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# Comparison of Evolut-R 34 mm Valve and Smaller Evolut-R Valves in Patients Undergoing Transcatheter Aortic Valve Implantation and Determination of Mild Paravalvular Leak Predictors

## ABSTRACT

**Objective:** The main purpose of this study was to evaluate and compare the in-hospital, 1-month and 1-year post-procedure outcomes of patients treated with Evolut-R 34 mm and Evolut-R 23/26/29 mm devices. Additionally, the study aimed to identify factors that could predict the occurrence of ≥ mild paravalvular leaks (PVL).

**Methods:** Between April 2015 and May 2022, 269 consecutive patients who underwent transcatheter aortic valve implantation (TAVI) with Evolut-R 34 mm (n=66, 24.5%) and Evolut-R 23/26/29 mm (n=203, 75.5%) devices in a single center were retrospectively analyzed.

**Results:** Patients in the Evolut-R 34 mm group had a lower female sex ratio (16.7% vs. 66.5%, $P < .001$, respectively), ejection fraction (50.7 ± 10.1% vs. 54.5 ± 9.3%, $P = .016$, respectively), and mean aortic gradient (7.4 ± 3.3 vs. 9.2 ± 5.0, $P = .026$, respectively) compared to the Evolut-R 23/26/29 mm group. The groups did not exhibit any statistically significant distinctions with regard to technical success, the need for a permanent pacemaker, occurrences of stroke, major vascular complications, PVL, major adverse cardiovascular and cerebrovascular events, or mortality. Peak velocity was confirmed as a significant predictor of ≥mild PVL in both patient groups in the receiver operating characteristic curve analysis. In logistic regression analysis; In patients with Evolut-R 34 mm valve, pre-TAVI aortic valve peak velocity (odds ratio (OR)=23.202; $P = .019$) and calcium volume 800 Hounsfield Units ($mm^3$) (OR=1.017; $P < .001$) were independent predictors of ≥mild PVL.

**Conclusion:** The Evolut-R 34 mm valve has shown comparable in-hospital results with smaller valve sizes. Pre-TAVI aortic valve peak velocity and calcium volume predicted ≥ mild PVL in Evolut-R 34 mm patients.

**Keywords:** Transcatheter aortic valve implantation, paravalvular leak, Evolut-R 34 mm, peak velocity

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## INTRODUCTION

Transcatheter aortic valve implantation (TAVI) is the favored treatment approach for individuals with symptomatic severe aortic stenosis (AS) who are deemed to have a moderate-to-high surgical risk, as an alternative to traditional surgical interventions.[1] Additionally, TAVI is becoming more commonly utilized for patients deemed to be at low surgical risk.[2,3]

In early 2017, the second-generation 34 mm self-expandable and partially retrievable prosthetic valve (Evolut-R, Medtronic, Minneapolis, Minn, USA) became accessible, supplanting the 31 mm non-retrievable version from the initial CoreValve platform's first generation. The Evolut-R 34 mm prosthesis was designed for the management of patients who have larger aortic valve (AV) annuli, specifically those with diameters ranging from 26 to 30 mm or circumferences falling between 81.7 and 94.2 mm, as illustrated in Figure 1. In contrast to the smaller Evolut-R valves (23/26/29 mm), this prosthesis offers

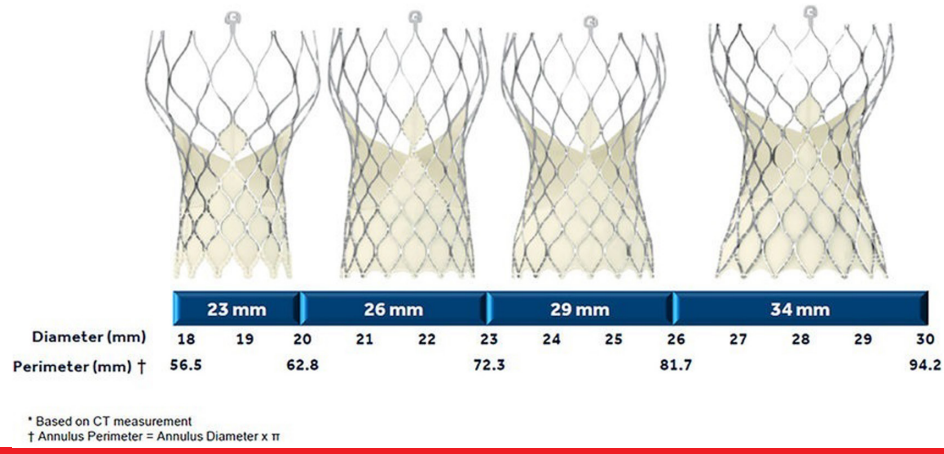


**Figure 1. CoreValve Evolut R size selection according to range of native aortic annulus diameters/perimeters (courtesy of Medtronic, Inc., Minneapolis, Minn, USA). CT, computed tomography.**

a greater degree of consistent radial force and features a broad stent design that can accommodate larger anatomical variations. This new device is designed to reduce paravalvular leak (PVL) rates and optimize deliverability in challenging large anatomies.[4,5] Compared to its predecessor CoreValve 31 mm, the Evolut-R 34 mm valve, the inflow part is wider and more cylindrical. It has also been modified to provide more consistent radial force. Furthermore, the outlet is designed to be shorter and narrower, enhancing its compatibility with aortic anatomies that have high angles. The lengthening of the pig pericardial inflow skirt is done to minimize paravalvular regurgitation. A 16-Fr EnVeo R delivery catheter is used to place the valve. The Nitinol delivery catheter capsule enables the possibility of retracting and recapturing the valve during the insertion process.

There are few studies comparing the in-hospital procedure results of the Evolut 34 mm device with the Evolut-R 23/26/29 mm devices. The results of these studies are conflicting in terms of device success, PVL, permanent pacemaker (PPM), and other complication rates.[6-10]

The objective of this study is to evaluate and compare patients who have undergone procedures with the EvolutR 34 mm valve and the Evolut-R 23/26/29 mm valve at our center. We evaluated patients' in-hospital outcomes as well as 1-month and 1-year mortality and major adverse cardiac and cerebrovascular events (MACCE) rates. In addition, we sought to find specific predictors of ≥mild PVL for both the EvolutR 34 mm and the Evolut-R 23/26/29 mm.

## HIGHLIGHTS

- Evolut-R 34 mm valve showed similar in-hospital results with smaller valve sizes
- Peak velocity and calcium volume are predictors of ≥ mild paravalvular leaks in Evolut-R 34 mm patients.
- The Evolut-R 34 mm valve performed better than expected.

## METHODS

Between April 2015 and May 2022, 269 consecutive patients who underwent TAVI with a self-expandable CoreValve Evolut device in our center were analyzed retrospectively.

A multidisciplinary cardiac team conducted an evaluation of the patients prior to the procedure. The valve implantation and subsequent patient monitoring were carried out by experienced interventional cardiologists. Patients who underwent balloon-expandable TAVI, those who had a valve-in-valve procedure, and individuals with bicuspid aortic valves were not included in the study.

As per the established protocol, patients scheduled for TAVI underwent regular screening assessments, which encompassed laboratory tests, transthoracic echocardiography (TTE), pulmonary function assessments, coronary angiography, and multislice computed tomography (MSCT) angiography. Severe AS was diagnosed using echocardiography criteria that included an AV area of ≤ 1.0 $cm^2$, an AV index of ≤ 0.6 $cm^2/m^2$, and a mean AV gradient exceeding 40 mmHg or a peak AV velocity exceeding 4.0 m/s, either at rest or during low-dose dobutamine stress testing. MSCT was used to assess various factors, including aortic anatomy, dimensions of the ascending aorta, size of the aortic annulus, positioning of the coronary arteries, structural characteristics of the AV, volume of AV calcification, AV area, and the conditions of the right, left, and non-coronary valves.

All interventions were carried out using conscious sedation alongside local anesthesia. Transfemoral access was the chosen approach for all patients. A temporary pacemaker was placed in the right ventricle before implantation and the valves were implanted with rapid pacing (100-140/min). Predilation and/or post-dilatation is left to the discretion of the implantation team. Arterial closure at the access site was provided using Perclose ProGlide® devices (Abbott Vascular, Santa Clara, Calif, USA).

The primary endpoints were technical success, new-onset stroke, acute renal failure, major bleeding, major vascular complications, PPM, arrhythmia, new-onset left bundle

branch block (LBBB), PVL, peri-procedural myocardial infarction (MI), MACCE, and death. Secondary endpoints were the Evolut-R 34mm and Evolut-R 23/26/29 mm specific ≥ mild PVL predictors. Procedural complications were determined in accordance with the classification criteria set forth by the Valve Academic Research Consortium (VARC)-3.[11]

All patients were evaluated with TTE by experienced echocardiographers at discharge. Post-procedure PVLs were evaluated according to VARC-3 criteria and classified as absent, mild, moderate–severe.

Technical success after TAVI was defined by several criteria: no in-hospital mortality, precise placement of the prosthetic valve in the correct anatomical position, absence of patient-prosthesis mismatch, a mean aortic gradient below 20 mm Hg, and no presence of moderate or severe PVL. These criteria align with the VARC-3 guidelines.[11]

The study was conducted with the written informed consent of all patients. The study was granted approval by the Local Ethics Committee (date and number: October 21, 2022-210). In accordance with the Helsinki Declaration, the study was conducted (2013).

### Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences Statistics 25.0 software (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was employed to assess whether each variable exhibited a normal distribution. Continuous variables that followed a normal distribution were presented as mean ± standard deviation, whereas those that did not conform to a normal distribution were described using median (interquartile range) values. For variables that exhibited a normal distribution, we employed Student's *t*-test to compare 2 groups, and one-way analysis of variance was utilized when comparing more than 2 groups. The Mann–Whitney *U*-test was employed to assess variables that did not adhere to a normal distribution. Categorical variables were presented as counts and percentages, and their comparisons were conducted using the Pearson chi-square test. After comparing more than 2 groups, post hoc analysis for multiple comparisons was performed on the parameters that were statistically significant. Receiver operating characteristic (ROC) analysis was used to test the capacity of independent variables to predict ≥mild PVL, besides to determine a cutoff value based on the highest sum of sensitivity and specificity. We utilized univariate and multiple logistic regression models to identify factors that predict the presence of ≥mild PVL. Parameters with $P < .05$ in the univariate analysis were included in the multiple analysis. A *P*-value below .05 was regarded as statistically significant.

The sample size calculation was performed using the G Power 3.1.9.7 software program. Estimated sample size was calculated using the Student's *t*-test with 0.95 (1-β err probe) power, $\alpha = .05$ error level and Cohen (d) effect size = 0.8. Based on these parameters, it was determined that a minimum of 88 patients (44 patients in each of the 2 groups, Group 1 and Group 2) would be appropriate to complete the study. The G Power 3.1.9.7 software program was utilized for post hoc power analysis. A test comparing the difference between 2 independent means was conducted. The power (1-β err probe) was determined as 0.999 with alpha 0.05 error level, Cohen (d) effect size = 0.8.

## RESULTS

### Baseline Characteristics

Our study comprised a total of 269 patients, with 66 patients (24.5%) receiving the Evolut-R 34 mm valve and 203 patients (75.5%) receiving the Evolut-R 23/26/29 mm valves (Figure 2). The average age of the patients was 78.9 ± 6.4 years, and there were no statistically significant differences between the 2 groups in terms of age (77.8 ± 6.7% vs. 79.3 ± 6.2%, $P = .115$, respectively). Female gender was significantly lower in the Evolut-R 34 mm valve group (16.7% vs. 66.5%, $P < .001$, respectively). Body mass index (kg/m$^2$) was found to be significantly higher in the Evolut-R 34 mm group (22.2 ± 1.8 vs. 21.7 ± 1.7, $P = .022$, respectively). According to the New York Heart Association (NYHA) classification, 96.3% of the patients are in the NYHA-3 and NHYA-4 classes. Of the patients in the Evolut-R 34 mm group, 69.7% were in the NHYA-3 class and 24.2% were in the NHYA-4 class. On the other hand, in the other group, 54.7% of the patients were in the NHYA-3 class and 42.4% were in the NHYA-4 class. A statistically significant distinction was observed between the groups ($P = .023$). When the groups were classified according to heart failure, heart failure was found significantly more in the Evolut-R 34 mm group than in the other group (51.5% vs. 35%, $P = .017$, respectively). The prevalence of smoking was notably greater in the Evolut-R 34 mm group, and this difference was statistically significant (43.9% vs. 18.2%, $P < .001$, respectively). The basic clinical and demographic characteristics of the patients are given in Table 1.

In the echocardiographic evaluations of the patients, in the Evolut-R 34 mm valve group; while AV doppler mean gradient (46.5 ± 6.7 vs. 49.5 ± 10.4, $P = .007$, respectively), AV doppler max gradient (75.9 ± 12.1 vs. 80.5 ± 16.6, $P = .014$, respectively), AV peak velocity (4.59 ± 0.26 vs. 4.77 ± 0.89,

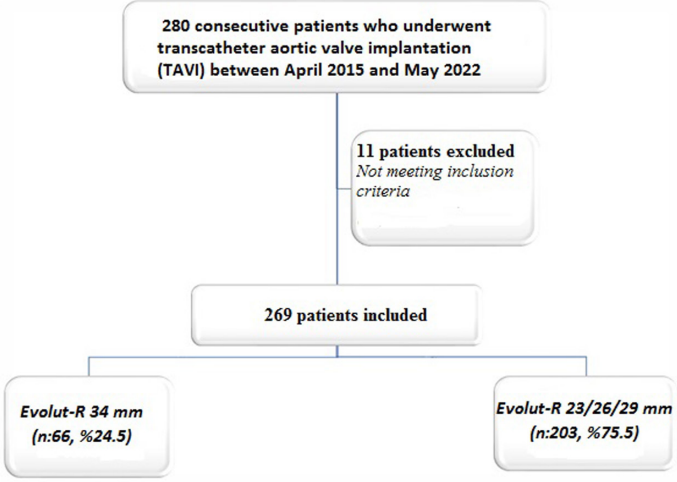


**Figure 2. Flow chart study population.**

**Table 1. Baseline Demographic and Clinical Characteristics of the Patients**

| Characteristics | Overall n = 269 | Evolut-R 34 mm n = 66 | Evolut-R 23/26/29 mm n = 203 | *P* |
|---|---|---|---|---|
| Age, years | 78.9 ± 6.4 | 77.8 ± 6.7 | 79.3 ± 6.2 | .115 |
| Sex, female, n (%) | 146 (54.3) | 11 (16.7) | 135 (66.5) | <.001 |
| Body mass index, kg/m$^2$ | 21.8 ± 1.7 | 22.2 ± 1.8 | 21.7 ± 1.7 | .022 |
| STS risk score, % | 8.59 ± 2.7 | 8.8 ± 3.0 | 8.5 ± 2.6 | .426 |
| NYHA Classification, n (%) | | | | |
| NYHA 2 | 10 (3.7) | 4 (6.1) | 6 (3.0) | |
| NYHA 3 | 157 (58.4) | 46 (69.7) | 111 (54.7) | .023 |
| NYHA 4 | 102 (37.9) | 16 (24.2) | 86 (42.4) | |
| Hypertension, n (%) | 151 (56.1) | 34 (51.5) | 117 (57.6) | .384 |
| Diabetes mellitus, n (%) | 66 (24.5) | 15 (22.7) | 51 (25.1) | .694 |
| Dyslipidemia, n (%) | 70 (26.0) | 12 (18.2) | 58 (28.6) | .095 |
| Previous PCI, n (%) | 89 (33.1) | 24 (36.4) | 65 (32.0) | .515 |
| Previous CABGO, n (%) | 33 (12.3) | 12 (18.2) | 21 (10.3) | .092 |
| COPD, n (%) | 28 (10.4) | 6 (9.1) | 22 (10.8) | .686 |
| Atrial fibrillation, n (%) | 58 (21.6) | 10 (15.2) | 48 (23.6) | .145 |
| Chronic renal failure, n (%) | 73 (27.1) | 15 (22.7) | 58 (28.6) | .354 |
| Heart failure, n (%) | 105 (39.0) | 34 (51.5) | 71 (35.0) | .017 |
| Anemia, n (%)- | 140 (52.0) | 29 (43.9) | 111 (54.7) | .129 |
| Smoking, n (%) | 66 (24.5) | 29 (43.9) | 37 (18.2) | <.001 |
| Balloon predilatation, n (%) | 76 (28.6) | 15 (23.1) | 61 (30.3) | .259 |
| Balloon postdilatation, n (%) | 66 (24.8) | 13 (20.0) | 53 (26.4) | .301 |

CABGO, coronary artery bypass graft operation; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; STS, society of thoracic surgeons.

*P* = .013, respectively), left ventricule ejection fraction (47.6 ± 12.9% vs. 51.7 ± 11.2%, *P* = .027, respectively) were found to be significantly lower, ascending aorta diameter (3.86 ± 0.50 vs. 3.63 ± 0.53, *P* = .007, respectively) was found to be higher. Systolic pulmonary artery pressure was lower in the Evolut-R 34 mm group (31.7 ± 21.1 vs. 39.4 ± 19.8, *P* = .013, respectively). As expected, aortic anulus diameter (27.1 ± 1.8 vs. 23.0 ± 2.4, *P* < .001, respectively), aortic annulus perimeter (86.1 ± 4.5 vs. 74.1 ± 6.5, *P* < .001, respectively), aortic annular area (544 ± 86 vs. 415 ± 75, *P* < .001, respectively), aort-right coronary artery (RCA) distance (19.0 ± 4.3 vs. 16.0 ± 3.0, *P* < .001, respectively), and aort-left mean coronary artery) distance (14.9 ± 4.1 vs. 12.6 ± 3.2, *P* < .001, respectively) were significantly higher in the Evolut-R 34 mm valve group in MSCT. There was no statistically significant distinction observed between the groups in relation to calcium volume 800 HU (mm$^3$). Additional echocardiographic and MSCT data for the patients are provided in Table 2.

The 4 valve groups are compared in Table 3. As a result, there were statistically significant variations between the groups

**Table 2. Baseline Echocardiographic and Multislice Computed Tomography Parameters**

| Echocardiographic Parameters | Overall n = 269 | Evolut-R 34 mm, n = 66 | Evolut-R 23/26/29 mm, n = 203 | *P* |
|---|---|---|---|---|
| AV doppler mean gradient, mm Hg | 48.8 ± 9.7 | 46.5 ± 6.7 | 49.5 ± 10.4 | .007 |
| AV doppler max gradient, mm Hg | 79.4 ± 15.7 | 75.9 ± 12.1 | 80.5 ± 16.6 | .014 |
| Aortic valve peak velocity (m/s) | 4.73 ± 0.79 | 4.59 ± 0.26 | 4.77 ± 0.89 | .013 |
| AV opening area (cm$^2$) | 0.68 ± 0.18 | 0.70 ± 0.18 | 0.67 ± 0.18 | .215 |
| LVEF, (%) | 50.7 ± 11.8 | 47.6 ± 12.9 | 51.7 ± 11.2 | .027 |
| LAD, cm | 4.46 ± 0.59 | 4.52 ± 0.63 | 4.44 ± 0.57 | .362 |
| Ascending aorta diameter, cm | 3.69 ± 0.53 | 3.86 ± 0.50 | 3.63 ± 0.53 | .007 |
| Moderate-severe MR, n (%) | 78 (29.7) | 19 (29.2) | 59 (29.8) | .931 |
| Moderate-severe AR, n (%) | 32 (12.3) | 9 (13.8) | 23 (11.7) | .653 |
| Moderate-severe TR, n (%) | 60 (22.7) | 13 (20) | 47 (23.6) | .546 |
| SPAP, mm Hg | 37.5 ± 20.5 | 31.7 ± 21.1 | 39.4 ± 19.8 | .013 |
| **Baseline Multislice Computed Tomography Measurements** | | | | |
| Aort-RCA distance, mm | 16.9 ± 3.7 | 19.0 ± 4.3 | 16.0 ± 3.0 | <.001 |
| Aort-LMCA distance, mm | 13.3 ± 3.7 | 14.9 ± 4.1 | 12.6 ± 3.2 | <.001 |
| Ascending aorta, mm | 34.6 ± 4.1 | 35.7 ± 4.4 | 34.0 ± 3.9 | .018 |
| Aortic anulus diameter, mm | 24.3 ± 2.8 | 27.1 ± 1.8 | 23.0 ± 2.4 | <.001 |
| NCC-sinus valsalva diameter, mm | 30.3 ± 5.5 | 34.3 ± 4.8 | 28.5 ± 4.9 | <.001 |
| RCC-sinus valsalva diameter, mm | 28.3 ± 4.8 | 31.4 ± 4.9 | 26.9 ± 4.1 | <.001 |
| LCC-sinus valsalva diameter, mm | 29.7 ± 6.7 | 33.6 ± 6.3 | 27.8 ± 6.2 | <.001 |
| Aortic annulus perimeter, mm | 77.9 ± 8.1 | 86.1 ± 4.5 | 74.1 ± 6.5 | <.001 |
| Aortic annular area, mm$^2$ | 456 ± 99 | 544 ± 86 | 415 ± 75 | <.001 |
| Angular angle, IQR | 49 (42-55) | 49 (40-55) | 48.5 (43-55) | .419 |
| AVC Volume (mm$^3$) | 729 ± 167 | 714 ± 206 | 734 ± 153 | .475 |
| Calcium volume 800 HU (mm$^3$) | 259 (148-357) | 265 (175-364) | 259 (148-352) | .540 |

Data are expressed as mean ± standard deviation (SD), frequencies (percentages), or as median (interquartile range) as appropriate.
AR, aortic regurjitation; AV, aortic valve; AVC, Aortic Valve Calcification; IQR, interquartile range; LAD, left atrium diameter; LCC, left coronary cusp; LMCA, left mean coronary artery; LVEF, left ventricule ejection fraction; MR, mitral regurjitation; NCC, non-coronary cusp; RCA, right coronary artery; RCC, right-coronary cusp; SPAP, systolic pulmonary artery pressure; TR, tricuspid regurjitation.

**Table 3. Basic Demographic and Clinical Characteristics of All Valve Groups**

| Characteristics | Overall n = 269 | 23 mm n = 25 | 26 mm n = 71 | 29 mm n = 107 | 34 mm n = 66 | *P* |
|---|---|---|---|---|---|---|
| Age, years | 78.9 ± 6.4 | 80.2 ± 7.9 | 79.3 ± 5.8 | 79.1 ± 6.1 | 77.8 ± 6.7 | .374 |
| Sex, female, n (%) | 146 (54.3) | 21 (84.0) | 55 (77.5) | 59 (55.1) | 11 (16.7) | <.001 |
| Body mass index, kg/m$^2$ | 21.8 ± 1.7 | 21.7 ± 1.4 | 21.1 ± 1.8 | 22.0 ± 1.6 | 22.2 ± 1.8 | .001 |
| STS risk score, % | 8.59 ± 2.7 | 8.3 ± 2.1 | 8.5 ± 2.7 | 8.5 ± 2.7 | 8.8 ± 3.0 | .854 |
| NYHA Classification, n (%) | | | | | | |
| NYHA 2 | 10 (3.7) | 0 (0) | 2 (2.8) | 4 (3.7) | 4 (6.1) | |
| NYHA 3 | 157 (58.4) | 14 (56.0) | 35 (49.3) | 62 (57.9) | 46 (69.7) | .129 |
| NYHA 4 | 102 (37.9) | 11 (44.0) | 34 (47.9) | 41 (38.3) | 16 (24.2) | |
| Hypertension, n (%) | 151 (56.1) | 16 (64.0) | 42 (59.2) | 59 (55.1) | 34 (51.5) | .681 |
| Diabetes mellitus, n (%) | 66 (24.5) | 5 (20.0) | 25 (35.2) | 21 (19.6) | 15 (22.7) | .104 |
| Dyslipidemia, n (%) | 70 (26.0) | 11 (44.0) | 23 (32.4) | 24 (22.4) | 12 (18.2) | .036 |
| Previous PCI, n (%) | 89 (33.1) | 8 (32.0) | 26 (36.6) | 31 (29.0) | 24 (36.4) | .670 |
| Previous CABGO, n (%) | 33 (12.3) | 2 (8.0) | 10 (14.1) | 9 (8.4) | 12 (18.2) | .234 |
| COPD, n (%) | 28 (10.4) | 2 (8.0) | 8 (11.3) | 12 (11.2) | 6 (9.1) | .938 |
| Atrium Fibrillation, n (%) | 58 (21.6) | 5 (20.0) | 17 (23.9) | 26 (24.3) | 10 (15.2) | .503 |
| Chronic renal failure, n (%) | 73 (27.1) | 4 (16.0) | 21 (29.6) | 33 (30.8) | 15 (22.7) | .366 |
| Heart failure, n (%) | 105 (39.0) | 5 (20.0) | 19 (26.8) | 47 (43.9) | 34 (51.5) | .003 |
| Anemia, n (%) | 140 (52.0) | 16 (64.0) | 42 (59.2) | 53 (49.5) | 29 (43.9) | .181 |
| Smoking, n (%) | 66 (24.5) | 4 (16.0) | 11 (15.5) | 22 (20.6) | 29 (43.9) | <.001 |
| Balloon Predilatation, n (%) | 76 (28.6) | 9 (36.0) | 29 (40.8) | 23 (21.5) | 15 (23.1) | .021 |
| Balloon Postdilatation, n (%) | 66 (24.8) | 5 (20.0) | 24 (33.8) | 24 (22.4) | 13 (20.0) | .198 |
| LVEF, (%) | 50.7 ± 11.8 | 55.7 ± 9.3 | 55.0 ± 9.9 | 48.6 ± 11.6 | 47.6 ± 12.9 | <.001 |

CABGO, coronary artery bypass graft operation; COPD, chronic obstructive pulmonary disease; LVEF, left ventricule ejection fraction; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; STS, society of thoracic surgeons.

in terms of gender, body mass index, dyslipidemia, heart failure, smoking, balloon predilatation, and left ventricule ejection fraction. These significant parameters were then evaluated with post hoc analysis. Especially in gender, significant differences emerge when 34 valves and other valves are compared separately ($P < .001$). The results are given in Table 4.

## Post-Procedure Results and Complications

Technical success was 88.5% in all patients, and there was no significant difference between the 2 groups. Post-procedure ejection fraction and mean gradient were found to be lower in the Evolut-R 34 mm valve group (50.7% vs. 54.5%, $P = .016$ and 7.4 vs. 9.2, $P = .026$, respectively). The mean implantation depth was higher in the Evolut-R 34 mm valve group (7.90 ± 0.50 vs. 5.38 ± 0.89, $P < .001$). A total of 20 patients were implanted with PPMs and no statistically significant difference was found between the groups. A mild PVL was identified in 111 patients, while 6 patients exhibited a moderate-severe PVL. The mean hospitalization time after the procedure was 3 days (interquartile range 2-6 days). Periprocedural MI occurred in 3 patients. While in-hospital mortality was observed in 15 patients, in-hospital MACCE occurred in 25 patients. While the total mortality was 35 at 1-year follow-up, 1-year MACCE was observed in 63 patients. No statistically significant difference was observed between the Evolut-R 34 mm and Evolut-R 23/26/29 mm valve groups in terms of PPM, paravalvuler leak, mortality, MACCE, and other complications. The procedural complications and clinical endpoints of the patients are presented in Table 5.

Paravalvular leak was present in 117 (43%) patients. The rate of PVL development was higher in male patients (53.0% vs. 40.1%, $P = .036$). Aortic valve peak velocity (m/s) and calcium volume 800 HU (mm$^3$) were found to be higher in patients who developed PVL (4.89 ± 0.78 vs. 4.60 ± 0.78, $P = .003$ and 364 (315-412) vs. 201(137-259), $P < .001$, respectively). The basic demographic characteristics of patients, both with and without PVL, are outlined in Table 6.

Peak velocity was confirmed on ROC analysis a significant predictor of ≥mild PVL both in the Evolut-R 34 mm (AUC = 0.749, $P < .001$) (cutoff = 4.45 mm$^3$ 78% sensitivity, 61% specificity) and Evolut-R 23/26/29 mm (AUC = 0.648, $P < .001$) (cutoff = 4.45 mm$^3$ 65% sensitivity, 63% specificity) population (Figure 3).

In univariate logistic regression analysis; in patients with Evolut-R 34 mm valve, Pre-TAVI AV peak velocity (odds ratio (OR) = 25.016; $P = .004$) and calcium volume 800 HU (mm$^3$) (OR = 1.017; $P < .001$) were independent predictors of ≥mild PVL. Furthermore, in patients with Evolut-R 23/26/29 mm valve, gender (OR = 1.861; $P = .039$), pre-TAVI AV peak velocity (OR = 1.517; $P = .011$), and calcium volume 800 HU (mm$^3$) (OR = 1.021; $P < .001$) were independent predictors of ≥ mild PVL. Independent predictors of ≥mild PVL in multiple logistic regression analysis: in patients with Evolut-R 34 mm valves,

**Table 4. Comparison of Significant Parameters Between Valves with Post Hoc Analysis**

| Parameters | Comparison of Valves | *P* |
|---|---|---|
| Sex, female, n (%) | 23 mm-26 mm | .489 |
| | 23 mm-29 mm | .008 |
| | 23 mm-34 mm | <.001 |
| | 26 mm-29 mm | .002 |
| | 26 mm-34 mm | <.001 |
| | 29 mm-34 mm | <.001 |
| Body mass index, kg/m$^2$ | 23 mm-26 mm | .560 |
| | 23 mm-29 mm | .827 |
| | 23 mm-34 mm | .584 |
| | 26 mm-29 mm | .006 |
| | 26 mm-34 mm | .002 |
| | 29 mm-34 mm | .904 |
| Dyslipidemia, n (%) | 23 mm-26 mm | .297 |
| | 23 mm-29 mm | .028 |
| | 23 mm-34 mm | .011 |
| | 26 mm-29 mm | .140 |
| | 26 mm-34 mm | .057 |
| | 29 mm-34 mm | .504 |
| Heart failure, n (%) | 23 mm-26 mm | .502 |
| | 23 mm-29 mm | .028 |
| | 23 mm-34 mm | .007 |
| | 26 mm-29 mm | .020 |
| | 26 mm-34 mm | .003 |
| | 29 mm-34 mm | .331 |
| Smoking, n (%) | 23 mm-26 mm | .952 |
| | 23 mm-29 mm | .606 |
| | 23 mm-34 mm | .013 |
| | 26 mm-29 mm | .394 |
| | 26 mm-34 mm | <.001 |
| | 29 mm-34 mm | .001 |
| Balloon predilatation, n (%) | 23 mm-26 mm | .670 |
| | 23 mm-29 mm | .128 |
| | 23 mm-34 mm | .200 |
| | 26 mm-29 mm | .005 |
| | 26 mm-34 mm | .023 |
| | 29 mm-34 mm | .849 |
| LVEF (%) | 23 mm-26 mm | .995 |
| | 23 mm-29 mm | .064 |
| | 23 mm-34 mm | .039 |
| | 26 mm-29 mm | .005 |
| | 26 mm-34 mm | .003 |
| | 29 mm-34 mm | .963 |

LVEF, left ventricule ejection fraction.

**Table 5. Procedural Complications and Clinical Endpoints of the Patients**

| Complications and Clinical Endpoints | Overall n = 269 | Evolut-R 34 mm, n = 66 | Evolut-R 23/26/29 mm, n = 203 | *P* |
|---|---|---|---|---|
| Ejection fraction, (%) | 53.4 ± 9.7 | 50.7 ± 10.1 | 54.5 ± 9.3 | .016 |
| Mean gradient, mm Hg | 8.8 ± 4.7 | 7.4 ± 3.3 | 9.2 ± 5.0 | .026 |
| Implantation depth mean, mm | 6.00 ± 1.35 | 7.90 ± 0.50 | 5.38 ± 0.89 | <.001 |
| Technical success, n (%) | 238 (88.5) | 56 (84.8) | 182 (89.7) | .288 |
| Permanent pacemaker, n (%) | 20 (7.4) | 8 (12.1) | 12 (5.9) | .095 |
| New-onset stroke, n (%) | 9 (3.3) | 1 (1.5) | 8 (3.9) | .341 |
| Pericardial tamponade, n (%) | 6 (2.2) | 1 (1.5) | 5 (2.5) | .651 |
| Arrhythmia, n (%) | 47 (17.5) | 9 (13.6) | 38 (18.7) | .345 |
| Acute renal insufficiency, n (%) | 12 (4.5) | 3 (4.5) | 9 (4.4) | .969 |
| Major bleedings, n (%) | 14 (5.2) | 2 (3.0) | 12 (5.9) | .360 |
| Major vascular complications, n (%) | 18 (6.7) | 4 (6.1) | 14 (6.9) | .813 |
| New-onset LBBB, n (%) | 92 (34.5) | 27 (40.9) | 65 (32.3) | .204 |
| Paravalvuler Leak, n (%) | | | | |
| Mild | 111 (41.6) | 30 (45.5) | 81 (40.3) | .461 |
| Moderate-severe | 6 (2.2) | 3 (4.5) | 3 (1.5) | .143 |
| Peri-procedural MI, n (%) | 3 (1.1) | 1 (1.5) | 2 (1.0) | .725 |
| Hospitalization, n (%) | 72 (26.8) | 17 (25.8) | 55 (27.1) | .831 |
| Hospitalization day, IQR | 3 (2-6) | 3 (2-6) | 3 (2-6) | .517 |
| In-hospital mortality, n (%) | 15 (5.6) | 5 (7.6) | 10 (4.9) | .415 |
| First month death, n (%) | 7 (2.6) | 2 (3.0) | 5 (2.5) | .801 |
| Fisrt year death, n (%) | 35 (13.0) | 8 (12.1) | 27 (13.3) | .805 |
| In-hospital MACCE, n (%) | 25 (9.3) | 6 (9.1) | 19 (9.4) | .948 |
| First month MACCE, n (%) | 32 (11.9) | 8 (12.1) | 24 (11.8) | .926 |
| 1-year MACCE, n (%) | 63 (23.4) | 16 (24.2) | 47 (23.2) | .856 |

Data are expressed as mean ± standard deviation (SD), frequencies (percentages) or as median (interquartile range) as appropriate. IQR, interquartile range; LBBB, left bundle branch block; MACCE, major adverse cardiac and cerebrovascular events; MI, myocardial infarction.

**Table 6. Comparison of Patients With and Without Paravalvular Leak**

| Characteristics | Overall n = 269 | Paravalvular Leak n = 117 | Without Paravalvular Leak n = 152 | *P* |
|---|---|---|---|---|
| Age, years | 78.9 ± 6.4 | 78.7 ± 6.0 | 79.1 ± 6.6 | .670 |
| Sex, male, n (%) | 146 (54.3) | 62 (53.0) | 61 (40.1) | .036 |
| Body mass index, kg/m$^2$ | 21.8 ± 1.7 | 21.8 ± 1.5 | 21.8 ± 1.9 | .701 |
| STS risk score, % | 8.59 ± 2.7 | 8.7 ± 2.8 | 8.4 ± 2.6 | .468 |
| Aortic valve peak velocity (m/s) | 4.73 ± 0.79 | 4.89 ± 0.78 | 4.60 ± 0.78 | .003 |
| Calcium volume 800 HU (mm$^3$) | 259 (148-357) | 364 (315-412) | 201 (137-259) | <.001 |
| LVEF (%) | 50.7 ± 11.8 | 49.7 ± 11.0 | 51.4 ± 12.3 | .237 |
| Hypertension, n (%) | 151 (56.1) | 69(59.0) | 82 (53.9) | .410 |
| Diabetes mellitus, n (%) | 66 (24.5) | 23 (19.7) | 43 (28.3) | .103 |
| Dyslipidemia, n (%) | 70 (26.0) | 30 (25.6) | 40 (26.3) | .900 |
| Previous PCI, n (%) | 89 (33.1) | 46 (39.3) | 43 (28.3) | .057 |
| Previous CABGO, n (%) | 33(12.3) | 18(15.4) | 15(9.9) | .172 |
| COPD, n% | 28 (10.4) | 14 (12.0) | 14 (9.2) | .463 |
| Atrium fibrillation, n (%) | 58 (21.6) | 28 (23.9) | 30 (19.7) | .407 |
| Chronic renal failure, n (%) | 73 (27.1) | 26 (22.2) | 47 (30.9) | .112 |
| Heart failure, n (%) | 105 (39.0) | 50 (42.7) | 55 (36.2) | .275 |
| Anemia, n (%) | 140 (52.0) | 56 (47.9) | 84 (55.3) | .228 |
| Smoking, n (%) | 66 (24.5) | 34 (29.1) | 32 (21.1) | .130 |
| Balloon predilatation, n (%) | 76 (28.6) | 27 (23.1) | 49 (32.2) | .098 |
| Balloon postdilatation, n (%) | 66 (24.8) | 25 (21.4) | 41 (27.0) | .289 |

CABGO, coronary artery bypass graft operation; COPD, chronic obstructive pulmonary disease; LVEF, left ventricule ejection fraction; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; STS, Society of Thoracic Surgeons.

pre-TAVI AV peak velocity (OR = 23.202; *P* = .019), and calcium volume were 800 HU (mm$^3$) (OR = 1.017; *P* < .001), while in patients with Evolut-R 23/26/29 mm valves, it was calcium volume 800 HU (mm$^3$) (OR = 1.021; *P* < .001)(Table 7).

## DISCUSSION

In our study, good procedural and in-hospital outcomes were observed in patients treated with Evolut-R 34 mm, similar to the Evolut-R 23/26/29 mm sizes. Majority of the patients with Evolut-R 34 mm valve were male, in addition, smoking and heart failure were detected at a higher rate. A lower mean aortic gradient was observed with the Evolut-R 34 mm compared to the smaller Evolut-R sizes (7.4 mm Hg vs. 9.2 mm Hg, *P* = .026). The overall mean gradient (8.8 mm Hg) was consistent with the results of the FORWARD recording (8.5 mm Hg) and the SURTAVI study (8.9 mm Hg).[12,13]

The technical success achieved with the Evolut-R 34mm valve was comparable to smaller valves (84.8% vs. 89.7%). It was also consistent with recently published studys.[6-8,10] In our study, the Evolut-R 34 mm valve group was exposed to a higher rate of radiation, more contrast material was used, and the recapture ability was used more frequently.

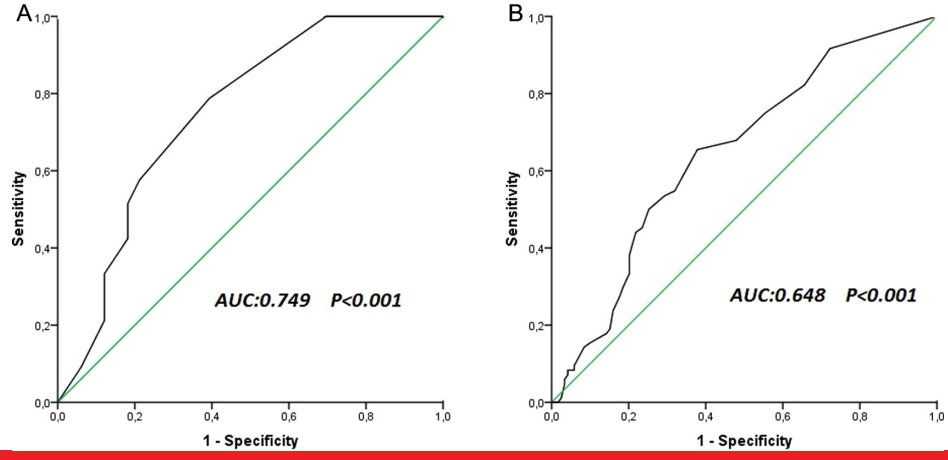


**Figure 3. Peak velocity in receiver operating characteristic curve analysis, A: Evolut-R 34 mm, B: Evolut-R 23/26/29 mm. AUC, area under the curve.**

**Table 7. Independent Predictors of ≥Mild Paravalvular Leak in the Univariate and Multiple Logistic Regression Analysis Model**

| | Univariate Analysis | | | Multivariate Analysis | | |
|---|---|---|---|---|---|---|
| All patients | OR | 95% CI | *P* | OR | 95% CI | *P* |
| Gender | 1.682 | 1.034-2.736 | .036 | 1.494 | 0.763-2.928 | .242 |
| Pre-TAVI aortic valve peak velocity | 1.594 | 1.153-2.204 | .005 | 1.712 | 1.088-2.694 | .020 |
| Calcium volume 800 HU ($mm^3$) | 1.020 | 1.015-1.025 | <.001 | 1.020 | 1.015-1.024 | <.001 |
| Evolut-R 34 mm | | | | | | |
| Pre-TAVI aortic valve peak velocity | 25.016 | 2.818-222.031 | .004 | 23.202 | 1.691-318.270 | .019 |
| Calcium volume 800 HU ($mm^3$) | 1.017 | 1.009-1.025 | <.001 | 1.017 | 1.009-1.026 | <.001 |
| Evolut-R 23/26/29 mm | | | | | | |
| Gender | 1.861 | 1.031-3.361 | .039 | 1.596 | 0.694-3.669 | .271 |
| Pre-TAVI aortic valve peak velocity | 1.517 | 1.098-2.094 | .011 | 1.594 | 0.996-2.551 | .052 |
| Calcium volume 800 HU ($mm^3$) | 1.021 | 1.015-1.027 | <.001 | 1.021 | 1.015-1.026 | <.001 |

OR, odds ratio; PCI, percutaneous coronary intervention.

Therefore, it can be considered that more operator experience is required with this device compared to smaller valve sizes.

The use of a smaller sheath and improved delivery capability (in-line sheath) on the Evolut-R 34 mm valve (16 Fr) compared to its predecessor 31 mm (18 Fr) reduced bleeding complication rates.[14] The 16-Fr equivalent EnVeo R delivery catheter system is of a larger size compared to the 14-Fr equivalent system utilized for the 23/26/29 mm Evolut R valves. Nonetheless, due to the larger iliofemoral vessels in this patient group, the incidence of bleeding and major vascular complications exhibited similar rates.

The Evolut-R 34 mm showed a slightly higher, if not significant, PPM ratio compared to the smaller Evolut-R valves (12.1% vs. 5.9%, respectively). This could be attributed to the increased pressure exerted on the conduction system by the Evolut-R 34 mm valve and its more conical inflow shape, in contrast to the smaller valves which have a more cylindrical shape. In addition, the higher implantation depth in the Evolut-R 34 mm valve group may explain this situation. We found lower rates of PPM compared to recent studies.[6-10] However, compared to the previous 31 mm self-expanding prosthesis, pacemaker rates are much lower.[14] This is a crucial consideration to ensure the safe utilization of the larger valve without causing a substantial increase in the rate of PPM implantations.

Post-procedure mild and moderate-severe PVL rates were similar in both groups. The fact that the Evolut-R 34 mm valve has an optimized oversize and enlarged sealing skirt may explain this. Although we found the rate of moderate-severe PVL similar to previous studies, we found a lower rate of mild PVL.[6,7,10] We also observed that PVL improved over time in patients treated with self-expandable valves, as previously reported.[7] In a study published in 2021, 60° aortic angulation was found to be a predictor of ≥moderate PVL for the Evolut-R 34 mm valve.[10] However, in our study, we aimed to determine the predictors of ≥mild PVL in both Evolut-R 34 mm and Evolut-R 23/26/29 mm valves. In both groups, 4.45 mm AV peak velocity was found to be a predictor of ≥mild PVL. In addition, independent predictors of ≥mild PVL were determined using regression analysis in both groups. Pre-TAVI AV peak velocity and calcium volume 800 HU ($mm^3$) were found in the Evolut-R 34 mm group, while only calcium volume 800 HU ($mm^3$) was found in the Evolut-R 23/26/29 mm group. Consistent with our study, a recent review article found that pre-TAVI AV peak velocity and calcium volume 800 HU ($mm^3$) ≥mild PVL predictors.[15] These predictors need to be confirmed by further studies with greater patient participation.

There were no statistically significant differences observed between the patient groups in relation to new-onset stroke, arrhythmia, new-onset LBBB, hospitalization, or peri-procedural MI. At the same time, in-hospital, 1-month and 1-year mortality, and MACCE rates were found to be similar. In this study, we investigated a consecutive series of real-world patients treated with Evolut-R devices at a high-volume center. The clinical implications of our study are important as it confirms the safety and efficacy of the Evolut-R 34mm.

### Study Limitations

The primary limitations of our study include the fact that it was conducted at a single center, the relatively small sample size, and the retrospective nature of the analysis for both study groups. This may expose him to selection bias. However, the primary operator being a single person can provide a relative advantage where decisions are at the operator's discretion in many respects. In addition, we did not have an independent echocardiographic core laboratory, and there was a lack of long-term follow-up.

## CONCLUSION

The Evolut-R 34 mm valve showed good in-hospital outcome in terms of mortality, MACCE, device success, PVL, PPM, and other complication rates compared to the Evolut-R 23/26/29 mm valve sizes. Pre-TAVI AV peak velocity and calcium volume were found to be independent predictors of ≥mild PVL in Evolut-R 34 mm patients. Multicenter prospective studies with higher patient numbers are needed to confirm our results.

**Ethics Committee Approval:** The study complied with the Declaration of Helsinki. Our study was approved by the Ethics

Committee of Diyarbakır Dr. Gazi Yaşargil Training and Research Hospital with the date 21/10/2022 and decision number 210.

**Informed Consent:** Informed consent was obtained from patients who agreed to participate in the study.

**Peer-review:** Externally peer-reviewed.

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