



# The impact of perceval sutureless aortic valve in multiple valve surgery: implications of short- and mid-term outcomes—a propensity score matched study

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**Background:** Sutureless aortic valve replacement (S-AVR) is a surgical alternative to conventional aortic valve replacement (C-AVR), recognized for its efficacy and clinical superiority in the treatment of valvular disease. Its use is gradually increasing not only in single-valve procedures but also in multiple valve surgeries. This study aimed to evaluate our experience with the Perceval S-AVR combined with mitral and tricuspid valve surgery such as multiple valve surgery, focusing on the clinical outcomes and operative time.

**Methods:** Between January 2017 and December 2022, 141 patients underwent surgical aortic valve replacement (AVR) using the bioprosthetic aortic valve at our institution. Of them, 42 patients (29.8%) underwent S-AVR with multivalve surgery. After 1:1 propensity score matching, 42 patients were selected as study subjects in each group. The primary endpoints were 30-day and follow-up mortality and major valve-related adverse events, such as structural valve dysfunction, valve thrombus, endocarditis, stroke, re-intervention, and pacemaker implantation.

**Results:** In matched cohort, the mean age  $74.3 \pm 4.2$  and  $74.2 \pm 6.2$  years in C-AVR and S-AVR groups, respectively. The in-hospital mortality rates were 2.4% and 0% ( $P > 0.999$ ), and follow-up mortality rates were 4.8% and 7.1% ( $P > 0.99$ ) in C-AVR and S-AVR groups, respectively. Paravalvular leakage and abnormal pressure acceleration were absent in both the groups, and the incidence of postoperative valve-related adverse events did not vary between the groups. The operation time, including for the mitral valve, tricuspid valve, and arrhythmia surgeries, was significantly shorter in the S-AVR group after matching (mean cardiopulmonary bypass time:  $132.52 \pm 39.20$  vs.  $115.50 \pm 25.70$  minutes,  $P = 0.001$ ; mean aortic cross clamp time:  $100.90 \pm 32.12$  vs.  $80.38 \pm 18.81$  minutes,  $P < 0.001$ ).

**Conclusions:** S-AVR may be considered a viable option in cases requiring multiple valve surgery, as it can reduce operation time without compromising clinical outcomes.

**Keywords:** Aortic valve; sutureless aortic valve replacement (S-AVR); multivalve surgery

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## Introduction

The field of the transcatheter aortic valve implantation (TAVI) is expanding rapidly, surgical valve replacement remains the gold standard treatment for multivalve diseases, including aortic valve diseases. Cardiopulmonary bypass (CPB) and aortic cross-clamping (ACC) are inevitable in surgical aortic valve replacement (AVR). The time for CPB with ACC is a critical predictor of mortality in multivalve surgical procedures, such as annulus suturing, valve placement, and knot tying (1,2). As shorter procedural time reduces the risk of ischemia-reperfusion injury, efforts have been undertaken to reduce the operative time, which is particularly important in multivalve surgeries that require longer ischemic duration.

Sutureless aortic valve replacement (S-AVR) with Perceval aortic valve was designed to reduce the CPB and ACC time owing to its simplicity and reproducibility, which allows easier implantation (3). In addition to the procedural time efficiency, the hemodynamic performance and clinical outcomes of the valve were comparable to those of conventional aortic valve replacement (C-AVR) (4,5). Thus, the indications for S-AVR have expanded to include aortic regurgitation, bicuspid aortic valve surgeries, and infective endocarditis. Good outcomes have been achieved in patients with mitral valve disease (3,6).

We performed S-AVR in patients with multivalve disease at our institution; combined maze procedures for atrial fibrillation (AF) treatment was also performed in some cases. We performed cardiac computed tomography (CT) each

time and used concepts such as aorto-mitral distance (AMD) and aorto-mitral angle (AMA) to determine the suitability of S-AVR with multivalve surgery. AMD refers to the distance from the base of the aortic annulus to the fibrous trigone of the mitral valve, as measured on CT images obtained during systolic phase. For accurate measurement, the distance is measured based on the coplanar plane of the annulus. Similar to AMD, AMA is measured on CT during the systolic phase by determining the angle of the line connecting the base of the aortic and mitral valve annulus. This angle is used to assess the feasibility of aortic valve implantation, considering the potential interference caused by the strut of the mitral tissue valve.

To date, few studies have compared the hemodynamic and clinical outcomes of S-AVR in multivalve settings with C-AVR. This study aimed to review the clinical outcomes of our institution, focusing on the procedural time and hemodynamic performance. Additionally, a unique aspect of this study is that factors related to aortic valve disease were included in the propensity score matching regression. We present this article in accordance with the STROBE reporting checklist (available at <https://jtd.amegroups.com/article/view/10.21037/jtd-24-1667/rc>).

## Methods

### Study design and patient population

Between January 2017 and December 2022, 141 patients underwent surgical bioprosthetic AVR with multivalve surgery. Of these, 42 patients (29.8%) underwent S-AVR with multivalve procedures (*Figure 1*). To minimize potential selection bias in single center study and surgeon's preference, we calculated a propensity score from selected variables, and matched each group patients in the C-AVR group and in the S-AVR group. Total 42 patients were identified in each group and were eligible for study analysis. At our institution, infective endocarditis, pure aortic regurgitation, and bicuspid aortic valve surgical cases, which are generally contraindicated for S-AVR, were included.

To evaluate valve function and hemodynamic status, echocardiography was performed periodically before surgery, immediate after surgery, at 6 months to 1 year postoperatively, and during the follow-up period. Data were prospectively collected from our institutional database. Intraoperative variables and surgical records were obtained in accordance with regulatory data protection standards. The study was conducted in accordance with the

### Highlight box

#### Key findings

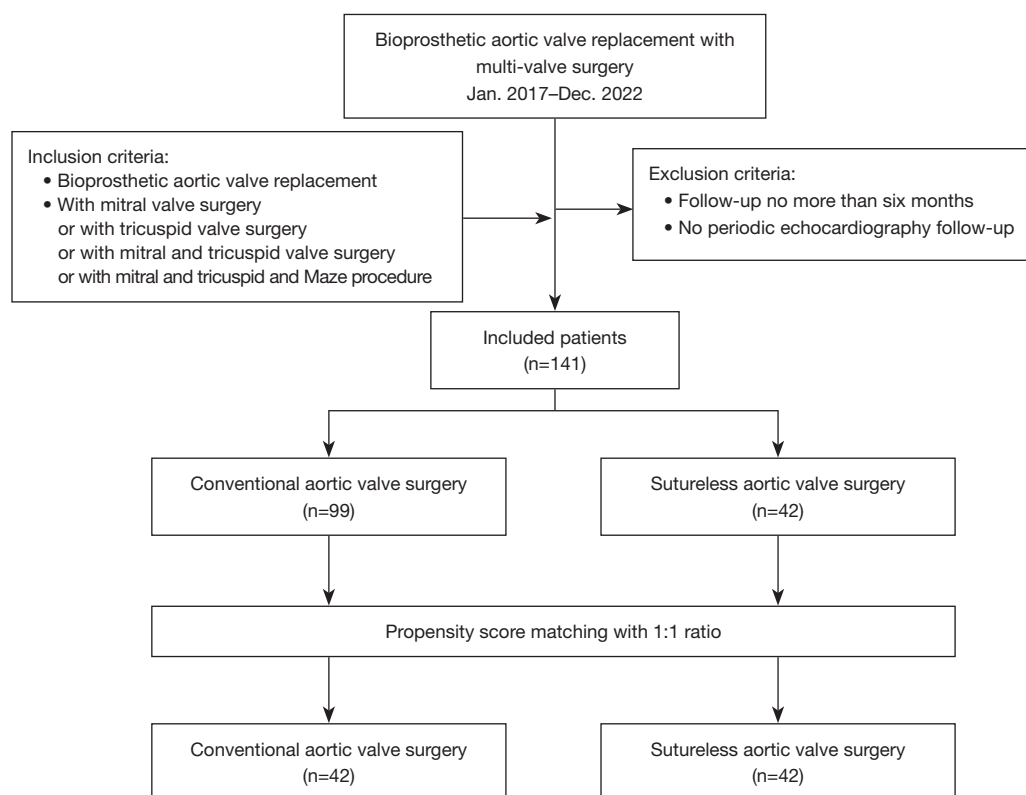
- Sutureless aortic valve replacement (S-AVR) was found to be superior in terms of operative time compared to conventional surgical replacement in multi-valve surgery, while showing no difference in clinical outcomes.

#### What is known and what is new?

- In multi-valve surgery, it was found that S-AVR can reduce cardiopulmonary bypass time and aortic cross-clamping time.
- There was no difference in outcomes, including mortality, and the pressure gradient and valve-related adverse events remained comparable to those of conventional valves.

#### What is the implication, and what should change now?

- Applying S-AVR in high-risk patients, for whom reducing operative time is beneficial in multiple valve surgery, may provide significant advantages.



**Figure 1** Study population diagram.

Declaration of Helsinki and its subsequent amendments. The study was approved by the Interstitial Review Board of Yonsei University Health System (No. 4-2024-1648) and individual consent for this retrospective analysis was waived.

### *Surgical technique*

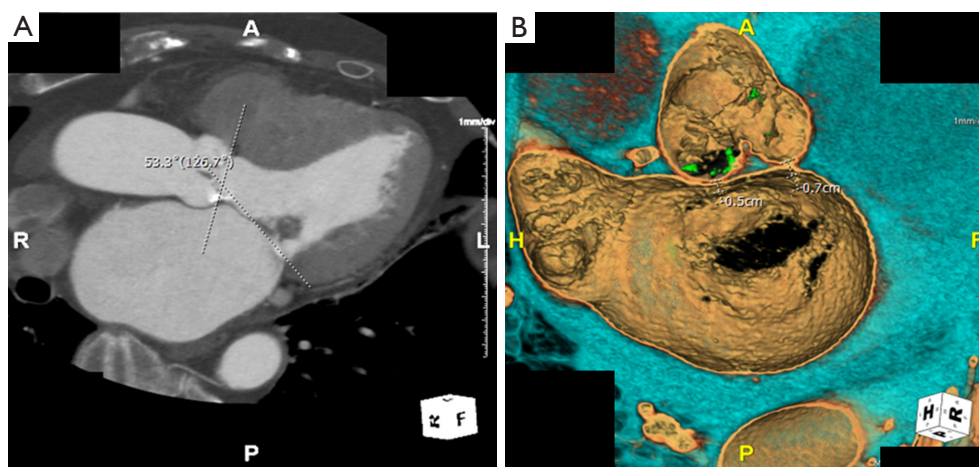
#### **Successful implantation of perceval aortic valve in multiple valve surgery**

All surgical approaches were performed via median sternotomy. The ACC was maintained at normothermia, and CPB was initiated by direct cannulation of the ascending aorta using the bicaval cannulation technique. First, a high transverse aortotomy was performed (around the yellow fat band on the ascending aorta, 3.5 cm above the aortic annulus) and the pathological valve leaflets were completely removed.

The sizing process was subsequently performed to avoid incorrect sizing following mitral valve replacement. Since retraction of the both atrium might cause the Perceval valve prosthesis to pop up if AVR is performed first, we routinely performed AVR as the last step during the CPB warming

period after the other valve procedures. This approach is a key factor in reducing the procedural time, including the omission of sutures for valve fixation.

Preoperative evaluation of the feasibility of using the Perceval valve in a double-valve setting was performed using preoperative cardiac CT to determine the critical points (*Figure 2*). The first is the AMD, which should be at least 5 mm for ensuring safe subvalvular fixation of the percutaneous valve. If the AMD is less than 5 mm, safe implantation is impossible because the inflow ring length is approximately 5 mm. The second point is the AMA, which should be  $>120^\circ$ . If the AMA is closer to  $90^\circ$ , the mitral valve struts on the left ventricular outflow tract (LVOT) side, which can cause disturbances during the ballooning process required for complete expansion of the Perceval valve. The last critical point is the correct positioning of the mitral valve struts, which is an intraoperative factor during mitral bioprosthesis implantation. The upper two struts were positioned at each trigone of the mitral annulus to avoid strut protrusion into the LVOT. Incorrectly positioned struts can cause disturbances during ballooning and distort the prosthetic mitral valve.



**Figure 2** Measurement of the aorto-mitral angle (A) and aorto-mitral distance (B) on preoperative three-dimensional computed tomography.

We performed tricuspid annuloplasty using the MC 3 ring or Tri-Ad ring after completing the mitral valve procedure if a tricuspid procedure was required. After all concomitant procedures were completed, a pre-sized and prepared perceval sutureless aortic valve was implanted using three guiding stitches during the warming period.

### Outcomes and definitions

The primary endpoints included the 30-day and follow-up period mortality, and the secondary endpoints were major valve-related adverse events (MVAEs) as defined by the Valve Academic Research Consortium 3 during the follow-up period (7).

### Statistical analysis

To minimize potential selection bias before comparing outcomes of two groups, propensity score matching was performed. Propensity score matching was conducted using the baseline clinical characteristics listed in *Table 1*. Although the number of patients in the C-AVR group was larger, 1:1 matching was applied to reduce bias in treatment effects and enhance accuracy.

All statistical analyses were performed using SPSS version 27 (IBM Corp., Chicago, IL, USA) and R version 4.3.2 (R for Statistical Computing). The normality of the data was tested using the Shapiro-Wilk test. Continuous variables are expressed as mean  $\pm$  standard deviation, and comparison of continuous variables between two groups was performed using either the *t*-test for normally distributed data or the

Mann-Whitney test for non-normally distributed data. Categorical variables are presented as frequencies and percentages, and distributions were compared using the chi-square test or Fisher's exact test based on their normality. Statistical significance was set at  $P < 0.05$ .

## Results

### Baseline characteristics

The detailed preoperative baseline characteristics of the patients are summarized in *Table 1*. Before propensity score matching, there were significant differences in the prevalence of preoperative comorbidities. However, after matching, 42 well-matched pairs were obtained as the final result. After propensity score matching, the mean age of the patients was  $74.3 \pm 4.2$  and  $74.2 \pm 6.2$  years in C-AVR and S-AVR group, respectively; no significant differences were observed between two groups.

The indications for AVR were aortic stenosis in 29 (69.0%) and 30 (71.4%) patients, aortic regurgitation in 9 (21.4%) and 7 (16.7%) patients, respectively, with no significant differences between the two groups. In addition, no difference was observed in the causes of aortic valve disease, including infective endocarditis, rheumatic valve disease, and degenerative valve disease.

### Operative characteristics

The intraoperative variables are summarized in *Table 2*. No intraoperative dislocation of the perceval sutureless

**Table 1** Baseline clinical characteristics of the study population before and after propensity score matching

| Variable                          | Before matching |              |        | After matching |              |        |
|-----------------------------------|-----------------|--------------|--------|----------------|--------------|--------|
|                                   | C-AVR (n=99)    | S-AVR (n=42) | ASMD   | C-AVR (n=42)   | S-AVR (n=42) | ASMD   |
| Age, years                        | 72.9±4.3        | 74.1±6.2     | 0.203  | 74.3±4.2       | 74.2±6.2     | -0.026 |
| Body surface area, m <sup>2</sup> | 1.5±0.1         | 1.5±0.2      | -0.296 | 1.5±0.1        | 1.5±0.2      | -0.012 |
| Sex, female                       | 60 (60.6)       | 29 (69.0)    | 0.180  | 30 (71.4)      | 29 (69.0)    | -0.051 |
| Hypertension                      | 51 (51.5)       | 29 (69.0)    | 0.379  | 28 (66.7)      | 29 (69.0)    | 0.052  |
| Diabetes mellitus                 | 25 (25.3)       | 15 (35.7)    | 0.218  | 14 (33.3)      | 15 (35.7)    | 0.050  |
| Atrial fibrillation               | 50 (50.5)       | 20 (47.6)    | -0.058 | 20 (47.6)      | 20 (47.6)    | 0.000  |
| Coronary artery disease           | 10 (10.1)       | 12 (28.6)    | 0.409  | 9 (21.4)       | 12 (28.6)    | 0.158  |
| Chronic lung disease              | 4 (4.0)         | 3 (7.1)      | 0.120  | 3 (7.1)        | 3 (7.1)      | 0.000  |
| Cerebrovascular disease           | 13 (13.1)       | 7 (16.7)     | 0.095  | 7 (16.7)       | 7 (16.7)     | 0.000  |
| Peripheral arterial disease       | 3 (3.0)         | 1 (2.4)      | -0.043 | 1 (2.4)        | 1 (2.4)      | 0.000  |
| Chronic kidney disease            | 9 (9.1)         | 2 (4.8)      | -0.203 | 3 (7.1)        | 2 (4.8)      | -0.112 |
| Hemodialysis                      | 3 (3.0)         | 4 (9.5)      | 0.221  | 2 (4.8)        | 4 (9.5)      | 0.162  |
| NYHA class III/IV                 | 13 (13.1)       | 8 (19.0)     | 0.178  | 8 (19.0)       | 9 (21.4)     | 0.058  |
| Previous cardiac surgery          | 11 (11.1)       | 8 (19.0)     | 0.202  | 7 (16.7)       | 8 (19.0)     | 0.061  |
| Aortic stenosis                   | 55 (55.6)       | 30 (71.4)    | 0.351  | 29 (69.0)      | 30 (71.4)    | 0.053  |
| Aortic regurgitation              | 29 (29.3)       | 7 (16.7)     | -0.339 | 9 (21.4)       | 7 (16.7)     | -0.128 |
| Aortic steno-regurgitation        | 14 (14.1)       | 5 (11.9)     | 0.931  | 4 (9.5)        | 5 (11.9)     | 0.074  |
| Bicuspid aortic valve             | 10 (10.1)       | 4 (9.5)      | -0.020 | 4 (9.5)        | 4 (9.5)      | 0.000  |
| Infective endocarditis            | 3 (3.0)         | 2 (4.8)      | 0.081  | 2 (4.8)        | 2 (4.8)      | 0.000  |
| Rheumatic valve disease           | 42 (42.4)       | 13 (33.3)    | -0.193 | 15 (35.7)      | 14 (33.3)    | -0.051 |
| Degenerative valve disease        | 47 (47.5)       | 24 (57.1)    | 0.195  | 22 (52.4)      | 24 (57.1)    | 0.096  |
| Moderate or severe MR             | 27 (27.3)       | 16 (38.1)    | 0.223  | 13 (31.0)      | 16 (38.1)    | 0.147  |
| Moderate or severe MS             | 28 (28.3)       | 7 (16.7)     | -0.312 | 9 (21.4)       | 7 (16.7)     | -0.128 |
| Moderate or severe TR             | 31 (31.3)       | 15 (35.7)    | 0.092  | 11 (26.2)      | 15 (35.7)    | 0.199  |

Values are mean ± standard deviation or n (%). ASMD, absolute standardized mean differences; C-AVR, conventional aortic valve replacement; MR, mitral regurgitation; MS, mitral stenosis; NYHA, New York Heart Association; S-AVR, sutureless aortic valve replacement; TR, tricuspid regurgitation.

valve and no mid-operative plan changes due to LVOT obstruction attributed to the strut of the bioprosthetic mitral valve were observed. In the S-AVR group, the proportion of mitral valve repair was higher than of mitral valve replacement compared to the C-AVR group.

In the propensity score-matched samples, in terms of operative time, the total CPB and ACC time significantly varied between the two groups (CPB time: 132.52±39.20 *vs.*

115.50±25.70 minutes, *P*=0.001; ACC time: 100.90±32.12 *vs.* 80.38±18.81 minutes, *P*<0.001). The S-AVR group had significantly reduced operation time compared to that of the C-AVR in all the subgroups, including the mitral valve, tricuspid valve, and arrhythmia surgeries (AVR + mitral valve procedure: 105.54±30.12 *vs.* 85.36±14.83 minutes, *P*<0.001; AVR + tricuspid valve procedure: 83.77±31.04 *vs.* 62.38±15.27 minutes, *P*=0.005; AVR + mitral + tricuspid

**Table 2** Operative information—concomitant procedure and operation time, before and after propensity score matching

| Variable                       | Before matching |              |         | After matching |              |         |
|--------------------------------|-----------------|--------------|---------|----------------|--------------|---------|
|                                | C-AVR (n=99)    | S-AVR (n=42) | P value | C-AVR (n=42)   | S-AVR (n=42) | P value |
| Concomitant procedure          |                 |              |         |                |              |         |
| Mitral valve repair            | 17 (17.2)       | 13 (31.0)    | 0.10    | 7 (16.7)       | 13 (31.0)    | 0.20    |
| Mitral valve replacement       | 61 (61.6)       | 16 (38.1)    | 0.01    | 27 (64.3)      | 16 (38.1)    | 0.02    |
| Bioprosthetic                  | 61 (61.6)       | 14 (33.3)    | 0.003   | 27 (64.3)      | 14 (33.3)    | 0.008   |
| Mechanical                     | 0               | 2 (4.8)      | 0.08    | 0              | 2 (4.8)      | 0.49    |
| Tricuspid valve repair         | 66 (66.7)       | 30 (71.4)    | 0.72    | 25 (59.5)      | 30 (71.4)    | 0.35    |
| Tricuspid valve replacement    | 0               | 1 (2.4)      | 0.29    | 0              | 1 (2.4)      | >0.99   |
| Maze procedure                 | 18 (18.2)       | 11 (26.2)    | 0.39    | 7 (16.7)       | 11 (26.2)    | 0.43    |
| Operation time                 |                 |              |         |                |              |         |
| CPB time, minutes              | 133.69±39.94    | 115.50±25.70 | 0.002   | 132.52±39.20   | 115.50±25.70 | 0.001   |
| ACC time, minutes              | 101.90±32.41    | 80.38±18.81  | <0.001  | 100.90±32.12   | 80.38±18.81  | <0.001  |
| AVR + MV procedure             | 105.13±31.12    | 85.36±14.83  | <0.001  | 105.54±30.12   | 85.36±14.83  | <0.001  |
| AVR + TV procedure             | 84.67±30.04     | 62.38±15.27  | 0.008   | 83.77±31.04    | 62.38±15.27  | 0.005   |
| AVR + MV + TV procedure        | 108.60±30.17    | 86.89±8.89   | 0.041   | 108.90±30.90   | 86.89±8.89   | 0.02    |
| AVR + MV + TV + maze procedure | 119.94±13.83    | 91.00±11.55  | <0.001  | 119.15±12.93   | 91.00±11.55  | <0.001  |

Values are mean ± standard deviation or n (%). ACC, aortic cross-clamp; AVR, aortic valve replacement; C-AVR, conventional aortic valve replacement; CPB, cardiopulmonary bypass; MV, mitral valve; TV, tricuspid valve; S-AVR, sutureless aortic valve replacement.

valve procedure: 108.90±30.90 *vs.* 86.89±8.89 minutes, *P*=0.02; AVR + mitral + tricuspid + maze procedure: 119.15±12.93 *vs.* 91.00±11.55 minutes, *P*<0.001).

Different types of annuloplasty rings were used, and the choice of ring type for rigidity was based on the surgeon's preference and condition of the patient's valve. The types of bioprosthetic valves used for aortic, mitral, and tricuspid valve replacements are shown in [Table S1](#).

### Follow-up outcomes

Patients were followed up for a median of 32.5 (14.0–49.0) months and with a median echocardiography follow-up time of 25.9 (8.0–41.0) months. The postoperative outcomes are shown in [Table 3](#). Among the patients in this study after propensity score matching, only 1 case of in-hospital mortality in the C-AVR group and no in-hospital mortality in the S-AVR group were observed (*P*>0.99). During the follow-up period, one case of cardiac-related mortality 2 months after surgery in the S-AVR group was noted and no difference in mortality was observed between the two groups ([Table 4](#)) ([Figure 3](#)).

No major adverse events were identified ([Table 4](#)). A higher rate of permanent pacemaker insertion was observed due to complete atrioventricular block in the S-AVR group during the follow-up; however, this was not significant when compared with the C-AVR group [1 (2.4%) *vs.* 4 (9.5%), *P*=0.35]. In MVAEs, no events occurred in either group for permanent pacemaker implantation.

### Hemodynamic results

In matched cohort, in the immediate postoperative pressure gradient, the peak systolic pressure gradient was 29.93±10.33 and 23.21±8.02 mmHg in the C-AVR and S-AVR groups, respectively, which was significantly lower in the S-AVR group (*P*=0.001), and the mean systolic pressure gradient was also lower in the in the S-AVR group (16.12±5.77 mmHg in C-AVR and 12.02±4.02 mmHg in S-AVR; *P*<0.001) ([Table 3](#)). [Figure 4](#) shows the comparison of the pressure gradient of the bioprosthetic aortic valve according to the time period; the pressure gradient of the perceval sutureless valve was lower in all the periods, namely immediately after surgery, up to 6 months of follow-

**Table 3** In-hospital outcomes, before and after propensity score matching

| Variables                 | Before matching |              |         | After matching |              |         |
|---------------------------|-----------------|--------------|---------|----------------|--------------|---------|
|                           | C-AVR (n=99)    | S-AVR (n=42) | P value | C-AVR (n=42)   | S-AVR (n=42) | P value |
| Re-operation for bleeding | 4 (4.0)         | 1 (2.4)      | >0.99   | 0              | 1 (2.4)      | >0.99   |
| Stroke                    | 0               | 0            | –       | 0              | 0            | –       |
| Acute kidney injury       | 2 (2.0)         | 4 (9.5)      | 0.06    | 1 (2.4)        | 4 (9.5)      | 0.35    |
| In-hospital mortality     | 2 (2.0)         | 0            | >0.99   | 1 (2.4)        | 0            | >0.99   |
| Aortic valve              |                 |              |         |                |              |         |
| Paravalvular leakage      | 1 (1.0)         | 0            | >0.99   | 0              | 0            | >0.99   |
| PSPG, mmHg                | 29.22±9.92      | 23.21±8.02   | 0.001   | 29.93±10.33    | 23.21±8.02   | 0.001   |
| MSPG, mmHg                | 15.65±5.37      | 12.02±4.02   | <0.001  | 16.12±5.77     | 12.02±4.02   | <0.001  |
| LVEF, %                   | 56.73±13.93     | 51.21±14.84  | 0.03    | 58.36±14.50    | 51.21±14.84  | 0.02    |

Values are mean ± standard deviation (SD) or n (%). C-AVR, conventional aortic valve replacement; S-AVR, sutureless aortic valve replacement; LVEF, left ventricular ejection fraction; MSPG, mean systolic pressure gradient; PSPG, peak systolic pressure gradient.

**Table 4** Mortality and valve related adverse events during follow-up, before and after propensity score matching

| Variables                    | Before matching |              |         | After matching |              |         |
|------------------------------|-----------------|--------------|---------|----------------|--------------|---------|
|                              | C-AVR (n=99)    | S-AVR (n=42) | P value | C-AVR (n=42)   | S-AVR (n=42) | P value |
| Mortality                    | 3 (3.0)         | 3 (7.1)      | 0.36    | 2 (4.8)        | 3 (7.1)      | >0.99   |
| Cardiac related              | 0               | 1 (2.4)      | 0.29    | 0              | 1 (2.4)      | >0.99   |
| Other                        | 3 (3.0)         | 2 (4.8)      | 0.63    | 2 (5.0)        | 2 (5.0)      | >0.99   |
| Structural valve dysfunction | 0               | 0            | >0.99   | 0              | 0            | >0.99   |
| Valve thrombus               | 0               | 0            | >0.99   | 0              | 0            | >0.99   |
| Endocarditis                 | 0               | 0            | >0.99   | 0              | 0            | >0.99   |
| Stroke                       | 0               | 0            | >0.99   | 0              | 0            | >0.99   |
| Re-intervention              | 1 (1.0)         | 0            | >0.99   | 0              | 0            | >0.99   |
| Pacemaker implantation       | 2 (2.0)         | 4 (9.5)      | 0.06    | 1 (2.4)        | 4 (9.5)      | 0.35    |
| Aortic valve                 |                 |              |         |                |              |         |
| PSPG, mmHg                   | 26.16±11.59     | 19.79±8.47   | 0.002   | 25.79±12.20    | 19.79±8.47   | 0.01    |
| MSPG, mmHg                   | 14.58±6.91      | 10.05±4.36   | <0.001  | 14.45±7.35     | 10.05±4.36   | 0.001   |
| Paravalvular leakage         | 2 (2.0)         | 0            | >0.99   | 1 (2.4)        | 0            | >0.99   |
| LVEF, %                      | 60.37±15.53     | 54.88±15.49  | 0.057   | 60.33±18.81    | 54.88±15.49  | 0.15    |

Values are mean ± standard deviation or n (%). C-AVR, conventional aortic valve replacement; S-AVR, sutureless aortic valve replacement; LVEF, left ventricular ejection fraction; MSPG, mean systolic pressure gradient; PSPG, peak systolic pressure gradient.

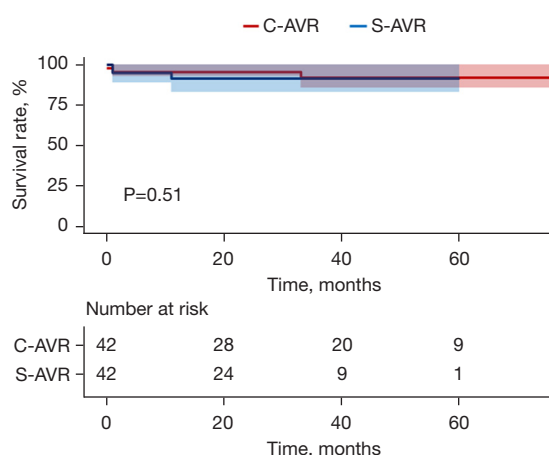
up, and up to 1 year. Left ventricular ejection fraction was significantly higher in the C-AVR group at 6 months of follow-up period; however, both groups recovered to a normal range thereafter (at 6 months: 59.1% *vs.* 41.8%,  $P<0.001$ ; at 1 year: 60.3% *vs.* 54.8%,  $P=0.058$ ) (Figure 4).

## Discussion

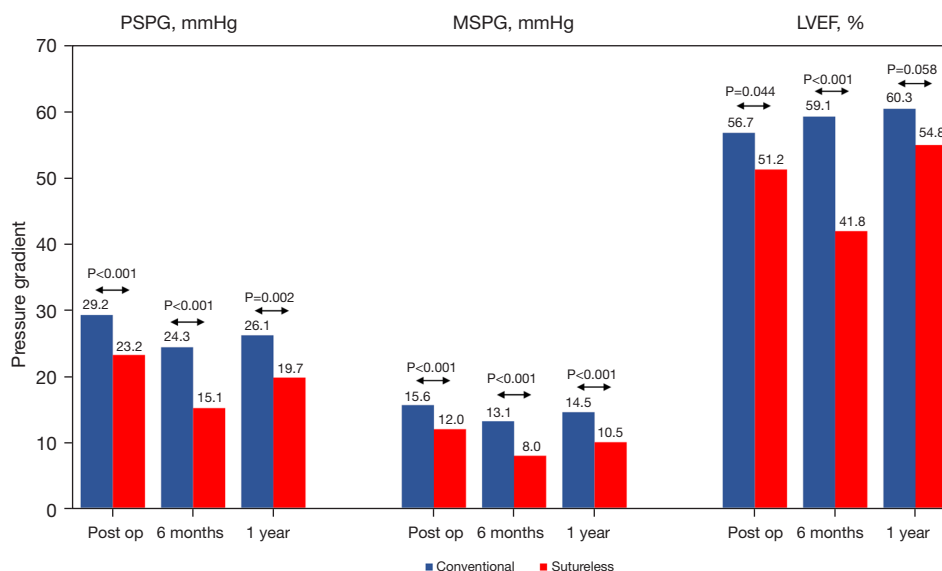
This study analyzed the clinical outcomes of C-AVR versus

S-AVR in patients with multiple valve diseases, particularly focusing on reducing the procedure time and clinical outcomes. Our results revealed that the operative time was significantly reduced in the S-AVR group, and no difference was observed in the clinical outcomes or hemodynamic performance between the two groups. The incidence of MVAEs did not vary, and the 30-days and follow-up mortality rates did not differ.

An increasing proportion of patients requiring AVR have coexisting multiple valve diseases; these patients are often elderly and have multiple comorbidities. Although patients at high operative risk, not necessarily those with advanced age, are candidates for TAVR owing to their comorbidities, several studies have revealed that approximately 20% of patients undergoing TAVR have moderate or severe MR; moreover, untreated MR is associated with early or late mortality (8,9). Therefore, despite the high perioperative mortality and complication rates associated with the surgical treatment of multivalve disease, correction may ultimately have a favorable impact on the long-term outcomes if indicated (10,11). Previous trials have shown that reducing the operative time is key to reducing ischemic-reperfusion injury in high-risk patients, thus resulting in the development of sutureless aortic valves (12,13). Therefore, this study confirmed that S-AVR can reduce operative time even in various type of multiple valve procedures. This finding can be correlated with previous studies that have



**Figure 3** Kaplan-Meier curve for survival rate after propensity score matching. C-AVR, conventional aortic valve replacement; S-AVR, sutureless aortic valve replacement.



**Figure 4** Hemodynamic changes over time reflecting echocardiogram results. LVEF, left ventricular ejection fraction; MSPG, mean systolic pressure gradient; PSPG, peak systolic pressure gradient.

reported no differences in clinical outcomes.

The sutureless valve, referred to as the Perceval valve in this study, is a viable alternative to the conventional valve for older high-risk patients requiring a multivalve procedure. Since its introduction in 2007, the Perceval valve has been increasingly utilized owing to its simplified valve replacement process and reduced operative time, and several studies have demonstrated clinical outcomes comparable to those following C-AVR (14,15). Although the instructions for Perceval valve implantation are standardized, malposition, such as popping up, remains a common complication during multivalve surgery; nevertheless, no such complications were noted in this study.

Several studies have demonstrated the operation time, that is the CPB and ACC time in cardiac surgery, to be an independent predictor of mortality and morbidity, especially in older high-risk patients (16,17). As mentioned above, S-AVR not only demonstrated no difference in the outcomes when compared with those of C-AVR, but also played a major role in reducing ischemic-reperfusion injury, mortality, and morbidity as the overall operation time decreased (4,9). S-AVR was able to achieve good results not only in isolated AVR cases, but also in cases where other procedures were involved, as it helped reduce the operation time; moreover, the present study provided meaningful results by comparing the operating time of conventional and sutureless surgery, including tricuspid valve and AF surgery, in addition to the results of other studies to date (18,19). However, since this study focused on operative time and clinical outcomes after valve surgery, it did not analyze postoperative arrhythmias. Nevertheless, the fact that the rate of pacemaker implantation—often considered a key limitation of S-AVR—was comparable to that of C-AVR makes this finding meaningful.

The peak and mean pressure gradients, which are indicators of the hemodynamic performance of S-AVR, remained stable during the follow-up period at 20 mmHg and 10 mmHg, respectively, regardless of concomitant surgery, similar to the findings of other studies (18–20). For maintaining stable hemodynamic performance and preventing the occurrence of PVL, accurate sizing of the sutureless aortic valve is crucial for ensuring long-term valve patency. Therefore, we performed a CT scan before surgery to measure the valvular area, diameter, distance of the aortic valve annulus, and diameter of the sinotubular junction and ascending aorta to predict the valve size (*Figure 5*). Although this study did not divide patients into groups based on implanted valve size for hemodynamic analysis due

to the limited sample size, the overall results showed that the S-AVR group had significantly lower pressure during follow-up period. This finding is considered meaningful.

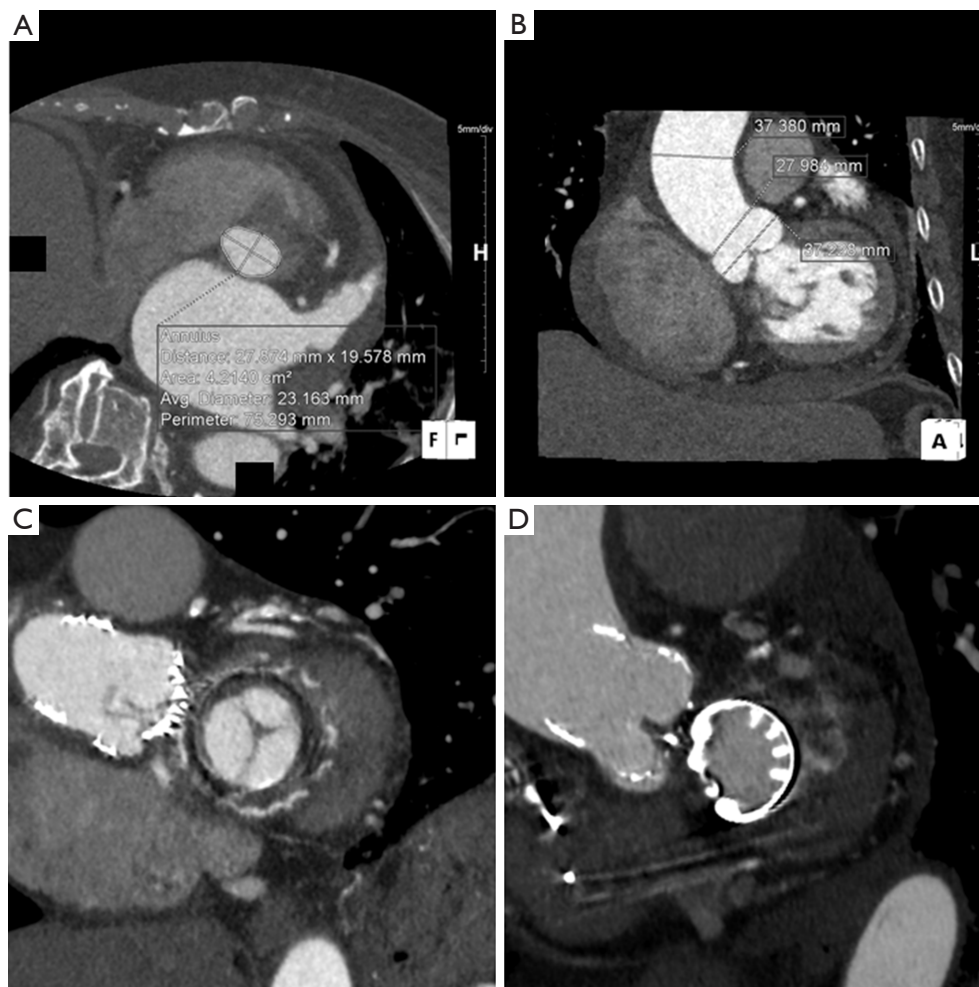
To our knowledge, this is the largest study on S-AVR that includes the mitral valve, tricuspid valve, and maze procedures. Correct positioning of the Perceval aortic valve is crucial, given the high potential for supra-annular malpositioning, especially in the case of the mitral valve. An important aspect of this process is that one of the struts can be positioned in the middle of the medial and lateral trigone of the mitral valve to avoid interference with the guiding suture used in S-AVR and prevent LVOT obstruction. Because supra-annular malposition often occurs during valve development with balloon pressure, it is important to fix the Perceval sutureless valve prosthesis 1–2 mm below the annulus, where it would normally be fixed, and maintain the Perceval valve in place during pressure application. As mentioned earlier, the difference between mitral valve repair and replacement in the two group does not appear to be due to the surgical approach itself. Instead, it is likely influenced by the structural relationship between the Perceval sutureless aortic valve's inflow ring and the mitral tissue valve strut, leading to a higher frequency of ring use.

### Limitation

This study has several limitations. First, it was a single-center study with a retrospective study design and a relatively small sample size. Patients in both groups had a short follow-up period and were not followed up for an equal amount of time, which could have affected the results and introduced bias. Therefore, further multicenter prospective randomized controlled studies comparing S-AVR and C-AVR should be conducted to provide more definitive results.

### Conclusions

S-AVR can be considered a safe and reliable alternative to C-AVR in patients with multiple valve diseases, including mitral and tricuspid valve diseases. As S-AVR can significantly reduce the CPB and ACC times through a more simplified surgical procedure, it may be particularly useful in high-risk patients for whom a long operative time may be a burden. Stable hemodynamic performance was maintained during the follow-up period. The key points mentioned in this study can be practically applied in real-world surgical settings. However, to further clarify these



**Figure 5** Cardiac CT. Preoperative measurement: (A) aortic valve related values, (B) diameter of sino-tubular junction and ascending aorta. Postoperative CT: (C) AVR with perceval sutureless medium, MVR with Hancock bioprosthesis valve 29 mm, (D) AVR with perceval sutureless medium, mitral annuloplasty with CG future ring 28 mm. AVR, aortic valve replacement; CT, computed tomography; MVR, mitral valve placement.

findings, long-term clinical outcomes and postoperative conditions of other valves, including the aortic valve, need to be evaluated. Additionally, a cost-effectiveness analysis will be necessary for comparison with TAVI.

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### Footnote

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**Ethical Statement:** The authors are accountable for all aspects of works in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. The study was approved by the Interstitial Review Board of Yonsei University Health System (No. 4-2024-1648) and individual consent for this retrospective analysis was waived.

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## References

1. Holst KA, Dearani JA, Burkhart HM, et al. Reoperative multivalve surgery in adult congenital heart disease. *Ann Thorac Surg* 2013;95:1383-9.
2. Shrestha M, Maeding I, Höffler K, et al. Aortic valve replacement in geriatric patients with small aortic roots: are sutureless valves the future? *Interact Cardiovasc Thorac Surg* 2013;17:778-82; discussion 782.
3. Mashhour A, Zhigalov K, Mkalaluh S, et al. Outcome of a Modified Perceval Implantation Technique. *Thorac Cardiovasc Surg* 2020;68:602-7.
4. Flameng W, Herregods MC, Hermans H, et al. Effect of sutureless implantation of the Perceval S aortic valve bioprosthesis on intraoperative and early postoperative outcomes. *J Thorac Cardiovasc Surg* 2011;142:1453-7.
5. Dokollari A, Ramlawi B, Torregrossa G, et al. Benefits and Pitfalls of the Perceval Sutureless Bioprosthesis. *Front Cardiovasc Med* 2021;8:789392.
6. Minh TH, Mazine A, Bouhout I, et al. Expanding the indication for sutureless aortic valve replacement to patients with mitral disease. *J Thorac Cardiovasc Surg* 2014;148:1354-9.
7. VARC-3 WRITING COMMITTEE; G  n  reux P, Piazza N, et al. Valve Academic Research Consortium 3: Updated Endpoint Definitions for Aortic Valve Clinical Research. *J Am Coll Cardiol* 2021;77:2717-46.
8. Nombela-Franco L, Ribeiro HB, Urena M, et al. Significant mitral regurgitation left untreated at the time of aortic valve replacement: a comprehensive review of a frequent entity in the transcatheter aortic valve replacement era. *J Am Coll Cardiol* 2014;63:2643-58.
9. Lloyd D, Luc JGY, Indja BE, et al. Transcatheter, sutureless and conventional aortic-valve replacement: a network meta-analysis of 16,432 patients. *J Thorac Dis* 2019;11:188-99.
10. Barreiro CJ, Patel ND, Fitton TP, et al. Aortic valve replacement and concomitant mitral valve regurgitation in the elderly: impact on survival and functional outcome. *Circulation* 2005;112:1443-7.
11. Zubarevich A, Szczechowicz M, Zhigalov K, et al. Sutureless aortic valve replacement in multivalve procedures. *J Thorac Dis* 2021;13:3392-8.
12. Iino K, Miyata H, Motomura N, et al. Prolonged Cross-Clamping During Aortic Valve Replacement Is an Independent Predictor of Postoperative Morbidity and Mortality: Analysis of the Japan Cardiovascular Surgery Database. *Ann Thorac Surg* 2017;103:602-9.
13. Ranucci M, Frigiola A, Menicanti L, et al. Aortic cross-clamp time, new prostheses, and outcome in aortic valve replacement. *J Heart Valve Dis* 2012;21:732-9.
14. Lamberigts M, Szece  l D, Rega F, et al. Sutureless aortic valves in isolated and combined procedures: Thirteen years of experience in 784 patients. *J Thorac Cardiovasc Surg* 2024;167:1724-1732.e1.
15. Zubarevich A, Amanov L, Arjomandi Rad A, et al. Single-Center Real-World Experience with Sutureless Aortic Valve Prosthesis in Isolated and Combined Procedures. *J Clin Med* 2023;12:4163.
16. Chalmers J, Pullan M, Mediratta N, et al. A need for speed? Bypass time and outcomes after isolated aortic valve replacement surgery. *Interact Cardiovasc Thorac Surg* 2014;19:21-6.
17. Salis S, Mazzanti VV, Merli G, et al. Cardiopulmonary bypass duration is an independent predictor of morbidity and mortality after cardiac surgery. *J Cardiothorac Vasc Anesth* 2008;22:814-22.
18. Shrestha M, Folliguet TA, Pfeiffer S, et al. Aortic valve replacement and concomitant procedures with the Perceval valve: results of European trials. *Ann Thorac Surg* 2014;98:1294-300.
19. Zubarevich A, Szczechowicz M, Arjomandi Rad A, et al. Conventional Biological versus Sutureless Aortic Valve Prostheses in Combined Aortic and Mitral Valve

- Replacement. *Life (Basel)* 2023;13:737.
20. Concistrè G, Chiaramonti F, Bianchi G, et al. Aortic Valve Replacement With Perceval Bioprosthesis: Single-

Center Experience With 617 Implants. *Ann Thorac Surg* 2018;105:40-6.

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