Patient #3 at 1-Year Follow-Up**

Multislice cardiac computer tomography ( $16 \times 0.75$  mm) showing the 2 CoreValve prostheses, 1 transannularly (white arrow) and 1 at the ascending aorta (black arrow).



**Figure 3. Patient #8 at End of the 2 CoreValves Implantation and Follow-Up**

(A) At the end of the 2 CoreValves implantation and (B) at 6-month follow-up. Both antero-posterior projections. (A) Aortographic image of the abdominal aorta, above the displaced CoreValve prosthesis. Note the infra-renal position of the prosthesis, the patent renal arteries (**white arrows**), and the slightly deformed proximal part of the prosthesis (**black arrow**). (B) Fluoroscopic control of the CoreValve prosthesis in the abdominal aorta. No displacement or further deformation of the prosthesis (**black arrow**). Note the position of the CoreValve relevant to the vertebrae.

did not receive any transfusions (Table 2, asterisk marked patient).

We experienced no periprocedural complications in any of the patients after the implantation of the second prosthesis, in-series to the misplaced one. The misplaced CoreValve functioned normally, from a hemodynamic point of view, as a valve conduit inside the aorta, and showed complete apposition against the aortic wall.

The follow-up period on the patients (Table 1) ranged from 5 to 20 months (mean  $10.6 \pm 6.1$  months; median 11 months). Two patients were followed for a period of more than 1.5 years, another 4 for almost 1 year and the remaining 2 for 6 months.

In total, 95 patient-months in follow-up were available for analysis. During this period, none of the 18 devices showed any sign of malfunction, especially none of the 9 that were extra-anatomically positioned. More specifically, during echo and fluoroscopy follow-up, there were no signs of valve migration or of new onset paravalvular regurgitation. No case of valve thrombosis was documented.

Structural valve deterioration was also not observed in any of the patients. Also, no cases of embolism were reported, either thrombotic or of other origin.

## Discussion

Since its introduction, and especially after Conformité Européenne approval in February 2007, the number of

patients treated by TAVI with the CoreValve ReValving technology has risen to over 4,000 worldwide. As our knowledge of the procedure's particularities expand, the need for management of special complications emerges. A misplaced prosthesis is such a complication and can be dealt with by various maneuvers.

A technical point worth mentioning is the way that the prosthesis moves "deeper," that is, toward the left ventricle. When half deployed, it moves by itself in this direction, because of its tendency to occupy the largest available space. Constant pull on the delivery catheter and pushing of the bent stiff wire against the ventricular apex are used to avoid a "too deep" implantation. Caution should be used, because after its deployment, the prosthesis can no longer be moved in this direction.

Movement in the other direction, which is "shallower" toward the aortic root, can be accomplished in the following 2 ways.

1. At the end of the deployment, but before the final release from the catheter's hinges, if the CoreValve prosthesis is too deep, it can be pulled proximally to its correct position by steadily pulling on the catheter.
2. Also, after its release, pulling a deeply deployed prosthesis can be accomplished. A snare catheter, 6-F compatible (Amplatz Goose Neck Snare) is inserted through the femoral or brachial arteries. The specific snare catheter has the advantage of a loop configuration, enabling easier

engagement to the prosthesis hinges. Our personal preference is to initially introduce the snare catheter from the femoral artery, through the existing arterial access site. This was the case in all 6 patients of this study, in which we performed this maneuver. The snare subsequently engages 1 of the 2 prosthesis hinges and constant pulling force is employed. As already stated, target is the normalization of the diastolic aortic pressure.

In cases where pulling from the femoral artery is unsuccessful, we then proceed with snaring from the brachial artery. The decision to use left versus right brachial artery depends mainly on the direction we wish to perform the pulling. Due to the limited experience, no solid recommendation can be further given.

Implantation of a second CoreValve prosthesis is sometimes the only measure left to the interventionalist performing TAVI in order to avoid open-heart emergency surgery or circulatory collapse. The second valve can be within the first ("valve-in-valve" concept). Another option is to pull (snare) the first higher in the ascending aorta and deploy a second in the correct anatomic position. This maneuver can also be carried out in cases when the prosthesis is accidentally withdrawn from the aortic annulus. Although the theoretical issue of aortic perforation by pulling the device can be raised, we do not consider it significant, as was also proven in this study (pulling uneventful in 6 of 6 patients). However, the operator should check the direction of the pulling, so that the hinges do not traumatize the aortic wall, and also check that the deformation of the aortic arch is not severe during the maneuver.

In 2 patients, the delivery catheter would not disengage the CoreValve hinges. Although this is a very rare occurrence, operator should always verify the release of the prosthesis. This is made fluoroscopically obvious when the catheter's distal part is some distance from the hinges. Otherwise, small back and forth movements of the catheter enable release of the CoreValve prosthesis.

After unsuccessful TAVI due to CoreValve misplacement, whether to put a new valve inside the first or pull the first one to another aortic location and implant a second in a "single strut layer" way, depends on operator preferences and sometimes on special procedural circumstances.

A second valve inside the already implanted valve is a feasible option and has been performed not only in our institution but also by others with procedural (5) as well as long-term (6) success.

Nevertheless, 2 valves in the same, or near same, anatomic position, partially overlapping each other, have the following disadvantages.

First, the amount of metal (nitinol) residing against the native aortic wall is doubled, and this way the time required for endothelialization is prolonged. By our approach, the

second prosthesis is implanted in series, so less metal is opposed to the wall.

Second, when 2 valves are implanted in close, but not complete, overlapping, the total size of the "skirt" is increased to more than the normal 1.2 cm. This increases the risk of covering the native coronary ostia. This is especially true in patients who have not undergone a CABG procedure and are totally dependent on a native coronary blood supply. Recommendations for exact placement of the device have been discussed elsewhere (7). When pulled and subsequently implanted in the ascending aorta, the prosthesis did not cause any vein bypass obstruction in those patients who had undergone a CABG procedure.

Third, a too deeply implanted CoreValve, causing aortic and mitral regurgitation, cannot be left in place. A second valve-in-valve prosthesis can resolve the issue with the aortic regurgitation. However, the mitral regurgitation caused by the initially misplaced prosthesis will remain, unless this prosthesis is removed away from the mitral apparatus.

For these reasons, we suggest that a CoreValve too deeply seated should be snared to its proper position. If this causes the prosthesis to be dislocated above the aortic annulus, or if the prosthesis is initially positioned in a supra-annular position, the following course of action is recommended. This prosthesis is captured with a snare, through the femoral access or preferably through the left or right brachial access, and pulled to the ascending aorta, just below the origin of the main vessel trunks.

While constantly kept there by continuous pulling, a second prosthesis is advanced and positioned in the usual manner. This maneuver was successful in all 9 patients that we treated.

In this study, we demonstrated that 2 CoreValves can be safely and effectively implanted in an in-series manner, without periprocedural complications. This way, the need for surgery is avoided, making TAVI a pure interventional procedure. Also, on follow-up, extending to 1.5 years, no problems arose due to the second prosthesis. We did not experience either periprocedural complications after the implantation of the second prosthesis, or any events in follow-up due to the misplaced CoreValve. The latter functioned normally, from a hemodynamic point of view, as a valve conduit inside the aorta and showed complete apposition against the aortic wall.

In the 18-F Expanded Evaluation Registry of 646 patients, a second valve was implanted in 2.6% of the patients (8). The distinction between a valve-in-valve or sequential valve implantation was not made. Similarly, the rate of a valve-in-valve procedure was 2% in a study of 86 patients implanted with the 21- or 18-F CoreValve ReValving system prosthesis from our center (4), and at 9.6% in another experienced center (7). In our experience, dedicated to the 18-F size system since July 2007, we report an incidence of 3.2% of patients receiving a second CoreValve prosthesis. Possible explanations for the discrepancy

include: 1) center-specific results; and 2) differing thresholds for implantation of a second valve.

Our patients were followed for up to 20 months, for a total of 95 patient-years. During this period, none of the devices showed any sign of malfunction, migration, or structural deterioration. The 2 in-series CoreValve prostheses showed no adverse clinical or hemodynamic sequelae.

## Conclusions

We demonstrated that 2 CoreValve prostheses can be safely and effectively implanted as a rescue maneuver in an in-series manner, without periprocedural complications.

This second prosthesis caused no problems on mid-term follow-up.

---

**Reprint requests and correspondence:** Dr. George Latsios, HELIOS Heart Center Siegburg, Ringstr 49, Siegburg, NWR, Germany. E-mail: glatsios@hotmail.com.

---

## REFERENCES

1. Grube E, Laborde JC, Gerckens U, et al. Percutaneous implantation of the CoreValve self-expanding valve prosthesis in high-risk patients with aortic valve disease: the Siegburg first-in-man study. *Circulation* 2006;114:1616-24.
2. Webb JG, Chandavimol M, Thompson CR, et al. Percutaneous aortic valve implantation retrograde from the femoral artery. *Circulation* 2006;113:842-50.
3. Webb JG, Pasupati S, Humphries K, et al. Percutaneous transarterial aortic valve replacement in selected high-risk patients with aortic stenosis. *Circulation* 2007;116:755-63.
4. Grube E, Schuler G, Buellesfeld L, et al. Percutaneous aortic valve replacement for severe aortic stenosis in high-risk patients using the second- and current third-generation self-expanding CoreValve prosthesis: device success and 30-day clinical outcome. *J Am Coll Cardiol* 2007;50:69-76.
5. Ussia GP, Mulè M, Tamburino C. The valve-in-valve technique: transcatheter treatment of aortic bioprosthesis malposition. *Catheter Cardiovasc Interv* 2009;73:713-6.
6. Ruiz CE, Laborde JC, Condado JF, Chiam PT, Condado JA. First percutaneous transcatheter aortic valve-in-valve implant with three year follow-up. *Catheter Cardiovasc Interv* 2008;72:143-8.
7. Piazza N, Schultz C, de Jaegere PP, Serruys PW. Implantation of two self-expanding aortic bioprosthetic valves during the same procedure—insights into valve-in-valve implantation (“Russian doll concept”). *Catheter Cardiovasc Interv* 2009;73:530-9.
8. Piazza N, Grube E, Gerckens U, et al. Procedural and 30-day outcomes following transcatheter aortic valve implantation using the third generation (18 Fr) CoreValve ReValving System: results from the multicentre, expanded evaluation registry 1-year following CE mark approval. *Euro-Interv* 2008;4:242-9.

---

**Key Words:** aortic valve disease ■ aortic stenosis ■ valve prosthesis.