



# Impact of transradial versus transfemoral access for preprocedural coronary angiography on TAVR-associated complications

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## ABSTRACT

**Background:** Vascular injury and bleeding complications remain frequent after transcatheter aortic valve replacement (TAVR). Whether the access-site of preprocedural coronary angiography (CAG) affects TAVR-related complications is not known. The aim of this study was to evaluate the impact of transradial (TRA) versus transfemoral access (TFA) for preprocedural CAG on outcomes in patients undergoing subsequent TAVR.

**Methods:** The study cohort included 1002 patients undergoing transfemoral TAVR, of whom 39.4% (395/1002) had undergone radial and 60.6% (607/1002) femoral access for pre-TAVR CAG. The primary endpoint was a composite of 30-day mortality and major vascular complications after TAVR. Key secondary endpoints included VARC-3-defined complications.

**Results:** The primary endpoint occurred less frequently in patients with prior TRA (3.3%) as compared to patients with prior TFA (6.3%,  $p = 0.04$ ), which was mainly driven by significantly lower rates of major vascular complications (0.8% vs 2.5%,  $p = 0.05$ ). Moreover, incidences of periprocedural access-related vascular injury and unplanned endovascular interventions were lower in TRA patients (13.2% vs 18.0%,  $p = 0.05$ ). The rate of major bleeding tended to be lower in the TRA (1.5%) as compared to the TFA group (3.5%) but was not significantly different ( $p = 0.07$ ). Moreover, the rate of life-threatening bleeding was comparable between both groups (0.5% vs 0.8%,  $p = 0.71$ ).

**Conclusion:** Transradial access for preprocedural CAG was associated with significantly lower rates of vascular complications following subsequent TAVR as compared to transfemoral access. However, despite the tendency to lower major bleedings with transradial access, no significant association was detectable between the access-site of coronary angiography and TAVR-related bleeding complications.

## 1. Introduction

Transcatheter aortic valve replacement (TAVR) has evolved as an

alternative to surgery for the treatment of symptomatic severe aortic stenosis [1]. Since its introduction in 2002, major technical and clinical advances have been achieved, leading to continuous improvement of

**Abbreviations:** ACT, Activated clotting time; ASARVI, Access-site and access-related vascular injury; CAG, Coronary angiography; CI, Confidence interval; INR, International normalized ratio; IQR, Interquartile range; OR, Odds ratio; PCI, Percutaneous coronary intervention; PTA, Percutaneous transluminal angioplasty; STS-PROM, Thoracic Surgeons predicted risk of mortality; TAVR, Transcatheter aortic valve replacement; TFA, Transfemoral artery access; TRA, Transradial artery access.

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procedural outcomes [2–6]. Nevertheless, TAVR remain to be associated with several procedure-specific complications. Among these, vascular and bleeding events are the most common procedure-related complications and are associated with increased morbidity and mortality [7,8]. Therefore, the prevention of vascular and bleeding complications is vitally important to further improve patients' outcomes.

In the field of coronary angiography (CAG), the selection of the access point has been shown to have a significant impact on the incidence of procedure-related complications [9–11]. Several randomized controlled studies have demonstrated, that transradial artery access (TRA) is superior to transfemoral artery access (TFA), which is associated with higher rates of bleeding and vascular complications after percutaneous coronary intervention (PCI) [12,13].

According to the current guidelines for the management of valvular heart disease, a preprocedural CAG is recommended before surgery or intervention to assess whether concomitant coronary revascularization is needed [14,15]. Moreover, cardiac catheterization for direct intracardiac hemodynamic and output measurements provides valuable additional information [15]. However, the impact of different vascular approaches for CAG on outcomes in patients undergoing subsequent TAVR has not been studied. In theory, prior femoral access and an associated access-site injury could pose an additional risk for the TAVR procedure.

We hypothesized that the selection of the TFA leads to increased procedure-specific complications, as is the case for PCI, including after the following TAVR procedure. The aim of our study was to assess if the selection of the vascular access point for preprocedural CAG is associated with the occurrence of vascular and bleeding complications in patients undergoing subsequent TAVR, and whether this might affect the clinical outcomes.

## 2. Methods

### 2.1. Patient population

The study cohort included 1002 consecutive patients with severe, symptomatic aortic stenosis treated by transfemoral TAVR between June 2017 and October 2020 with the use of next generation transcatheter heart valves at the Heart Center Bonn.

All included patients underwent a detailed evaluation protocol, including transesophageal echocardiography and multidetector computed tomography as well as a diagnostic coronary and aorto-iliofemoral angiography. Reconstructed computed tomography images were used for the assessment of the diameters of the aortic valve and the access vessel. Surgical risk assessment included consideration of both the EuroSCORE II and the Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM) estimate, as well as further aspects not included in the scores, such as frailty and malnutrition.

After evaluation, all cases were discussed within the local interdisciplinary heart team. The study protocol was approved by the local ethics committee (No. 077/14) and complied with the ethical guidelines of the 1975 Declaration of Helsinki. All the patients provided written informed consent to participate.

### 2.2. Study endpoints

The primary endpoint of the study was a composite of 30-day all-cause mortality and major vascular complications after TAVR. Key secondary endpoints included major and life-threatening bleeding complications, stroke, myocardial infarction, acute kidney injury and new pacemaker implantation at 30 days according to the Valve Academic Research Consortium 3 definition criteria [16]. Follow-up data of the patients were collected during routine outpatient visits and via standardized telephone interviews with the referring cardiologists or general practitioners.

### 2.3. Preprocedural coronary angiography

Preprocedural diagnostic coronary angiography was performed in all patients four to six weeks before TAVR. An indication of PCI was based on the current guidelines for myocardial revascularization [17–19]. Interventional strategies including the selection of the appropriate access point was left to the discretion of the treating physician, who made the decision according to patient's individual sclerotic burden. In the case of transradial access, a TR Band radial compression device (Terumo Medical Corporation, Tokyo, Japan) was applied, and patent hemostasis was ensured using a pulse oximetry sensor. In patients undergoing transfemoral access, hemostasis was achieved by the default use of an Angio-Seal vascular closure device (Terumo Medical Corporation, Tokyo, Japan) followed by the application of a pressure bandage for three hours.

### 2.4. Vascular access management during TAVR

At the beginning of the TAVR procedure, all the patients underwent a routinely performed cross-over angiography for the guidance of the puncture of the common femoral artery. Two ProGlide devices were used for pre-closure of the access site, as described previously [20]. At the end of the procedure, selective contralateral angiography was performed to assess any vascular or bleeding complications.

Periprocedural access-site and access-related vascular injuries (ASARVI) were classified into four categories according to Sedaghat *et al.*: type I, blush or minimal extravasation; type II, moderate extravasation (<5 mm); type III, major extravasation (greater than 5 mm) including vessel perforation/rupture; and type IV, vessel dissection/occlusion [21].

Standard vascular access management started with bleeding prevention by hemostasis through manual compression, followed by the application of a pressure bandage for twelve hours. In cases of relevant extravasation or persistent bleeding in the final cross-over angiography, a percutaneous transluminal angioplasty (PTA) was performed, and a covered nitinol stent-graft was implanted, if necessary. After the TAVR procedure, a duplex ultrasonography of the femoral and iliac vessels was performed in clinically apparent hematoma or femoropopliteal bruits.

### 2.5. Statistical analysis

Continuous variables are presented as means with a standard deviation or as the median and interquartile range (IQR) according to a normal distribution, as assessed using the Kolmogorov–Smirnov test. Differences in continuous variables were tested with the Student's *t*-test or Mann–Whitney *U* test, depending on the distribution. Categorical variables are given as absolute numbers and percentages. Fisher's exact test was used to assess differences in categorical variables. Independent predictors of the primary endpoint were identified by first including the parameters in a univariate regression analysis and subsequently entering the significant predictors in a stepwise multivariate logistic regression model. Statistical analyses were performed with SPSS version 28 (IBM Corporation, Somers, NY). Statistical significance was considered as a two-tailed probability value  $\leq 0.05$ . All the authors vouch for the accuracy and completeness of the data and analyses.

## 3. Results

The overall study population was elderly (mean age  $80.9 \pm 6.0$  years), but at relatively low surgical risk, with a median STS-PROM of 3.0%, (IQR: 2.1 – 4.5%) and a median EuroSCORE II of 3.5% (IQR: 2.1 – 6.0%). Preprocedural coronary angiography was performed via transradial artery access in 395 (39.4%) cases and via transfemoral access in 607 (60.6%) patients. The baseline characteristics of the patients, as stratified according to vascular access sight of the preprocedural coronary angiography, are summarized in Table 1. Clinical characteristics

**Table 1**  
Baseline Characteristics of the Patients.

|   | Overall Cohort (n = 1002) | TRA Group (n = 395) | TFA Group (n = 607) | p Value |
|---|---------------------------|---------------------|---------------------|---------|
| Age, years                                  | 80.9 ± 6.0                | 80.6 ± 6.2          | 81.2 ± 5.8          | 0.17    |
| Body mass index, kg/m <sup>2</sup>          | 26.8 ± 4.8                | 26.9 ± 4.8          | 26.7 ± 4.8          | 0.36    |
| Female, %                                   | 457 (45.6)                | 184 (46.6)          | 273 (45.0)          | 0.65    |
| EuroSCORE II, %                             | 3.5 (2.1–6.0)             | 3.3 (2.0–5.7)       | 3.6 (2.2–6.2)       | 0.06    |
| STS-PROM, %                                 | 3.0 (2.1–4.5)             | 2.9 (2.0–4.1)       | 3.0 (2.0–4.7)       | 0.07    |
| Left ventricular ejection fraction, %       | 55.3 ± 11.6               | 56.3 ± 11.0         | 54.8 ± 12.0         | 0.05    |
| Chronic obstructive pulmonary disease, %    | 144 (14.4)                | 55 (13.9)           | 89 (14.7)           | 0.78    |
| Coronary artery disease, %                  | 640 (63.9)                | 242 (61.3)          | 398 (65.6)          | 0.18    |
| Myocardial infarction, %                    | 123 (12.3)                | 39 (9.9)            | 84 (13.8)           | 0.06    |
| Previous coronary artery bypass grafting, % | 120 (12.0)                | 39 (9.9)            | 81 (13.3)           | 0.11    |
| Previous stroke, %                          | 105 (10.5)                | 36 (9.1)            | 69 (11.4)           | 0.29    |
| Arterial hypertension, %                    | 845 (84.3)                | 336 (85.1)          | 509 (83.9)          | 0.65    |
| Diabetes mellitus, %                        | 291 (29.0)                | 113 (28.6)          | 178 (29.3)          | 0.83    |
| Dyslipidemia, %                             | 660 (65.9)                | 259 (65.6)          | 401 (66.1)          | 0.89    |
| Peripheral artery disease, %                | 414 (41.2)                | 167 (42.5)          | 246 (40.5)          | 0.56    |
| Carotid artery disease, %                   | 362 (36.1)                | 151 (38.2)          | 211 (34.8)          | 0.28    |
| Atrial fibrillation, %                      | 427 (42.6)                | 162 (41.0)          | 265 (43.7)          | 0.43    |
| Creatinine, mg/dL                           | 1.10 (0.89–1.40)          | 1.06 (0.85–1.38)    | 1.13 (0.91–1.41)    | <0.01   |
| Chronic kidney disease ≥ Stage 4, %         | 79 (7.9)                  | 26 (6.6)            | 53 (8.7)            | 0.23    |
| INR   | 1.1 (1.0–1.1)             | 1.0 (1.0–1.1)       | 1.1 (1.0–1.2)       | 0.20    |
| Activated partial thromboplastin time, sec  | 24.0 (23.0–27.0)          | 24.0 (23.0–27.0)    | 24.0 (22.5–27.0)    | 0.35    |
| Hemoglobin, g/dl                            | 11.7 ± 1.7                | 11.6 ± 1.7          | 11.8 ± 1.8          | 0.24    |
| Hematocrit, %                               | 34.7 ± 4.9                | 34.4 ± 4.8          | 34.8 ± 5.0          | 0.34    |
| Platelets, G/L                              | 199 (163–242)             | 201 (163–244)       | 197 (164–241)       | 0.57    |
| Highest ACT, sec                            | 226 (200–260)             | 226 (200–263)       | 227 (202–259)       | 0.69    |
| Last ACT, sec                               | 199 (144–238)             | 198 (141–232)       | 201 (145–241)       | 0.28    |
| Oral anticoagulation, %                     | 474 (47.3)                | 174 (44.1)          | 300 (49.4)          | 0.11    |
| Dual antiplatelet therapy, %                | 478 (47.7)                | 201 (50.8)          | 277 (45.6)          | 0.12    |
| Triple Therapy, %                           | 27 (2.7)                  | 10 (2.5)            | 17 (2.8)            | 0.85    |

STS-PROM, Society of Thoracic Surgeons Predicted Risk of Mortality; INR, international normalized ratio; ACT, activated clotting time.

were well balanced between the two groups, except for a higher left ventricular ejection fraction and a lower level of creatinine in patients with radial compared to femoral access (56.3 ± 11.0 vs 54.8 ± 12.0%,  $p = 0.05$ ; 1.06 vs 1.13 mg/dL,  $p < 0.01$ , respectively). However, the rate of peripheral artery disease (42.5% vs 40.5%,  $p = 0.56$ ) and coronary artery disease (61.3% vs 65.6%,  $p = 0.18$ ) as well as prior myocardial infarction (9.9% vs 13.8%,  $p = 0.06$ ) did not differ between the two groups.

In the overall cohort, a PCI was performed in 289 (28.8%) cases and did not differ between patients with TRA (26.6%) as compared to patients with TFA (30.3%,  $p = 0.23$ ). Among these cases, 4.3% of the patients underwent multivessel PCI, without a statistically significant difference between both groups (3.8% vs 4.6%,  $p = 0.63$ ). The majority of patients received a PCI of the left anterior descending vessel (47.8%) using a drug eluting stent, followed by the revascularization of the right coronary artery (36.0%) and the left circumflex artery (27.0%), as presented in Table 2. The median procedure and fluoroscopy time were

**Table 2**  
Peri- and Postprocedural Coronary Angiography Data.

|   | Overall Cohort (n = 1002) | TRA Group (n = 395) | TFA Group (n = 607) | p Value |
|---|---------------------------|---------------------|---------------------|---------|
| Percutaneous coronary intervention, %           | 289 (28.8)                | 105 (26.6)          | 184 (30.3)          | 0.23    |
| Multivessel coronary intervention, %            | 43 (4.3)                  | 15 (3.8)            | 28 (4.6)            | 0.63    |
| <b>Coronary Vessels Treated, %</b>              |                           |                     |                     |         |
| Left main stem coronary artery                  | 19 (1.9)                  | 6 (1.5)             | 13 (2.1)            | 0.64    |
| Left anterior descending artery                 | 138 (13.8)                | 49 (12.4)           | 89 (14.7)           | 0.35    |
| Left circumflex artery                          | 78 (7.8)                  | 26 (6.6)            | 52 (8.6)            | 0.28    |
| Right coronary artery                           | 104 (10.4)                | 41 (10.4)           | 63 (10.4)           | 1.0     |
| <b>Postprocedural Characteristics</b>           |                           |                     |                     |         |
| Procedural time, min                            | 35.0 (20.0–55.0)          | 37.5 (20.0–50.0)    | 35.0 (20.0–55.0)    | 0.65    |
| Fluoroscopy time, min                           | 8.0 (4.0–13.0)            | 9.0 (4.0–14.0)      | 8.0 (4.0–13.0)      | 0.24    |
| Contrast volume, mL                             | 92.5 (65.0–125.0)         | 95.5 (66.0–125.0)   | 91.5 (65.0–125.0)   | 0.67    |
| <b>Postprocedural Vascular Complications, %</b> |                           |                     |                     |         |
| Pseudoaneurysm                                  | 4 (0.4)                   | 0                   | 4 (0.7)             | 0.16    |
| Arteriovenous fistula                           | 0                         |                     |                     |         |
| Ileo-femoral dissection                         | 0                         |                     |                     |         |
| Stenosis/Radial artery occlusion                | 5 (0.5)                   | 4 (0.1)             | 1 (0.2)             | 0.08    |

35.0 min (IQR: 20.0 – 55.0 min) and 8.0 min (IQR: 4.0 – 13.0 min), respectively, and were comparable between both groups ( $p \geq 0.24$ ). The average amount of contrast agent given was 92.5 mL (IQR: 65.0 – 125.0 mL), with no significant difference observed between TRA and TFA patients. The rates of postprocedural vascular complications were comparably low in both groups and included pseudoaneurysms occurring only in the TFA group (0.7%) as well as stenosis/occlusion of the access vessel in 1.0% in the TRA group versus 0.2% in the TFA group ( $p = 0.08$ ).

Overall, TAVR was predominantly performed with the use of the balloon-expandable Edwards SAPIEN 3/Ultra prosthesis (55.2%), followed by the Medtronic Evolut R/PRO prosthesis (39.2%), as shown in Table 3. Periprocedural access-related vascular injury occurred in 28.8% of the overall study population, with higher rates of ASARVI I and II in the TFA group as compared to the TRA group (11.7% vs 7.8%,  $p = 0.05$ ; 8.7% vs 5.3%,  $p = 0.05$ ; respectively). Consistent with this observation, a bailout unplanned endovascular intervention was required more often in the TFA group (18.0% vs 13.2%,  $p = 0.05$ ), which was mainly driven by higher rates of percutaneous transluminal angioplasty (PTA) in the TFA group (12.2% vs 6.6%,  $p < 0.01$ ). Postprocedural duplex ultrasonography of the access site revealed comparable rates of pseudoaneurysm and vascular dissections in both groups ( $p \geq 0.69$ ), but higher rates of common femoral artery stenosis in the TFA group (15.8% vs 11.4%,  $p = 0.05$ ). However, a secondary endovascular intervention was required in only 4.3% of patients with duplex-ultrasound-detected stenosis of the common femoral artery.

### 3.1. Primary and key secondary endpoints

The primary endpoint, a composite of 30-day all-cause mortality and major vascular complications was observed more frequently in the TFA group (6.3%) as compared to the TRA group (3.3%,  $p = 0.04$ ), Table 4 and Fig. 1. This was mainly driven by higher rates of major vascular complications in the TFA group (2.5% vs 0.8%,  $p = 0.05$ ), whereas no

**Table 3**  
Peri- and Postprocedural TAVR Data.

|   | Overall Cohort (n = 1002) | TRA Group (n = 395) | TFA Group (n = 607) | p Value |
|---|---------------------------|---------------------|---------------------|---------|
| Edwards SAPIEN 3/Ultra, %                       | 553 (55.2)                | 216 (54.7)          | 337 (55.5)          | 0.84    |
| Evolut R/PRO, %                                 | 388 (38.7)                | 154 (39.0)          | 234 (38.6)          | 0.89    |
| Other valve types, %                            | 61 (6.1)                  | 25 (6.3)            | 36 (5.9)            | 0.79    |
| <b>Periprocedural Vascular Complications, %</b> |                           |                     |                     |         |
| ASARVI I  | 102 (10.2)                | 31 (7.8)            | 71 (11.7)           | 0.05    |
| ASARVI II                                       | 74 (7.4)                  | 21 (5.3)            | 53 (8.7)            | 0.05    |
| ASARVI III                                      | 34 (3.4)                  | 12 (3.0)            | 22 (3.6)            | 0.72    |
| ASARVI IV                                       | 79 (7.9)                  | 32 (8.1)            | 47 (7.7)            | 0.91    |
| Unplanned bailout endovasc. interv.             | 161 (16.1)                | 52 (13.2)           | 109 (18.0)          | 0.05    |
| Unplanned PTA                                   | 100 (10)                  | 26 (6.6)            | 74 (12.2)           | <0.01   |
| Unplanned stent implantation                    | 61 (6.1)                  | 26 (6.6)            | 35 (5.8)            | 0.59    |
| <b>Postprocedural Vascular Complications, %</b> |                           |                     |                     |         |
| Pseudoaneurysm                                  | 60 (6.0)                  | 22 (5.6)            | 38 (6.3)            | 0.69    |
| Arteriovenous fistula                           | 8 (0.8)                   | 3 (0.8)             | 5 (0.8)             | 1.0     |
| Ileo-femoral dissection                         | 82 (8.2)                  | 31 (7.8)            | 51 (8.4)            | 0.81    |
| Stenosis  | 141 (14.1)                | 45 (11.4)           | 96 (15.8)           | 0.05    |

TAVR, transcatheter aortic valve replacement; ASARVI, access-site and access-related vascular injury; endovasc. interv., endovascular interventions; PTA, percutaneous transluminal angioplasty.

**Table 4**  
Clinical Endpoints.

|                                   | Overall Cohort (n = 1002) | TRA Group (n = 395) | TFA Group (n = 607) | p Value |
|-----------------------------------|---------------------------|---------------------|---------------------|---------|
| <b>Primary endpoint, %</b>        | 51 (5.1)                  | 13 (3.3)            | 38 (6.3)            | 0.04    |
| 30-day mortality                  | 37 (3.7)                  | 10 (2.5)            | 27 (4.4)            | 0.13    |
| Major vascular complication       | 18 (1.8)                  | 3 (0.8)             | 15 (2.5)            | 0.05    |
| <b>Key secondary endpoints, %</b> |                           |                     |                     |         |
| Life-threatening bleeding         | 7 (0.7)                   | 2 (0.5)             | 5 (0.8)             | 0.71    |
| Major bleeding                    | 27 (2.7)                  | 6 (1.5)             | 21 (3.5)            | 0.07    |
| Minor vascular complication       | 176 (7.6)                 | 63 (5.9)            | 113 (18.6)          | 0.31    |
| Stroke                            | 17 (1.7)                  | 5 (1.3)             | 12 (2.0)            | 0.46    |
| Myocardial infarction             | 4 (0.4)                   | 2 (0.5)             | 2 (0.3)             | 0.65    |
| Acute kidney injury               | 82 (8.2)                  | 30 (7.6)            | 52 (8.6)            | 0.64    |
| New permanent pacemaker           | 95 (9.5)                  | 46 (11.6)           | 49 (8.1)            | 0.08    |

significant difference was detectable in 30-day mortality rates between the TFA and TRA group (4.4% vs 2.5%,  $p = 0.13$ ).

Vascular complications were caused by a periprocedural vascular injury requiring unplanned endovascular interventions in 7 (38.9%) cases, followed by a dissection and a pseudoaneurysm of the common femoral artery in 4 (22.2%) and 3 (16.7%) cases, and a postprocedural access-related vascular injury in 2 (11.1%) cases, all of them resulting in major bleeding events. A closure device failure and a vascular injury of the external iliac artery occurred each in one case. Of the observed TAVR-related vascular complications in the TFA group, 66.7% (10/15) were access-way related and occurred ipsilateral to the vascular access point of the preprocedural coronary angiography.

Regarding bleeding events, there was a tendency to higher rates of major bleedings in the TFA group (3.5%) as compared to the TRA group (1.5%), however this difference was not significant ( $p = 0.07$ ). Moreover, the rate of life-threatening bleeding was comparable between both groups (0.8% vs 0.5%,  $p = 0.71$ ), as shown in the **Graphical Abstract**. Of all the bleeding complications observed in the TFA group, 10 out of 26 (38.5%) were both access-related and ipsilateral to the access point of the preprocedural catheterization.

### 3.2. Predictors of clinical outcomes

Univariate and multivariate analyses revealed that high levels of hemoglobin (OR: 0.82 [95% CI: 0.70–0.97],  $p = 0.02$ ) and TFA (OR: 2.0 [95% CI: 1.03–4.00],  $p = 0.04$ ) were independently associated with the primary endpoint, as shown in **Table 5**. There was no significant association of left ventricular ejection fraction (OR: 1.0 [95% CI: 0.97–1.02],  $p = 0.77$ ), oral anticoagulation (OR: 1.38 [95% CI: 0.78–2.46],  $p = 0.27$ ) or prior multivessel PCI (OR: 0.90 [95% CI: 0.21–3.85],  $p = 0.89$ ) with outcome in the univariate analyses.

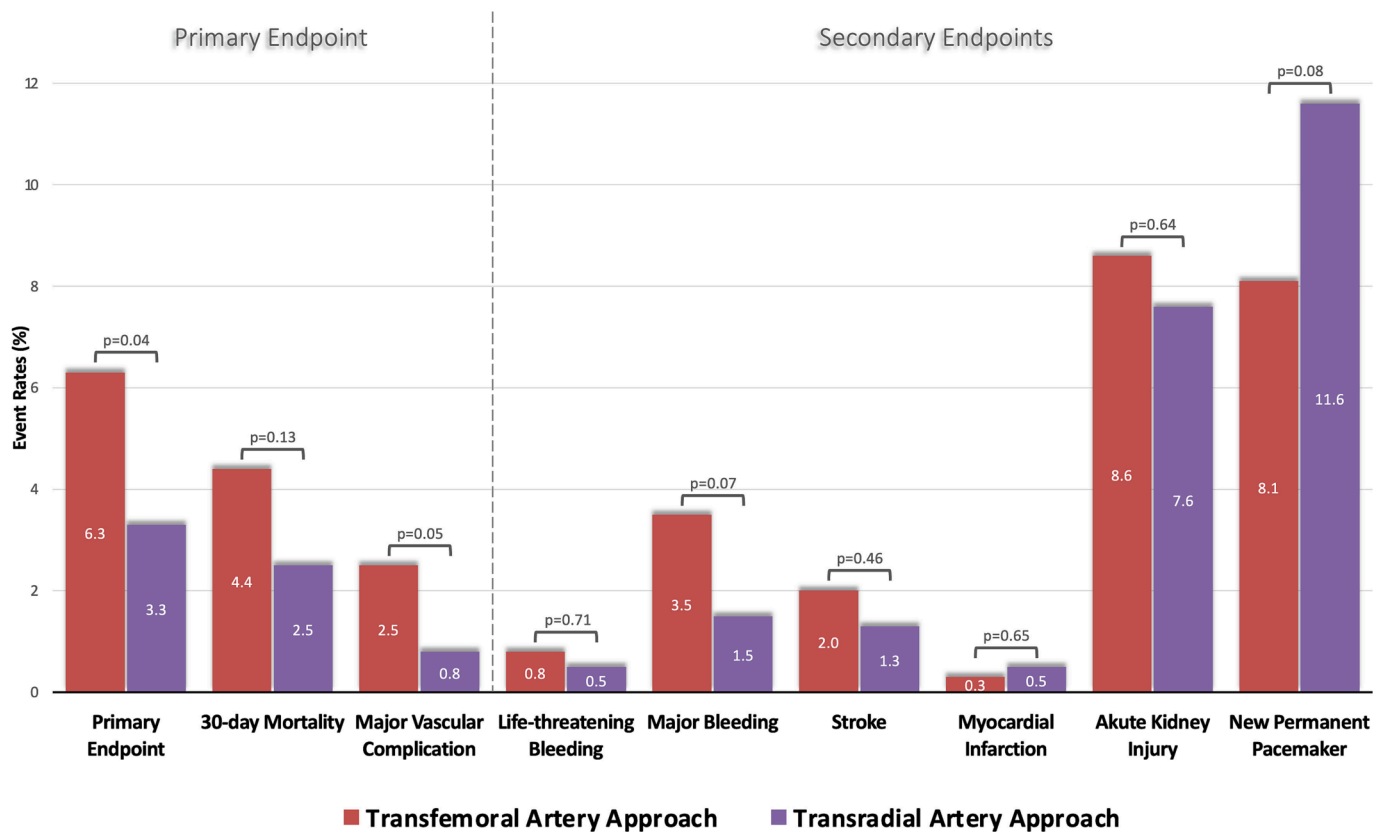
## 4. Discussion

The key findings of our observational study with a total of 1002 patients undergoing transfemoral TAVR with next generation transcatheter heart valves are:

1. Radial access for preprocedural coronary angiography was associated with significantly lower rates of major vascular complications following subsequent TAVR.
2. The need for unplanned endovascular interventions during the TAVR-procedure was less frequent in patients with prior radial, as compared to femoral access.
3. Despite a tendency to higher rates of major bleeding in the TFA group, no significant association was detectable between the vascular access point for preprocedural CAG and TAVR-related bleeding complications.
4. The access-site of preprocedural CAG was not associated with further complications related to subsequently performed TAVR, such as myocardial infarction or stroke.

Despite considerable advances in the field of TAVR, major vascular complications remain a significant procedure-specific issue, affecting morbidity and mortality [5,8,22]. In the present study, transradial access was found to be associated with a more than 50% reduced occurrence of the combined primary endpoint ( $p = 0.04$ ). This difference was mainly driven by a relative reduction of major vascular complication by 70% ( $p = 0.05$ ) with radial access, but not in 30-day all-cause mortality rates ( $p = 0.13$ ). These findings are consistent with previous studies comparing radial with femoral access for diagnostic angiography and PCI, that reported favorable outcomes with radial access due to a lower incidence of access-related complications [9,10]. The randomized controlled RIVAL trial showed a significant reduction in local major vascular complications with radial compared to femoral access, whereas differences between the groups in the secondary outcomes of 30-day mortality and major bleeding were not significant [12]. The MATRIX trial, a randomized controlled study comparing radial with femoral access for coronary angiography in patients with acute coronary syndrome, reported reduced net adverse clinical events in the radial access cohort, which were driven by a reduction in major bleeding events [13]. In the present study, despite a tendentially lower rate of major bleedings with transradial access, no significant association was found between the selection of the vascular access point for preprocedural CAG and the occurrence of bleeding complications following subsequent TAVR ( $p \geq 0.07$ ). However, the overall incidence of major vascular and bleeding complication was low in our study cohort, as compared to the reported complication rates from other multicenter trials in low-risk patients, such as the PARTNER 3 trial [23]. This may be because we only included low-risk patients undergoing transfemoral TAVR with next-generation transcatheter heart valves by the experienced operators at our high-volume center and that a standard operating procedure for vessel closure and vascular complication management was already established.

Although, transradial access is considered the default approach for cardiac catheterization in most countries and recommended by the recent guidelines, strategies in patients receiving preprocedural coronary angiography for the preoperative management of valvular heart



**Fig. 1.** The primary endpoint, a composite of 30-day mortality and major vascular complications after TAVR was significantly less frequent in patients with prior transradial access for preprocedural coronary angiography. This was mainly driven by significantly lower rates of major vascular complications. However, no significant association was detectable between the access-site of coronary angiography and bleeding complications after TAVR.

**Table 5**  
Predictors of the Primary Endpoint.

|                                  | Univariable analysis |      |              | Multivariable analysis |             |                    |
|----------------------------------|----------------------|------|--------------|------------------------|-------------|--------------------|
|                                  | p Value              | OR   | 95% CI       | P value                | OR          | 95% CI             |
| EuroSCORE II                     | <0.01                | 1.12 | 1.10 – 1.18  | 0.12                   | 1.06        | 0.98 – 1.16        |
| STS-PROM                         | <0.01                | 1.11 | 1.03 – 1.20  | 0.77                   | 1.02        | 0.88 – 1.19        |
| Chronic kidney disease ≥ Stage 4 | <0.01                | 3.11 | 1.50 – 6.49  | 0.26                   | 1.68        | 0.68 – 4.18        |
| Diabetes                         | 0.03                 | 1.92 | 1.10 – 3.40  | 0.18                   | 1.52        | 0.81 – 2.84        |
| Hematocrit                       | 0.02                 | 0.93 | 0.88–0.99    | 0.16                   | 0.95        | 0.90 – 1.02        |
| Hemoglobin                       | <0.01                | 0.78 | 0.678 – 0.91 | <b>0.02</b>            | <b>0.82</b> | <b>0.70 – 0.97</b> |
| Transfemoral artery access       | 0.04                 | 1.96 | 1.03 – 3.73  | <b>0.04</b>            | <b>2.0</b>  | <b>1.03 – 4.00</b> |

OR, odds ratio; CI, confidence interval; STS-PROM, Society of Thoracic Surgeons Predicted Risk of Mortality.

disease still varies significantly between centers [11,17–19,24]. This may be a consequence of the fact that, despite standardized use of reconstructed computed tomographic images for the assessment of the access vessel diameters and calcification in most centers, aortiliofemoral angiography is still a part of the preprocedural diagnostic setting in patients with severe aortic stenosis, which may lead to a preference of the transfemoral access [25–27]. However, it must be considered, that these patients undergo a repetitive iatrogenic injury of the access site in relatively quick succession. Furthermore, vascular closure devices, such as the Angio-Seal, are commonly used to reduce

the time to achieve hemostasis at the femoral arterial puncture site in patients undergoing transfemoral percutaneous procedures [28]. Of interest, according to previous reports, components of the Angio-Seal are absorbed within 60–90 days, but the time between preprocedural coronary angiography and subsequent TAVR is generally only around four weeks [29,30]. One consequence of this may be an increased susceptibility to local vascular lesions, thus resulting in access-related vascular complications [21]. In our study, the occurrence of mild to moderate periprocedural vascular extravasation was almost 60% more frequent in patients with prior transfemoral access. Moreover, despite standardized access way management, an unplanned endovascular intervention was more frequently required in patients with TFA, which was mainly powered by a relative increase in the requirement for PTA by 46% in the TFA cohort compared to the TRA cohort. This was also reflected in the postprocedural assessment of the access site, where higher rates of duplex-ultrasound-detected stenosis of the common femoral artery were observed in patients with prior transfemoral access for coronary angiography. However, most of these patients were clinically inapparent and a secondary endovascular intervention was required in only 4.3% of cases. Overall, our analysis confirms previous findings in patients undergoing coronary angiography and percutaneous interventions that indicate the existence of a range of benefits for radial access [13]. In line, TFA was found to be an independent predictor of the primary endpoint (p = 0.04) in our study.

**5. Limitations**

Limitations of this study include the nonrandomized character of our single-center experience and the absence of external core laboratories. However, to our knowledge, this is the first study evaluating the impact of radial versus femoral access for preprocedural coronary angiography

on outcomes in patients undergoing subsequent TAVR. Moreover, although the baseline characteristics were well balanced between the two groups, our retrospective observational data are vulnerable to residual confounding factors. In addition, due to the lack of a standardized recommendation for the default approach for cardiac catheterization in the beginning of the study period, the access site was selected at the physician's discretion, which probably led to a certain selection bias in our analysis. However, towards the end of the study period, TRA came to be considered the default strategy for preprocedural coronary angiography.

## 6. Conclusion

The use of transradial access for preprocedural coronary angiography in patients with severe aortic stenosis undergoing subsequent TAVR was associated with lower rates of periprocedural vascular injury and major vascular complications, as compared to patients with transfemoral access. However, despite a tendency to lower major bleedings with transradial access, no significant association was found between the selection of the vascular access point for coronary angiography and the occurrence of bleeding complications following subsequent TAVR.

## CRediT authorship contribution statement

**Baravan Al-Kassou:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Hasanin Al-Shaikh:** Data curation, Investigation, Writing – review & editing. **Adem Aksoy:** Data curation, Methodology, Writing – review & editing. **Jasmin Shamekhi:** Data curation, Investigation, Writing – review & editing. **Andreas Zietzer:** Data curation, Writing – review & editing. **Atsushi Sugiura:** Data curation, Investigation, Writing – review & editing. **Verena Veulemans:** Conceptualization, Investigation, Validation, Writing – original draft, Writing – review & editing. **Matti Adam:** Conceptualization, Investigation, Validation, Writing – review & editing. **Eberhard Grube:** Project administration, Supervision, Writing – review & editing. **Farhad Bakhtiary:** Resources, Software, Writing – review & editing. **Sebastian Zimmer:** Formal analysis, Project administration, Writing – review & editing. **Malte Kelm:** Methodology, Resources, Software, Supervision, Writing – review & editing. **Stephan Baldus:** Methodology, Resources, Software, Supervision, Writing – review & editing. **Georg Nickenig:** Methodology, Project administration, Resources, Software, Supervision, Writing – review & editing. **Alexander Sedaghat:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

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