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Early Outcomes With the Evolut PRO Repositionable Self-Expanding Transcatheter Aortic Valve With Pericardial Wrap

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ABSTRACT

OBJECTIVES This study sought to evaluate the Medtronic Evolut PRO Transcatheter Aortic Valve System in patients with severe symptomatic aortic stenosis.

BACKGROUND A next-generation self-expanding transcatheter aortic valve was designed with an external pericardial wrap with the intent to reduce paravalvular leak while maintaining the benefits of a low-profile, self-expanding, and repositionable supra-annular valve.

METHODS The Medtronic Evolut PRO Clinical Study included 60 patients undergoing transcatheter aortic valve replacement with the Evolut PRO valve at 8 investigational sites in the United States. Clinical outcomes at 30 days were evaluated using Valve Academic Research Consortium-2 criteria. The 2 primary safety endpoints were the incidence of all-cause mortality at 30 days and the incidence of disabling stroke at 30 days. The primary efficacy endpoint was the proportion of patients with no or trace prosthetic valve regurgitation at 30 days. An independent echocardiographic core laboratory (Mayo Clinic, Rochester, Minnesota) was used to adjudicate all echocardiographic assessments.

RESULTS All 60 patients received the Evolut PRO valve. At 30 days, 1 patient (1.7%) died and 1 patient (1.7%) experienced a nonfatal disabling stroke. Paravalvular regurgitation at 30 days was absent or trace in 72.4% of patients and was mild in the remainder of patients, with no patients having worse than mild paravavlular leak. The mean atrioventricular gradient was 6.4 ± 2.1 mm Hg and effective orifice area was 2.0 ± 0.5 cm^2 at 30 days.

CONCLUSIONS The safety and efficacy results of this study support the use of the Evolut PRO System for the treatment of severe symptomatic aortic stenosis in patients who are at increased surgical risk, resulting in excellent hemodynamics and minimal paravalvular leak (The Medtronic TAVR 2.0 US Clinical Study; NCT02738853) (J Am Coll Cardiol Intv 2018;11:160–8) © 2018 by the American College of Cardiology Foundation.

Transcatheter aortic valve replacement (TAVR) with the self-expanding CoreValve system (Medtronic, Minneapolis, Minnesota) has been associated with superior hemodynamics and improved survival in randomized studies compared with surgical aortic valve replacement (SAVR) in patients at increased surgical risk (1,2). SAVR, however, has consistently shown superior results with regard to post-procedure paravalvular leak (PVL) across randomized studies of TAVR and SAVR (1,3–5).

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In addition, significant PVL following TAVR has been associated with adverse outcomes, including worsening heart failure (New York Heart Association [NYHA] functional classification ≥II) and increased short- and long-term mortality (6–10).

Since the first randomized studies comparing TAVR with SAVR, successive technological improvements in transcatheter aortic valves have led to improved survival and fewer complications (2,3,11–15). These design iterations have included systems that are lower in profile, can be repositioned during deployment, have optimized radial force, and have improved annular sealing (12–16).

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The Evolut PRO transcatheter aortic valve (Medtronic) represents the next-generation self-expanding valve in the CoreValve Evolut family. Building off the Evolut R valve platform, the Evolut PRO valve includes an external porcine pericardial wrap with the intent to diminish the incidence of PVL while maintaining the benefits of a low-profile, self-expanding valve with supra-annular function. Like the Evolut R valve, the Evolut PRO valve can be recaptured or repositioned to assist in optimal positioning at the level of the aortic annulus. The purpose of the Medtronic Evolut PRO US Clinical Study was to evaluate the new Evolut PRO System for the treatment of severe symptomatic aortic stenosis in patients at increased risk for SAVR.

METHODS

STUDY DESIGN. The Medtronic Evolut PRO US Clinical Study was a prospective, multicenter, controlled, nonrandomized single-arm study conducted at 8 investigational sites in the United States. The protocol was designed in collaboration between the sponsor, Medtronic, and the principal investigators for the trial (J.K.F. and M.R.W.). Clinical site selection, data collection, monitoring, and statistical analyses were performed by the sponsor. Each institutional review board approved the study protocol and each patient provided written, informed consent. The trial was conducted in accordance with the International Conference on Harmonization, Good Clinical Practice Guidelines, and the Declaration of Helsinki. An independent clinical events committee adjudicated all endpoint-related adverse events according to Valve Academic Research Consortium (VARC-2) definitions (17) and an independent echocardiographic core laboratory (Mayo Clinic, Rochester, Minnesota) adjudicated all echocardiographic assessments. Patients underwent assessments at baseline, discharge, and at 30 days, and will be followed at 6 months, and then annually out to 5 years.

VALVE DESIGN. The Evolut PRO valve is a repositionable self-expanding transcatheter aortic valve with similar properties to the Evolut R valve. The principal design modification is an external porcine pericardial wrap that has been added to cover the first 1.5 cells (~12 mm) with the aim of enhancing annular sealing and minimizing PVL. The remainder of the valve including the self-expanding nitinol frame with supra-annular porcine pericardial leaflets is otherwise unchanged from the Evolut R valve design (**Figure 1**).

PATIENT SELECTION. Inclusion criteria were the presence of severe symptomatic aortic stenosis in

ABBREVIATIONS AND ACRONYMS

NYHA = New York Heart Association

PVL = paravalvular leak

SAVR = surgical aortic valve replacement

TAVR = transcatheter aortic valve replacement

Services, Medtronic, Minneapolis, Minnesota; [i]Department of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota; and the [j]Department of Cardiothoracic Surgery, New York University-Langone Medical Center, New York, New York. Funded by Medtronic, Minneapolis, Minnesota. Dr. Forrest has received grant support/research contracts and consultant fees/honoraria/speakers bureau fees from Edwards Lifesciences and Medtronic. Dr. Mangi has received speaking fees and consulting fees from Thoratec Corporation; and speaking, training, and proctoring fees from Medtronic Corporation and Edwards LifeSciences. Dr. Popma has received grants from Medtronic, Boston Scientific, Abbott Vascular, and Direct Flow Medical; and serves on the medical advisory board of Boston Scientific and Cordis. Dr. Reardon serves on an advisory board for Medtronic. Dr. Kleiman has received fees for providing educational services from Medtronic. Dr. Yakubov has received institutional research grants from Medtronic, Direct Flow Medical, and Boston Scientific; and serves on an advisory board for Medtronic and Boston Scientific. Dr. Watson serves on the speakers bureau and is a proctor for Boston Scientific, Edwards, Medtronic, and Liva Nova. Dr. Kodali has received grant/research support from Boston Scientific, Claret Medical, Edwards Lifesciences, and Medtronic; serves on the steering committee for Claret Medical, Edwards Lifesciences, and Meril; holds equity in Thubrikar Aortic Valve and Dura Biotech; and received honoraria from Claret Medical and St. Jude Medical. Dr. George is a consultant for Medtronic. Dr. Tadros is a consultant and proctor and has received research support from Medtronic and St. Jude Medical. Dr. Zorn receives consulting fees from Medtronic. Dr. Kipperman is a consultant for Medtronic. Dr. Saul is an employee and shareholder of Medtronic. Dr. Qiao is an employee and shareholder of Medtronic. Dr. Williams serves as a consultant for Edwards Lifesciences and Medtronic; as a speaker for Abbott Laboratories; and has received research grants from Medtronic. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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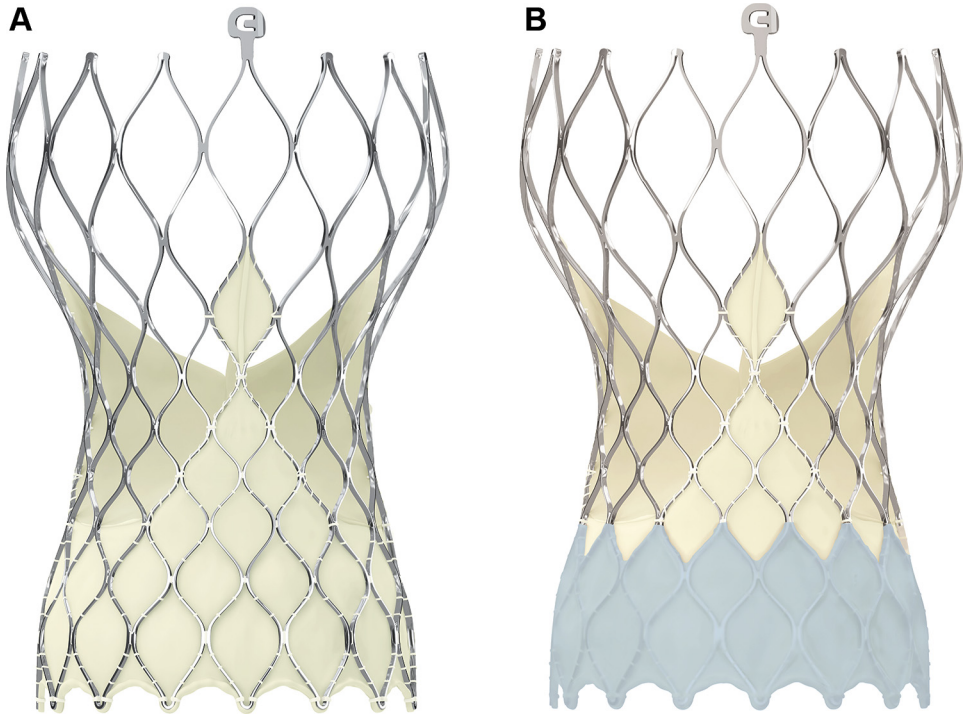
FIGURE 1 The Evolut R and the Evolut PRO Transcatheter Aortic Valves



The Evolut R **(A)** and Evolut PRO **(B)** transcatheter aortic valves are similar with the exception that a porcine pericardial wrap has been added to the first 2 rows of cells **(shaded)** with the intent to reduce paravalvular leak. © Medtronic 2017.

patients who were deemed high or extreme risk for SAVR by the heart team at each site (including a minimum of 1 interventional cardiologist and 2 cardiothoracic surgeons). Severe stenosis required documentation of an aortic valve area of <1.0 cm^2 (or aortic valve area index <0.6 cm^2/m^2) by the continuity equation and a mean aortic valve gradient >40 mm Hg or a maximal velocity >4.0 m/s at rest. Patients assessed as NYHA functional class II or greater were considered symptomatic. After heart team evaluation at each site, patients were subsequently reviewed to confirm eligibility and anatomic suitability by an independent national screening committee consisting of physician investigators. Key patient exclusion criteria included recent gastrointestinal bleeding preventing the use of antiplatelets, end-stage renal disease, severe left ventricular dysfunction (ejection fraction <20%), recent (within 6 months) cerebrovascular accident or transient ischemic attack, coronary revascularization or myocardial infarction within the prior 30 days, or a life expectancy of <1 year. Anatomic exclusions included any previous aortic valve implantation; severe aortic, mitral, or tricuspid regurgitation; a nontricuspid aortic valve; an aortic annulus <56.5 mm or >81.6 mm in perimeter (perimeter derived diameter <18 mm or >26 mm); or inadequate mean sinus of Valsalva diameter (<25 mm for the 23-mm valve, <27 mm for the 26-mm valve, or <29 mm for the 29-mm valve). The protocol instructed that patients were to be implanted within 30 days of approval by the screening committee.

Multidetected computed tomography with a 64-slice minimum scanner using retrospective gating was used for anatomic assessments in all patients. Images were analyzed in end-systole to measure the perimeter-based annular diameters of the aortic annulus, the aortic root, the diameters of the sinus of Valsalva, and the height of the coronary arteries. The sizing guidelines were based on a perimeter-derived diameter and were the same as those used with the predicate Evolut R valve (13). Peripheral vasculature suitability (minimal vessel diameter ≥5.5 mm) was also assessed using computed tomography, and using this information patients were approved to undergo TAVR via the transfemoral or an alternative access route (direct aortic or subclavian artery).

PROCEDURAL DETAILS. The details of the procedure and delivery system have been described previously (1,2,12,13). The Evolut PRO valve is designed to be delivered via a 16-F equivalent catheter EnVeo InLine Sheath (Medtronic) through vessels ≥5.5 mm in diameter. Alternatively, the entire system including the inline sheath can be delivered through a separate 20-F catheter introducer. The decision to use the inline sheath or a separate 20-F catheter introducer sheath was at the operators' discretion. Before valve delivery, the decision to balloon pre-dilate the native valve was also left to the discretion of the operators at each site. Once in position across the native aortic valve, the Evolut PRO valve is deployed in a stepwise fashion, which does not require the use of rapid ventricular pacing. At any stage of deployment before complete release, the valve can be partially resheathed or fully recaptured to allow for repositioning as needed. An implant depth of between 3 and 5 mm below the native annulus was recommended as the optimal depth, and repositioning before final release was suggested when the initial depth was significantly out of this range.

ECHOCARDIOGRAPHIC ANALYSIS. All patients underwent transthoracic echocardiograms at baseline (defined as within 10 weeks before review by the heart team), before hospital discharge, and at 30 days. The use of transesophageal echocardiography during the procedure was left to the operators' discretion. All transthoracic echocardiographic analyses were completed by an independent echocardiography core laboratory (Mayo Clinic, Rochester, Minnesota). Total aortic regurgitation was evaluated as the degree of paravalvular and transvalvular aortic regurgitation. The parameters used to quantify aortic regurgitation instituted by the core laboratory have been previously described (13).

ENDPOINTS. The 2 primary safety endpoints were the incidence of all-cause mortality at 30 days and the incidence of disabling stroke per the VARC-2 definitions (17) at 30 days. Secondary safety endpoints included the VARC-2-defined composite safety endpoint (all-cause mortality, all stroke, life-threatening bleeding, stage 2 or 3 acute kidney injury, coronary artery obstruction, major vascular complication, and valve-related dysfunction requiring repeat procedure).

The primary efficacy endpoint was the proportion of patients with none or trace total aortic regurgitation at 30 days by transthoracic echocardiography. Secondary efficacy endpoints included hemodynamic performance metrics at 30 days by echocardiography and VARC-2 device success rates at 1 to 7 days. Device success is a composite of the absence of procedural mortality and correct position of the valve and the intended performance of the valve (no patient prosthesis-mismatch [an indexed effective orifice area >0.85 cm^2/m^2 for patients with body mass index <30 kg/cm^2, or >0.70 cm^2/m^2 for patients with body mass index ≥30 kg/cm^2], a mean gradient <20 mm Hg or peak velocity of <3.0 m/s, and no moderate or severe prosthetic valve regurgitation).

STATISTICAL METHODS. The analysis group for this report comprised the 60 patients who underwent attempted implant of the Evolut PRO transcatheter aortic valve. Baseline categorical variables are presented as percentages and continuous variables as mean ± SD or median (interquartile range). Continuous variables were compared using the Student *t*-test. Event rates are reported as Kaplan-Meier estimates. All statistical analyses were performed using Statistical Analysis Systems software version 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

PATIENTS. A total of 60 patients underwent attempted implant with the Evolut PRO transcatheter aortic valve between June 2016 and November 2016. Baseline characteristics are listed in **Table 1**. The patient population was elderly (mean age, 83.3 years), frail (81.7% of patients), and with increased surgical risk (mean Society of Thoracic Surgeons Predictor of Mortality = 6.4%). The patient population comprised 65% women, 70.0% of patients had NYHA functional class III or IV symptoms, and 15.0% had a previously placed permanent pacemaker.

PROCEDURAL OUTCOMES. Of the 60 patients who underwent attempted implant, all 60 received the Evolut PRO valve (100% implant success). Procedural information and outcomes are listed in **Table 2**. The Evolut PRO valve was delivered via iliofemoral access in 98.3% of patients and general anesthesia was used in 58.3% of cases. No patients met the anatomic criteria for a 23-mm valve, 24 patients (40.0%) received a 26-mm valve, and 36 patients (60.0%) received a 29-mm valve. The 16-F equivalent catheter inline sheath was used in 46 (76.7%) of the cases. Pre-TAVR balloon aortic valvuloplasty was performed in 51.7% of patients and post-dilation of the valve was performed in 26.7% of patients. Of the 31 patients who underwent pre-dilation, 6 patients (19.4%) also underwent post-dilation. Of the 29 patients who did not have pre-TAVR balloon valvuloplasty, post-dilation was performed in 10 patients (34.5%). The

TABLE 1 Baseline Characteristics (N = 60)

Age, yrs	83.3 ± 7.2
BSA, m^2	1.8 ± 0.2
Female	39 (65.0)
STS PROM Score, %	6.4 ± 3.9
NYHA functional class	
I	0 (0.0)
II	18 (30.0)
III	41 (68.3)
IV	1 (1.7)
Diabetes	26 (43.3)
Serum creatinine >2 mg/dl	1 (1.7)
Chronic lung disease/COPD	18 (30.0)
Peripheral vascular disease	26 (43.3)
Cerebrovascular disease	11 (18.3)
Previous CABG	10 (16.7)
Previous PCI	14 (23.3)
Previous MI	6 (10.0)
Atrial fibrillation/atrial flutter	11 (18.6)
Other comorbidities and medical history	
Porcelain aorta*	3 (5.0)
Severely atherosclerotic aorta†	2 (3.4)
Frailty	49 (81.7)
Abnormal chest wall anatomy	1 (1.7)
Chest wall complications from prior surgery	5 (8.3)
Evidence of radiation damage	0 (0.0)
History of multiple recurrent pleural effusions	2 (3.3)
IMA (or other conduits) crossing midline	4 (6.9)
Cirrhosis of the liver	0 (0.0)
Pre-existing permanent pacemaker or defibrillator	9 (15.0)
Left ventricular ejection fraction, %	58.9 ± 12.4

Values are mean ± SD or n (%) that reflect missing values. *As documented in medical history. †Based on screening multidetector computed tomography.

BSA = body surface area; CABG = coronary artery bypass grafting; COPD = chronic obstructive pulmonary disease; IMA = internal mammary artery; MI = myocardial infarction; NYHA = New York Heart Association; PCI = percutaneous coronary intervention; STS PROM = Society of Thoracic Surgery Predictor of Mortality.

repositioning feature using either resheathing or recapturing of the valve was used in 21 patients (35.0%). The mean implant depth, estimated by fluoroscopy (site reported), was 4.2 ± 1.4 mm after release for nonrepositioned valves and 4.5 ± 2.1 mm for the repositioned valves (p = 0.608). Placement of a second valve was required in 1 patient after the first valve was inadvertently pulled up into the ascending aorta when the tip of the nose-cone snared an outflow crown during removal of the delivery system. There were no cases of annular rupture, coronary obstruction, or structural damage to the mitral valve apparatus. The median length of stay post-procedure was 2.0 days (interquartile range: 2.0 to 4.0 days).

DEVICE SUCCESS. The VARC-2 device success results at 1 to 7 days post-procedure are reported in Table 3.

TABLE 2 Procedural Outcomes (N = 60)

General anesthesia	35 (58.3)
Implanted valve size, mm	
23	0 (0.0)
26	24 (40.0)
29	36 (60.0)
Pre-implant balloon valvuloplasty	31 (51.7)
Post-implant balloon valvuloplasty	16 (26.7)
Access site	
Iliofemoral	59 (98.3)
Subclavian	1 (1.7)
Direct aortic	0 (0.0)
Mean implant depth, mm*	4.3 ± 1.6
Need for repositioning†	21 (35.0)
More than 1 valve implanted	1 (1.7)
Length of stay, days	2.0 (2.0-4.0)

Values are n (%), mean ± SD, or median (interquartile range). *By fluoroscopy. †Repositioning can include resheathing or full recapture of the valve.

In all but 1 patient (described previously), a single valve was implanted in the proper anatomic position and patient prosthesis mismatch was absent in 85.7%. All patients had a mean atrioventricular gradient <20 mm Hg. In 1 patient, the post-procedure echocardiography demonstrated moderate PVL; however, at 30-day follow-up this leak was mild in severity.

CLINICAL OUTCOMES. One patient died within 30 days (1.7%) and 1 patient experienced a disabling nonfatal stroke (1.7%) (Table 4). At 30 days, aortic regurgitation assessments were available in 58 patients and was none or trace in 42 patients (72.4%) (Figure 2). All regurgitation was paravalvular in nature and there were no patients with intravalvular aortic regurgitation at 30 days. Mild PVL was present

TABLE 3 Valve Academic Research Consortium-2 Device Success at 1 to 7 Days Post- Procedure

	Evolut PRO (N = 60)
Absence of procedural mortality	59/60 (98.3)
Correct positioning of single valve in proper anatomic location	59/60 (98.3)
Intended performance of prosthetic heart valve	42/50 (84.0)
Absence of patient prosthesis mismatch	42/49 (85.7)
Mean gradient <20 mm Hg or peak velocity <3 m/s	58/58 (100)
Absence of moderate or severe prosthetic regurgitation	59/60 (98.3)

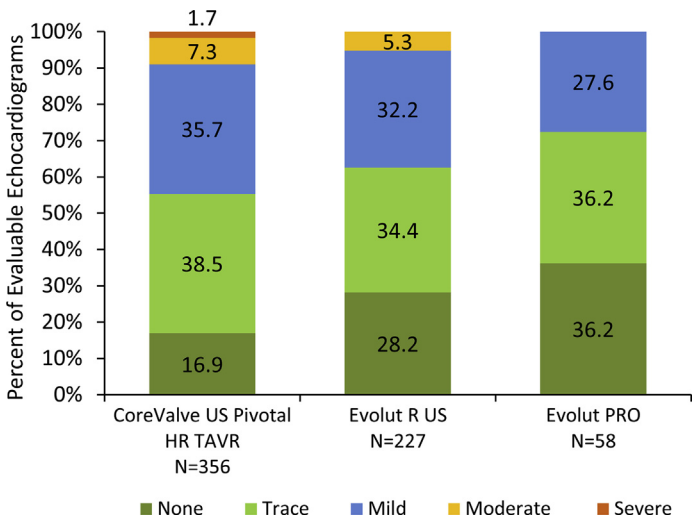
Values are n/N (%).

TABLE 4 Safety Endpoint Outcomes at 30 Days (N = 60)

All-cause mortality	1 (1.7)
Any stroke	1 (1.7)
Disabling stroke	1 (1.7)
Nondisabling stroke	0 (0.0)
Myocardial infarction	0 (0.0)
Life-threatening or disabling bleeding	7 (11.7)
Acute kidney injury: stage 2 or 3	1 (1.7)
Coronary artery obstruction	0 (0.0)
Vascular complications	7 (11.7)
Major vascular complication	6 (10.0)
Minor vascular complication	1 (1.7)
Valve-related dysfunction requiring repeat procedure	0 (0.0)
VARC-2 composite endpoint	9 (15.0)
Valve embolization or migration	1 (1.7)
New permanent pacemaker*	6 (11.8)

Values are n of patients (Kaplan-Meier rate). *Excluding patients with a pacemaker at baseline.

FIGURE 2 Paravalvular Leak at 30 Days



Echocardiographic core laboratory paravalvular leak at 30 days for patients treated with CoreValve bioprosthesis (1), the Evolut R valve (13), and the Evolut PRO valve.

in 16 patients (27.6%) at 30 days, and no patients had greater than mild PVL (Table 5).

ADDITIONAL ENDPOINTS. Major vascular complication occurred in 6 patients for a 30-day rate of 10.0%, and 7 (11.7%) patients experienced a life-threatening or disabling bleed. NYHA functional class improved in 51 patients (86.4%), remained unchanged in 7 patients (11.9%), and there were no patients with reported worsening NYHA functional class at 30 days (1 patient died before 30 days and in 1 patient NYHA assessment was not performed). Of the 60 patients in the study, 6 (10%) received a permanent pacemaker. Excluding the 9 patients with a pacemaker at baseline, the 30-day Kaplan-Meier rate of new pacemakers was 11.8% (Table 4).

DISCUSSION

We report here the clinical outcomes of patients undergoing TAVR with the new Evolut PRO valve. This valve represents the next-generation development of the Evolut platform, designed to enhance annular sealing while maintaining the benefits of a supra-annular, self-expanding, and repositionable valve. The safety and efficacy results of this study support the use of this valve in patients with severe symptomatic aortic stenosis with excellent valve performance, low pacemaker rates, and exceptional annular sealing.

PARAVALVULAR LEAK. The Evolut PRO valve was developed with the intent of reducing PVL after

TABLE 5 Echocardiographic Findings at 30 Days for Evolut PRO (N = 60)

Aortic valve function	
Mean aortic gradient, mm Hg	6.4 ± 2.1 (55)
Maximum aortic velocity, m/s	1.7 ± 0.3 (55)
Aortic valve area, cm^2	2.0 ± 0.5 (47)
Aortic valve area index, cm^2/m^2	1.1 ± 0.3 (47)
Total aortic regurgitation	58
None	21 (36.2)
Trace	21 (36.2)
Mild	16 (27.6)
Moderate	0 (0.0)
Severe	0 (0.0)
Paravalvular leak	58
None	21 (36.2)
Trace	21 (36.2)
Mild	16 (27.6)
Moderate	0 (0.0)
Severe	0 (0.0)
Transvalvular aortic regurgitation	57
None	57 (100)
Trace	0 (0.0)
Mild	0 (0.0)
Moderate	0 (0.0)
Severe	0 (0.0)
Patient prosthesis mismatch per VARC-2*	5/47 (10.6)

Values are mean ± SD (n), N, n (%), or n/N (%). *Per Valve Academic Research Consortium (VARC-2) definition (indexed effective orifice area ≤0.85 cm^2/m^2 for patients with body mass index <30 kg/cm^2, or <0.7 cm^2/m^2 for patients with body mass index ≥30 kg/m^2) (17).

TAVR. In this study with the Evolut PRO valve, we found that 72% of patients had no or trace PVL, which is a 16% relative increase in the proportions of patients with no or trace PVL at 30 days compared with the earlier-generation Evolut R valve in the United States (13). Furthermore, there were no cases of moderate (or severe) PVL with the Evolut PRO valve at 30 days in this study. As a result of successive improvements to the valve design including the addition of the pericardial wrap and standardization in implanting technique we have now seen a reduction in the frequency of moderate or severe PVL at 30 days from 9.0% in the CoreValve US Pivotal High Risk Trial (1), to 5.3% in the CoreValve Evolut R US Trial (13), to now 0% in the Evolut PRO Clinical Trial (**Figure 2**). Although there is still ongoing debate about whether residual mild PVL is associated with increased mortality (9,18), there is growing consensus that moderate or worse AR is associated with increased mortality following TAVR (2,6–8,10). In addition, as TAVR is studied in patients at lower risk for SAVR and in whom expected survival is longer than the originally studied cohorts, the presence of mild PVL may take on increasing importance. The benefits of enhanced sealing at the level of the annulus and reduced PVL accomplished by the addition of the pericardial tissue wrap did result in the need for a 2-F catheter increase in delivery catheter size as compared with the Evolut R system (16-F catheter vs. 14-F catheter).

PACEMAKERS. SAVR has been associated with lower rates of requirements for new pacemakers as compared with TAVR. Advancements to reduce PVL after TAVR, and in particular the interaction between the valve and anatomy at the level of the membranous septum and left ventricular outflow tract, has the potential to create conduction system disturbances (19–22). Modifications to the SAPIEN XT valve to make the SAPIEN 3 (Edwards Lifesciences, Irvine, California) that included the addition of a polyethylene terephthalate fabric seal around the inflow portion of the valve resulted in an increased incidence of pacemakers at 30 days (23). The addition of the outer pericardial wrap of the Evolut PRO valve did not increase the incidence of new permanent pacemaker implantations as compared with the Evolut R valve at 30 days and in fact was lower than in initial studies with the Evolut R valve (11.8% for Evolut PRO and 19.7% for Evolut R). These results are likely because the pericardial wrap is not designed to exert extra force on the left ventricular outflow tract but rather to help fill potential gaps caused by annular calcification and irregularities. Additionally, the low new pacemaker rates seen in this study may also be caused by increased operator experience and comfort with the Evolut valve delivery features, which allow for accurate valve positioning including the use of the resheathing and recapturing features. Indeed the site-reported average depth of valve implant in this study was 4.3 mm, and did not differ between patients who required valve repositioning and those who did not (4.2 mm vs. 4.5 mm, respectively; $p = 0.608$).

HEMODYNAMICS. Although the mid- and long-term effects of patient-prosthesis mismatch have not been well studied to date in transcatheter aortic valves, the data for SAVR are more robust. Previous studies have shown that between 20% and 70% of patients undergoing SAVR are left with some degree of patient-prosthesis mismatch (24). In addition, for patients undergoing SAVR, there is a significant correlation between patient-prosthesis mismatch, cardiac events, and all-cause and cardiovascular mortality over mid- and long-term follow-up (25,26). The hemodynamic performance of the supra-annular CoreValve Evolut platform has been shown to produce large effective orifice areas and low, single-digit mean gradients thereby minimizing the risk of patient prosthesis mismatch (1,2,13). Importantly, in this study we have shown that the addition of the outer pericardial wrap to the Evolut PRO valve did not change the hemodynamic performance of the valve as compared with the Evolut R valve. This is important because previous modification to valves in the past to reduce PVL, which added extra material at level of the left ventricular outflow tract, have been shown to increase the risk of patient prosthesis mismatch (27).

STUDY LIMITATIONS. There were no patients in our study that met the indications for the 23-mm bioprosthesis; however, because the Evolut PRO valve is an iterative product based on the Evolut R valve, one would expect these modifications to have similar results. Event rates reported from our small study compared with other reports may be a differential effect or characteristic of the small sample size (28). Experience with more patients treated with this new valve is needed.

CONCLUSIONS

The study demonstrates the Evolut PRO valve's safety and efficacy for the treatment of patients with severe aortic stenosis who are at increased risk for SAVR. The valve builds off the Evolut R platform by adding an outer pericardial wrap to enhance annular

sealing while maintaining supra-annular function and the ability to reposition. The results of this study demonstrate a low incidence of PVL with low rates of new permanent pacemakers and excellent hemodynamics with single-digit gradients.

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PERSPECTIVES

WHAT IS KNOWN? Paravalvular leak following TAVR has been associated with adverse outcomes.

WHAT IS NEW? Next-generation transcatheter aortic valves with an external pericardial wrap demonstrated improved annular sealing with less paravalvular leak while maintaining excellent hemodynamic performance.

WHAT IS NEXT? Continued improvements in transcatheter aortic valve technology have the potential to decrease patient risk and improve patient outcomes, thus continuing to redefine the landscape of aortic valve replacement.

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