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# Outcomes of Valve-in-Valve Transcatheter Aortic Valve Implantation with and without Bioprosthetic Valve Fracture

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**Short Running Title:** Outcome of VIV-TAVI with and without BVF

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**Abstract**

**Background:** Bioprosthetic valve fracture (BVF) is a technique to reduce gradients in valve-in-valve transcatheter aortic valve implantation (VIV-TAVI) procedures. Outcome of VIV-TAVI with BVF has not been compared with VIV-TAVI without BVF.

**Aims:** To evaluate the outcome of VIV-TAVI with BVF compared to VIV-TAVI without BVF.

**Methods:** In total, 81 cases of BVF-VIV-TAVI (BVF-group) from 14 centres were compared to 79 cases of VIV-TAVI without BVF (control-group).

**Results:** VARC-2 defined device success was 93% in the BVF- and 68.4% in the control-group ($p<0.001$). The mean transvalvular gradient decreased from 37 ± 13mmHg to 10.8 ± 5.9mmHg ($p<0.001$) in the BVF- and from 35 ± 16mmHg to 15.8 ± 6.8mmHg ($p<0.001$) in the control-group with a significantly higher final gradient in control ($p<0.001$). The transvalvular gradients did not significantly change over time. In-hospital major adverse events occurred in 3.7% in BVF- and 7.6% in control-group ($p=0.325$). A linear mixed model identified BVF, self-expanding transcatheter heart valves (THVs) and other surgical aortic valve (SAV) types other than Mitroflow as predictors for lower transvalvular gradients.

**Conclusions:** Compared to VIV-TAVI alone, VIV-TAVI with BVF resulted in a significantly lower transvalvular gradient acutely and at follow-up. Independent predictors for lower gradients were the use of self-expanding THVs and the treatment of SAVs other than Mitroflow, irrespective of BVF-performance. BVF significantly reduced the gradient independently from transcatheter or surgical valve type.

**Classifications:** Aortic Stenosis, Degenerative valve, TAVI**,** Valve-in-Valve

**Abbreviations**

BASILICA= Bioprosthetic or native aortic scallop intentional laceration to prevent iatrogenic coronary artery obstruction during TAVR

BVF = bioprosthetic valve fracture

ID = internal diameter

PPM = Prosthesis-Patient-Mismatch

SAV = surgical aortic valve

STJ = sinotubular junction

THV = transcatheter heart valve

VIV-TAVI = valve in valve transcatheter aortic valve implantation

VTC = virtual transcatheter heart valve to coronary ostium distance

VTSTJ = virtual transcatheter heart valve to sinotubular junction distance



**Condensed Abstract**

Outcome of BVF in 81 versus non-BVF in 79 patients undergoing VIV-TAVI revealed a 93% vs 68.4% device success rate and a significantly lower mean gradient (10.8 mmHg vs 15.8 mmHg), which remained stable over time. In-hospital major adverse event-rate was 3.7% versus 7.6% (p=0.325). Predictors for lower gradients were the use of self-expanding THVs and the treatment of SAVs other than Mitroflow.

## Introduction

Valve-in-Valve transcatheter aortic valve implantation (VIV-TAVI) is a valuable therapeutic approach in patients with degenerated surgical aortic valve bioprostheses (1). Up to 45% of patients after surgical aortic valve (SAV) replacement have prothesis-patient-mismatch (PPM), which is particularly frequent in patients with small SAVs (2,3). In this cohort VIV-TAVI may result in high residual gradients, which impact survival (1, 4-6).

Bioprosthetic valve fracture (BVF) is a technique to reduce gradients in VIV-TAVI procedures by fracturing the sewing ring of the SAV with high-pressure non-compliant balloon inflation (7-10). A comparison of acute as well as long-term outcome data between VIV-TAVI with BVF versus without BVF in patients with comparable baseline characteristics including SAV type is missing and is the scope of the present study.



## Material and Methods

Fourteen international centres provided data of BVF-VIV-TAVI procedures in patients with degenerated SAVs with fracturable or dilatable sewing rings. Data were collected retro- and prospectively. Patients with VIV-TAVIs performed in the same time period in SAVs, which were suitable for but did not undergo BVF, served as a control-group.

Deteriorated SAVs were categorized as stenotic, regurgitant or mixed (stenosis and regurgitation ≥ moderate). Indexed effective orifice area (iEOA) and PPM were calculated after surgical valve replacement. PPM was defined as mild (iEOA ≥ 0.85-1.0), moderate (iEOA 0.65-0.85) or severe (iEOA≤0.65). The technique of BVF has been described elsewhere (9). Timing of BVF (before or after transcatheter heart valve (THV) implantation) and choice of balloon size was per operator's discretion. BVF was performed with non-compliant balloons 1 – 6 mm larger than the SAV's true internal diameter (ID). THVs were categorized as adequately or oversized for the patient's SAV based on recommendations of the Valve in Valve App version 2.0 (UBQO Limited, London, United Kingdom). BVF was considered successful if the inflation

pressure dropped suddenly without balloon perforation and the THV was fully expanded (in case of SAVs, which cannot be fractured but remodelled). Device success was defined as correctly implanted THV without the use of a second valve and with a final mean gradient < 20mmHg, no moderate/severe aortic regurgitation and the absence of procedural death.

VARC-2 defined early safety composite, clinical efficacy after 30 days and peri-procedural complications including aortic root rupture, ventricular septal perforation, balloon rupture leading to clinical consequences, cardiac tamponade, coronary obstruction, among others as well as reinterventions at follow-up were evaluated.

**Statistical Analysis**

Continuous data were summarized as means +/- standard deviations or as medians [25th and 75th percentiles] as appropriate. Categorical data were presented as N (%). A linear mixed model was applied to associate mean gradient at discharge and follow-up to the treatment groups (BVF vs control), THV type (self-expanding vs balloon-expandable) and SAV type (Mitroflow vs non-Mitroflow). Estimates were adjusted with baseline mean transvalvular gradient. The time of measurement was included in the model. The response variable was logarithmic-transformed to fulfill model assumptions. Parameter estimates and 95 % confidence intervals of the parameter estimates were presented. Wilcoxon and Pearson / Fisher's exact tests were conducted to compare variables between groups. All p-values were two-sided and a p-value < 0.05 was considered significant. All calculations were performed with the statistical analysis software R (R Core Team, 2020).

**Results**

BVF-VIV-TAVI was performed in 81 in the time period between August 2015 to March 2020 and VIV-TAVI alone in 79 patients in the time period between July 2014 to March 2020. Baseline data are summarized in Table 1. Both groups were comparable with the exception of

more male patients (65 vs 42%, p=0.004), larger SAVs (24.1±2.4 vs 22.1±2.1, p<0.001) and true IDs

(20.7 ± 2.5mm vs 19.1 ± 1.8, p < 0.001) in the control-group.

Ten types of surgical valves were treated, dominantly Mosaic (Medtronic, Minneapolis, MN, USA), Mitroflow (Sorin Group USA Inc, Arvada, CO, USA), Perimount (Edwards Lifesciences, Irvine, CA, USA) and Magna (Edwards Lifesciences, Irvine, CA, USA). The most common mode of degeneration according to standardized definition was stenosis and mixed (94% vs 78% in control-group, p=0.036). Mean interval to SAV failure in the BVF-group was 10.9 ± 3.4 vs 11.8 ± 4.6 years (p=0.08). Moderate/severe PPM was present in the BVF-group in 54%/9% vs 45%/3% (p=0.072). Baseline mean gradient in the BVF-group was 37 ± 13 mmHg vs 35 ± 16mmHg (p=0.11), iEOA was 0.81 ± 0.24 $cm^2/m^2$ vs 0.85 ± 0.32$cm^2/m^2$ (p=0.73). Moderate/severe aortic regurgitation was more frequent in the control-group (66% vs 50%, p=0.049). Main access was transfemoral (p=0.34), cerebral protection was more often applied in the BVF-group (31% vs 9%, p=<0.001, Table 2). Balloon-expandable Sapien (Edwards Lifesciences) THVs were slightly more often utilized in the control-group (29 vs 22%). Among the self-expanding THVs in both groups the most prevalent was Evolut™ (Medtronic, Minneapolis, MN, USA).

For BVF the TRUE® Dilatation balloon (Bard Peripheral Vascular Inc., Tempe, AZ, USA) was used for valve fracturing in 88% and ATLAS® Gold (Bard Peripheral Vascular Inc., Tempe, AZ, USA) in 12%. BVF was performed in 89% after THV implantation, in 11% before. Balloons were 2.8 ±1.1 mm (range 1 – 6mm) oversized in relation to the true ID of the SAV and inflated with a pressure of 15.8 ± 3.6 atm. In 84% THV sizing was in accordance with the recommendation of the Valve in Valve App, in 16% the THVs were oversized. Procedure duration was longer in the BVF-group (87 ± 42min vs 57 ± 25 min, p<0.001), as well as fluoroscopy time (26.2 ± 18min vs 16.6 ± 11.9min, p< 0.001).

**In-hospital outcome**

Device success was achieved in 93% in the BVF- and in 68.4% in the control-group (p<0.001). The main reason for procedure failure was a residual mean gradient ≥ 20mmHg in both groups, which was found in 5 of 6 failures in the BVF- and in 22 of 25 failures in the control-group (Table 3).

Failures due to high gradients were predominantly seen in Mitroflow valves (100% in BVF- and 62.5% in the control-group). Out of 5 failures in the BVF-group, 3 patients received a self-expanding and 2 a balloon-expandable THV. Out of 22 failures in the control-group, 14 patients received a self-expanding and 8 a balloon-expandable THV. Only in the control-group a second valve was required in 3 cases (in 2 patients Evolut THVs were malpositioned, one received a 2nd Evolut and one a Sapien. A third patient received a second Sapien after embolization of the first into the left ventricle, which was retrieved surgically (Table 3).

The mean gradient decreased from 37 ± 13mmHg to 10.8 ± 5.9mmHg (p<0.001) in the BVF- and from 35 ± 16mmHg to 15.8 ± 6.8mmHg (p<0.001) in the control-group (Figure 1). The difference in the final mean gradient between the BVF- and the control-group was significant (p<0.001). At discharge, moderate paravalvular aortic regurgitation was present in only one case in the control-group.

Severe in-hospital complications occurred in 3.7% in BVF- and 7.6% in the control-group, (p=0.325). In the BVF-group one patient died from an iliac artery perforation, in the control-group one from severe cardiomyopathy and another from coronary obstruction at day 3. Other complications were 2 ventricular septal ruptures after BVF with balloons 4mm larger than the true ID of the SAV, both without clinical consequences. In the control-group 2 strokes occurred and 1 coronary obstruction, which could be managed by percutaneous coronary intervention.

**Outcome at Follow-Up**

Clinical follow-up rate was 88.8% in the BVF-group (9 patients lost to follow-up) with a mean follow-up time of 276 days (range 25 – 1710 days) and 86% in the control-group (11 patients lost to follow-up) with a mean follow-up time of 1184 days (range 30 – 2211 days).

In the BVF-group 1 patient died of unknown cause, one patient needed a second valve due to severe aortic regurgitation, which was not present at discharge but developed within 12 weeks. BVF during index procedure was performed with a 2 mm oversized balloon.

Another patient was re-hospitalized due to heart failure and pneumonia. He had no THV dysfunction. In the control-group 11 patients died, one death was valve-related. Five patients required a surgical reintervention, 2 due to THV dysfunction, 3 due to endocarditis.

In the BVF-group echocardiographic follow-up was obtainable in 59 of 71 patients (83.1%) with a mean follow-up time of 281 (range 25 – 709 days) in the BVF- and in 55 of 66 patients (83.3%) with a mean follow-up time of 831 (range 37 – 2081 days) in the control-group.

In both groups the mean gradient remained stable over time (BVF-group: 10.8 ± 5.9 mmHg at discharge, 12.4 ± 6.3 mmHg at follow-up, control-group: 15.8 ± 6.8 at discharge and 18.4± 9.4mmHg at follow-up, Figure 1).



**Linear mixed model to predict mean transvalvular gradient from baseline data**

The linear mixed model (Table 4) identified 3 predictors for a lower mean gradient: BVF compared to non-BVF (Fig 1), the use of self-expandable compared to balloon-expandable THVs (Fig 2), and other SAVs compared to Mitroflow valve (Fig 3).

This interaction of THV and SAV type was observable in both BVF- and control-group (Fig 2 and Fig 3). The lowest gradients were achieved with BVF in non-Mitroflow SAVs and the use of self-expanding THVs (Fig 4 left upper panel). The highest gradients in VIV-procedures were found if a Mitroflow SAV was treated with a balloon-expandable THV without performing BVF (Fig 4, lower panel right).

## Discussion

The main findings of the present study are:

1. In patients with degenerated SAVs, BVF in VIV-TAVI resulted in a significant mean gradient reduction compared to VIV-TAVI alone.
2. The difference in the mean gradient between both groups remained stable over time.
3. Independent predictors for lower gradients were the use of self-expanding THVs and the treatment of SAVs other than Mitroflow irrespective of BVF-performance.
4. Compared to VIV-TAVI alone BVF significantly reduced the gradient independently from THV or SAV type.

Although VIV-TAVI is an attractive option to avoid reoperation in failed SAVs, it has some major shortcomings. In small SAVs it can result in high gradients which impact mortality (1). Procedural results and long-term outcome of VIV-TAVI have been analysed in large registries (1, 4). The post-procedure mean gradient after VIV-TAVI reported by Dvir et al was 15.8±8.9mmHg (1), which has been replicated in the current control-group (15.8±6.8mmHg). Also, the mean gradient at long-term follow-up of the control-group (18.4 ± 9.4mmHg) is consistent with prior findings after 1 year (16.9 mmHg and 17.6 mmHg, 1, 4). As evident from our data, but not emphasized in the registries mentioned, a mean gradient of such magnitude implicates, that a significant number of patients present with a mean gradient ≥ 20 mmHg, which per VARC-definition is a device failure. In particular in these patients the risk of reintervention increases over time (11).

BVF integrated in a VIV-TAVI-procedure has been shown to be feasible in reducing transvalvular gradients (12). Aim of the present study was to compare acute as well as long-term data of a VIV-TAVI-group with a cohort of patients who underwent VIV-TAVI in conjunction with BVF. To the best of our knowledge this analysis is the first to compare clinical and hemodynamic outcome of VIV-TAVI with BVF versus VIV-TAVI alone. The control-

group comprises patients, who have been treated in a similar time period, who differ in baseline data only marginally and whose potentially crackable SAVs were not fractured.

In the control-group with significantly more male patients the SAVs and true IDs were larger compared to the BVF-group, which would attenuate the difference in the final mean transvalvular gradient between both groups. Despite the larger true IDs in the control-group, however, the mean gradient after BVF was significantly lower, in fact in the same range of what has been shown by others (12). For that reason, there was a striking difference in the VARC-defined device failure rate, which was mainly driven by a final mean gradient ≥ 20mmHg, in favour of BVF (6.2% vs 27.8%, p<0.001). In consequence, these patients with higher gradients in our control-group would have been candidates for BVF.

The gradient after VIV-TAVI remained stable at follow-up, which is in accordance with prior findings (1, 4). So far, however, it was unknown whether gradient stability is also seen after BVF. The present study, for the first time, shows that there is no significant change in the gradient after BVF over time. Additionally, we could show that also the achieved difference in the gradient between BVF and the control-group (5mmHg) stays stable over time (6mmHg). Because higher gradients are a risk factor for mortality and reintervention, BVF may potentially improve long-term survival and reduce the reintervention rate by correcting a pre-existing PPM (6).

A key question is, whether the achievement of favourable gradients by BVF comes with an increased procedural risk, as the safety of BVF-procedures so far has only been examined in small studies. In this context a comparison with a non-BVF VIV-TAVI-group is of interest. We found a 30-day mortality rate of 1.2% in BVF, which corresponds to findings of Allen et al (12), and 2.5% in the control-group, which corresponds to the data of the PARTNER 2 Valve-in-Valve Registry (4). Of concern, however, are two ventricular septal perforations observed after BVF, both performed with 4mm oversized balloons. Both patients had an uneventful clinical course without further treatment. Although we could not identify any unsuitable

anatomy in these patients, based on this very limited experience we would recommend not to oversize the balloon > 3 mm and precaution should be taken with aggressive BVF in the presence of severe annular or LVOT calcification or narrow anatomy.

Another complication was the development of severe valvular aortic regurgitation in one patient 3 months after BVF, which was performed with a 2 mm oversized balloon after THV implantation and possibly resulted in leaflet damage. Although in our cohort BVF was performed after THV implantation in 89%, the best timing of BVF (prior or after TAVI) is still open for discussion (12).

Coronary obstruction is an additional potential danger in VIV-procedures. This complication is determined by virtual THV to coronary ostium distance (VTC), virtual THV to sinotubular junction distance (VTSTJ) and the leaflet in relationship to the coronary ostia and sinotubular junction (STJ). When cracking the valve, VTC is even more narrowed, which increases the risk of coronary obstruction. In the BVF-group, no such case occurred. In 3 patients, however, preventive measures were taken like BASILICA interventions (2 patients) and stent implantation in chimney technique (1 patient). In contrast, we observed 2 coronary obstructions in the control-group, which caused the death of one patient. Based on our limited experience, BVF is not increasing the risk of coronary obstructions, but further investigations have to undermine this impression.

To look for independent predictors for lower final gradients, which could be helpful for future procedure planning and performance, a linear mixed model was applied. Three independent predictors were identified: the performance of BVF, the use of self-expanding THVs and the treatment of SAVs other than Mitroflow. Interestingly, these latter two predictors were valid for both the BVF- as well as the control-group. That balloon-expandable compared to self-expanding THVs in VIV-TAVI lead to higher gradients has already been shown (11). We now could demonstrate that this also applies for BVF in VIV-TAVI, which has not been described before.

The Mitroflow as a risk factor for higher gradients is a novel finding. Different to other SAVs treated in this cohort this valve has leaflets sutured outside the stent. Whether this particular valve design impacts the gradient needs to be examined in larger series.

Eventually it would be desirable to develop an algorithm how to treat degenerated SAVs and achieve an optimal result. Our findings may contribute to this proposal by providing the information, that treatment of a Mitroflow SAV with a Sapien THV leads to the highest gradients, treatment of a non-Mitroflow SAV with a self-expanding THV to the lowest (Central illustration). However, in any combination of SAVs with THVs, performance of BVF significantly reduces the gradient acutely and over time (Fig. 4).

## Limitations

This is an observational study with inherent limitations. There was no echocardiographic core lab, data were not adjudicated by an independent committee. Timing of BVF and the degree of balloon oversizing was per operator's discretion. The control cohort was not randomized and differed in some aspects that may have extenuated the difference in the gradients between both groups.



## Conclusions

In patients with degenerated SAVs, VIV-TAVI in conjunction with BVF resulted in a significantly lower gradient compared to VIV-TAVI alone. The gradient as well as the difference in gradient between both groups remained stable over time. Independent predictors for lower final gradients were the performance of BVF, the use of self-expanding THVs and the treatment of SAVs other than Mitroflow. BVF significantly reduced the gradient independently from THV or SAV type.

**Impact on daily practice**

Regarding the final transvalvular gradient, the most unfavourable clinical scenario in VIV-procedures would be the treatment of a Mitroflow SAV with a balloon-expandable THV without performing BVF. The lowest gradient can be achieved in SAVs other than Mitroflow treated with self-expanding THVs in conjunction with BVF.

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**Figure legends**

**Figure 1** Reduction in mean transvalvular gradients by BVF (red line) vs non-BVF (blue line) in VIV-TAVI procedures acutely and over time.

**Figure 2** Mean gradients acutely and over time in VIV-TAVI after BVF (continuous line) or without BVF (dashed line) in Sapien THVs (blue) and in self-expanding THVs (red).

**Figure 3** Mean gradients acutely and over time in VIV-TAVI after BVF (continuous line) or without BVF (dashed line) in Mitroflow SAVs (blue) and in non-Mitroflow SAVs (red).

**Figure 4:** Model-based estimates of the mean transvalvular gradient over time after BVF (red lines) and without BVF (blue lines) for patients with self-expanding THVs in non-Mitroflow SAVs (left upper panel), for patients with non-Mitroflow SAVs and Sapien THVs (left lower panel), for patients with Mitroflow SAV and self-expanding THVs (right upper panel) and patients with Mitroflow SAVs and Sapien THVs (right lower panel). Model based estimates are adjusted to the baseline gradient.



**Central illustration:**

**Summary of mean transvalvular gradients in VIV-TAVI with and without BVF:**

The highest transvalvular gradients are expected in patients with Sapien in Mitroflow without BVF, the lowest in patients with Evolut in non-Mitroflow valves with BVF. In any combination BVF reduces by approximately 6mmHg.

**Table 1 Baseline data**

| | N | BVF (N=81) | Control (N=79) | P-Value |
|---|---|---|---|---|
| Age(years) | 160 | 76±8 | 75±11 | 0.91 |
| Female gender,% | 160 | 58(47) | 35(28) | 0.004 |
| Height(cm) | 156 | 167.4±10.8 | 172.4±9.5 | 0.004 |
| Weight(kg) | 159 | 74±15 | 80±16 | 0.033 |
| Hypertension,% | 160 | 80(65) | 76(60) | 0.51 |
| Diabetes,% | 160 | 31(25) | 25(20) | 0.43 |
| Glomerular filtration rate(ml/min) | 146 | 58±20 | 61±24 | 0.37 |
| Coronary artery disease,% | 147 | 41(28) | 54(43) | 0.11 |
| Myocardial infarction,% | 108 | 17(14) | 26(7) | 0.33 |
| Prior cerebrovascular event,% | 149 | 11(8) | 11(9) | 0.99 |
| Atrial fibrillation,% | 149 | 27(19) | 37(29) | 0.21 |
| Bundle branch block,% | 119 | 20(16) | 29(11) | 0.26 |
| Permanent pacemaker,% | 149 | 9(6) | 15(12) | 0.22 |
| Log. EuroScore I(%) | 138 | 22±12 | 25±19 | 0.55 |
| NYHA class III-IV,% | 159 | 83(67) | 96(75) | 0.006 |
| Surgical valve type,% | 160 | | | <0.001 |
| CE Standard (can be remodelled) | | 4(3) | 10(8) | |
| Epic | | 5(4) | 0(0) | |
| Magna | | 20(16) | 1(1) | |
| Mitroflow | | 28(23) | 10(8) | |
| Mosaic | | 22(18) | 46(36) | |
| Perimount | | 20(16) | 15(12) | |
| Trifecta (can be remodelled) | | 1(1) | 4(3) | |
| Freedom Solo | | 0(0) | 6(5) | |
| Freestyle | | 0(0) | 6(5) | |
| Sutureless Perceval | | 0(0) | 1(1) | |
| Surgical valve size(mm) | 160 | 22.1±2.1 | 24.1±2.4 | <0.001 |
| True ID(mm) | 158 | 19.1±1.8 | 20.7±2.5 | <0.001 |
| Mean valve duration(years) | 155 | 10.9± 3.4 | 11.8±4.6 | 0.079 |
| Mode of deterioration | 158 | | | 0.036 |
| Stenosis | | 47(38) | 36(28) | |
| Regurgitation | | 6(5) | 19(15) | |
| Mixed | | 47(38) | 44(34) | |
| iEOA($cm^2/m^2$) | 141 | 0.81±0.14 | 0.83±0.12 | 0.19 |
| PPM moderate/severe,% | 149 | 62(50) | 48(33) | 0.072 |
| Perimeter derived diameter(mm) | 74 | 19.5±2.3 | 21.4±2.7 | 0.001 |
| Area($mm^2$) | 67 | 295±72 | 355±95 | 0.002 |
| LVOT diameter | 70 | 21.8±6.9 | 26.0±3.8 | 0.003 |
| LMCA height(mm) | 93 | 10.3±4.7 | 12.7±5.6 | 0.042 |
| RCA height(mm) | 90 | 13.0±5.6 | 18.1±5.3 | <0.001 |
| AV max gradient(mmHg) | 129 | 64±20 | 60±25 | 0.096 |
| AV mean gradient(mmHg) | 148 | 37±13 | 35±16 | 0.11 |
| Aortic valve area($cm^2$) | 94 | 0.81±0.24 | 0.85±0.32 | 0.73 |
| Aortic regurgitation moderate/severe,% | 152 | 50(38) | 0.66(50) | 0.049 |
| Mitral regurgitation: moderate/severe,% | 133 | 27(17) | 0.28(20) | 0.92 |
| Ejection fraction(%) | 154 | 56±11 | 53±11 | 0.15 |
| Pulmonary pressure(mmHg) | 99 | 44±17 | 45±13 | 0.58 |

**Table 2 Procedural data**

| | N | BVF (N=81) | Control (N=79) | P-Value |
|---|---|---|---|---|
| THV type,% | 160 | | | 0.004 |
| Sapien 3 | | 22(18) | 29(23) | |
| Allegra | | 2(2) | 0(0) | |
| Evolut R/Pro | | 70(57) | 59(47) | |
| Acurate Neo | | 1(1) | 1(1) | |
| Portico | | 2(2) | 0(0) | |
| J-valve | | 1(1) | 0(0) | |
| DFM | | 0(0) | 1(1) | |
| Lotus | | 0(0) | 9(7) | |
| THV size(mm) | 160 | 23.7±1.7 | 24.8±2.3 | <0.001 |
| THV oversized in relation to SAV | 160 | (13) | 0(0) | |
| Contrast(ml) | 143 | 100±55 | 84±50 | 0.076 |
| Fluoroscopy time(min) | 139 | 26.2±18.0 | 16.6±11.9 | <0.001 |
| Procedure duration(min) | 138 | 87±42 | 57±25 | <0.001 |
| Cerebral protection | 159 | 31(25) | 9(7) | <0.001 |
| Access transfemoral | 158 | 94(75) | 99(77) | 0.34 |
| Balloon type for BVF | 81 | | | |
| True Dilatation | | 88(71) | | |
| Atlas | | 12(10) | | |
| Balloon oversizing in relation to true ID | 79 | 2.8±1.1 | | |
| Balloon size(mm) | 79 | 21.8±1.8 | 21.1±2.0 | |
| Max balloon pressure(atm) | 65 | 15.8±3.6 | | |
| Final mean transvalvular gradient(mmHg) | 145 | 10.8± 5.9 | 15.8±6.8 | <0.001 |

**Table 3 Complications in-hospital for VIV-TAVI with BVF vs without BVF**

| | | **BVF** (N=81) | **Control** (N=79) | **P-Value** |
|---|---|---|---|---|
| Device success,% | | 93(75) | 68(54) | < 0.001 |
| Prothesis failure,%* | | 6(5) | 28(22) | |
| 2nd valve required,% | | 0(0) | 4(3) | |
| In-hospital mortality,% + | | 1(1) | 3(2) | |
| Ventricular septal rupture,% | | 3(2) | (0) | |
| Aortic root rupture,% | | 0(0) | (0) | |
| All-Stroke,% | | 0(0) | 3(2) | |
| Coronary obstruction,% | | 0(0) | 3(2) | |
| Balloon rupture,% | | 0(0) | (0) | |
| Cardiac tamponade,% | | 0(0) | (0) | |
| Permanent pacemaker,% | | 1(1) | 3(2) | |

** due to residual gradient ≥ 20mmHg*

*+ BVF: retroperitoneal bleeding after balloon rupture in iliac artery. Control: one patient due to severe cardiomyopathy, one patient due to coronary obstruction @ day 3*



## Tavle 4: Model summary

The predictors, parameter estimates, standard errors, test statistic and p-value. Re-transformation of the parameter estimates (exp_est) and confidence intervals (ci_lower, ci_upper).

| | **Parameter estimate** | **std. error** | **Z-statistic** | **p-value** | **exp_est** | **ci_lower** | **ci_upper** |
|---|---|---|---|---|---|---|---|
| Baseline log. AV Gradient | 0.329 | 0.078 | 4.224 | < 0.001 | 1.390 | 1.193 | 1.619 |
| Follow up (months) | 0.003 | 0.002 | 1.700 | 0.089 | 1.003 | 1.000 | 1.007 |
| Control vs BVF group | 0.501 | 0.086 | 5.820 | **< 0.001** | 1.650 | 1.394 | 1.952 |
| Self-expandable valve type (Sapien: others) | 0.254 | 0.114 | 2.225 | **0.026** | 1.290 | 1.031 | 1.613 |
| Surgical valve type (Mitroflow: others) | 0.414 | 0.102 | 4.072 | **< 0.001** | 1.513 | 1.240 | 1.847 |
| Interaction surgical valve * Group | -0.137 | 0.179 | -0.764 | 0.445 | 0.872 | 0.614 | 1.239 |
| Interaction THV * Group | -0.024 | 0.152 | -0.159 | 0.873 | 0.976 | 0.724 | 1.316 |

**Figure 1**

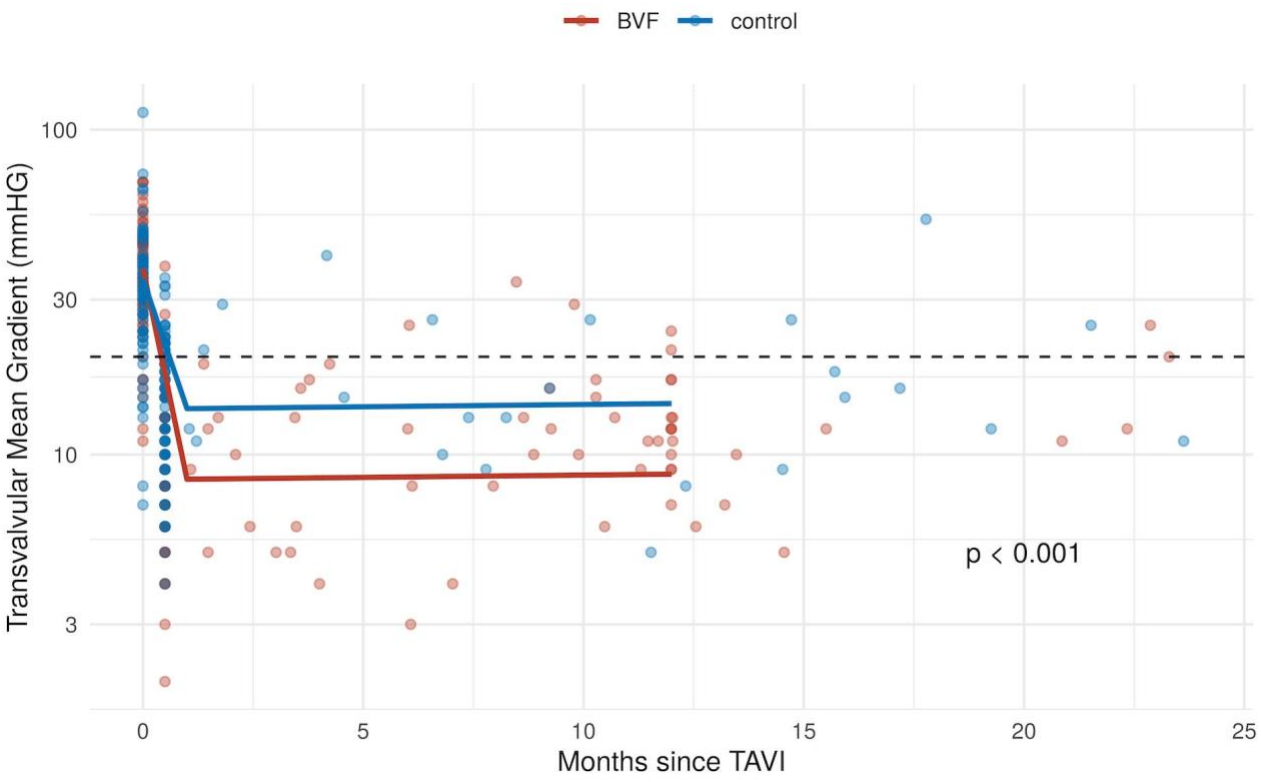


**Figure 2**

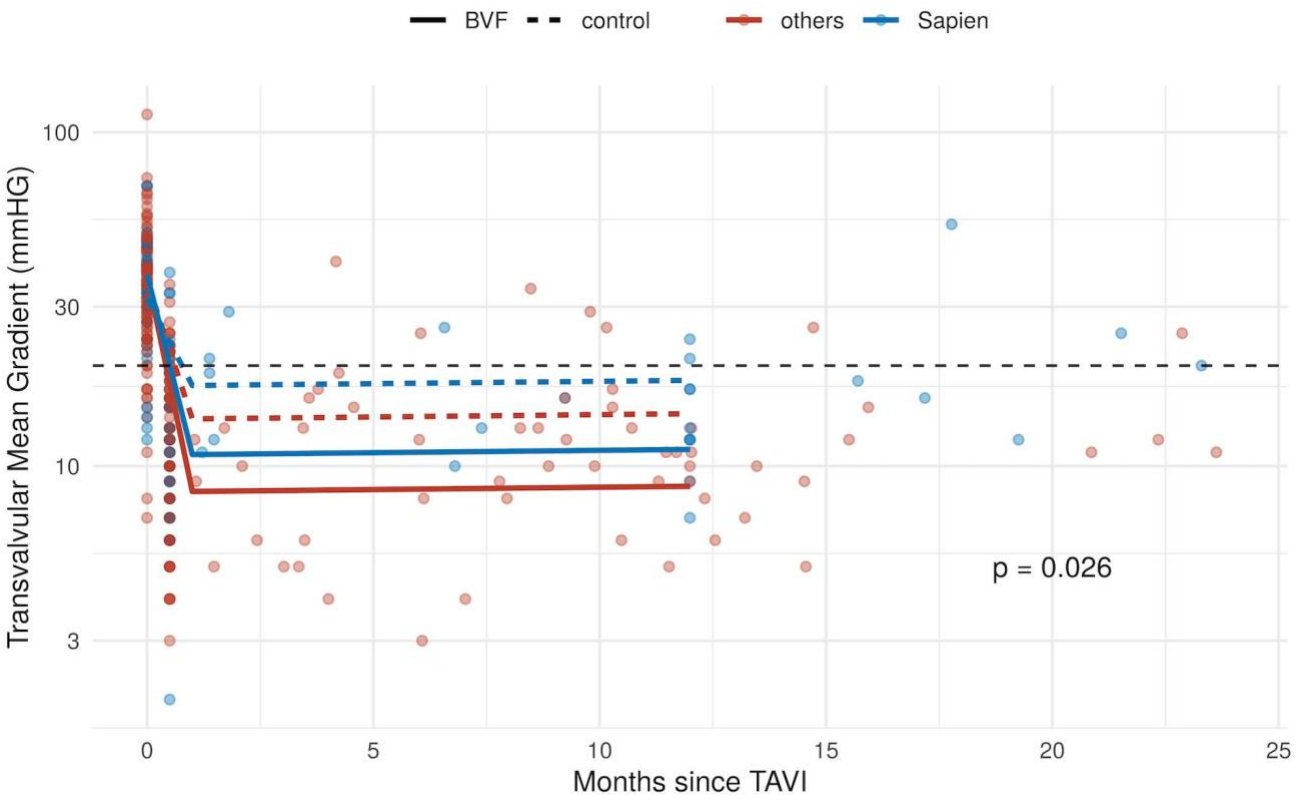


**Figure 3**

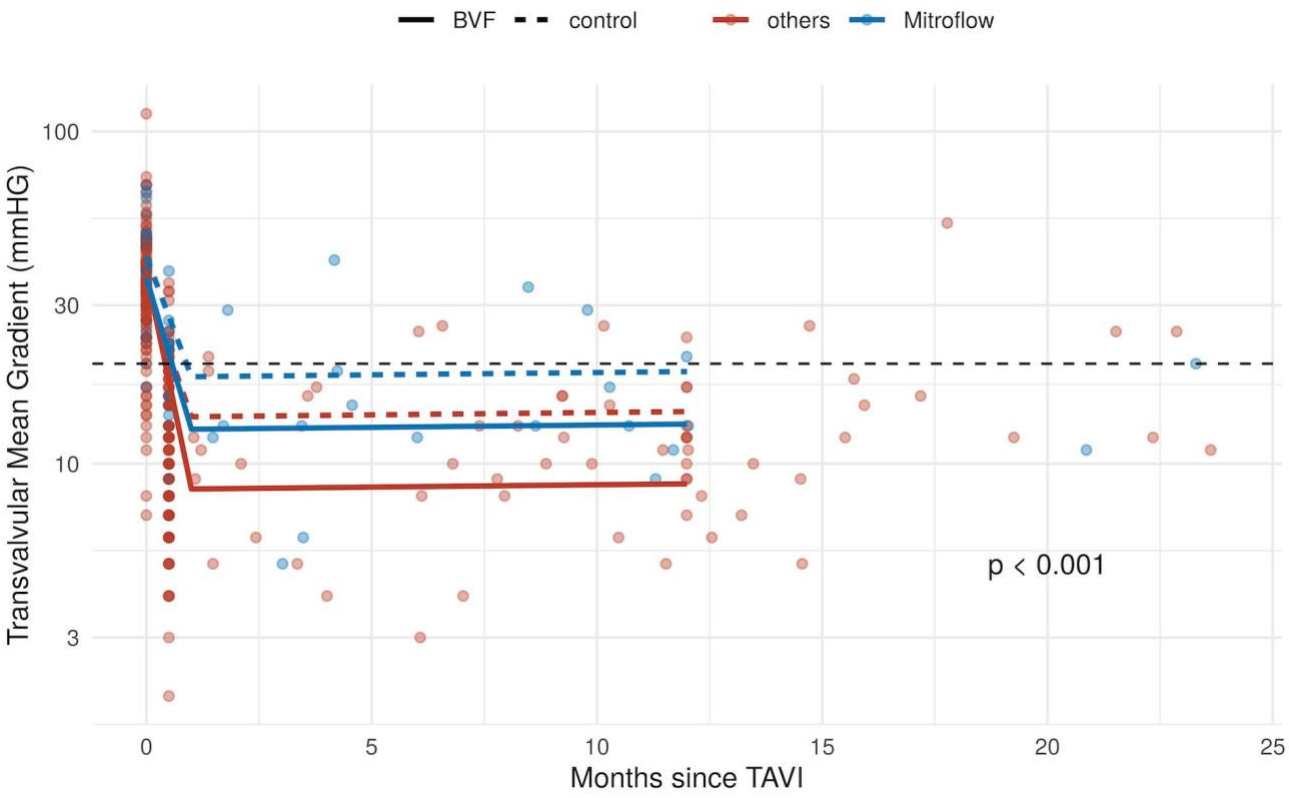
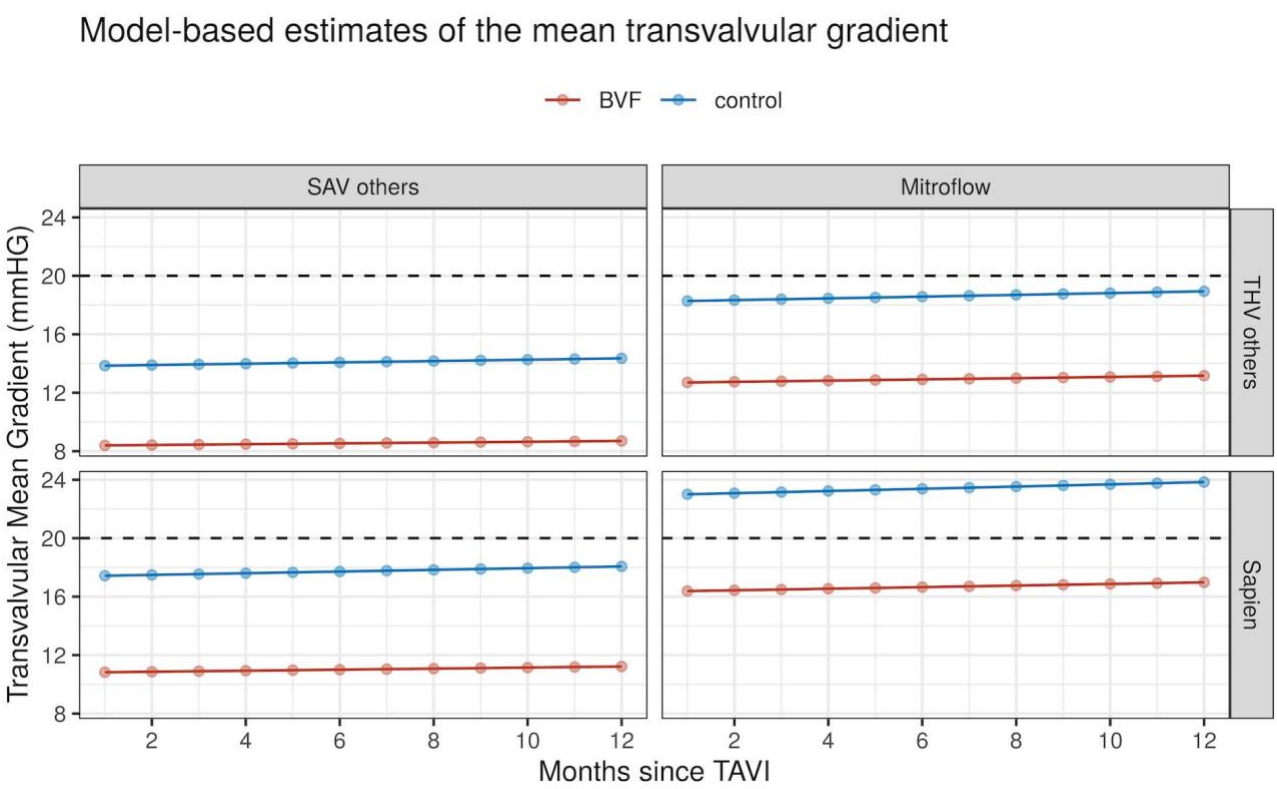


**Figure 4**




*Model-based estimates are adjusted to baseline gradient = 36.1*

## Central Illustration