# Impact of Direct Transcatheter Aortic Valve Replacement Without Balloon Aortic Valvuloplasty on Procedural and Clinical Outcomes

## Insights From the FRANCE TAVI Registry

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**CME/MOC/ECME Objective for This Article:** At the end of the activity the reader should be able to: 1) recognize the evolution of transcatheter aortic valve replacement (TAVR) procedure over time; 2) understand the location for balloon aortic valvuloplasty (BAV) during TAVR; and 3) compare the outcomes of Direct TAVR versus BAV as part of the TAVR procedure.

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## ABSTRACT

**OBJECTIVES** This study sought to describe the current practices and compare outcomes according to the use of balloon aortic valvuloplasty (BAV) or not during transcatheter aortic valve replacement (TAVR).

**BACKGROUND** Since its development, aortic valve pre-dilatation has been an essential step of TAVR procedures. However, the feasibility of TAVR without systematic BAV has been described.

**METHODS** TAVR performed in 48 centers across France between January 2013 and December 2015 were prospectively included in the FRANCE TAVI (Registry of Aortic Valve Bioprostheses Established by Catheter) registry. We compared outcomes according to BAV during the TAVR procedure.

**RESULTS** A total of 5,784 patients have been included in our analysis, corresponding to 2,579 (44.6%) with BAV avoidance and 3,205 (55.4%) patients with BAV performed. We observed a progressive decline in the use of BAV over time (78% of procedures in 2013 and 49% in the last trimester of 2015). Avoidance of BAV was associated with similar device implantation success (97.3% vs. 97.6%; $p = 0.40$). TAVR procedures without BAV were quicker (fluoroscopy 17.2 $\pm$ 9.1 vs. 18.5 $\pm$ 8.8 min; $p < 0.01$) and used lower amounts of contrast (131.5 $\pm$ 61.6 vs. 141.6 $\pm$ 61.5; $p < 0.01$) and radiation (608.9 $\pm$ 576.3 vs. 667.0 $\pm$ 631.3; $p < 0.01$). The rates of moderate to severe aortic regurgitation were lower with avoidance of BAV (8.3% vs. 12.2%; $p < 0.01$) and tamponade rates (1.5% vs. 2.3%; $p = 0.04$).

**CONCLUSIONS** We confirmed that TAVR without BAV is frequently performed in France with good procedural results. This procedure is associated with procedural simplification and lower rates of residual aortic regurgitation.


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**ABBREVIATIONS AND ACRONYMS**

**AS** = aortic stenosis

**BAV** = balloon aortic valvuloplasty

**TAVR** = transcatheter aortic valve replacement

Continuous development has improved the results of transcatheter aortic valve replacement (TAVR), and this technique is considered the preferred treatment for severe aortic stenosis (AS) in high-surgical-risk patients (1,2). Despite continuous simplification of the original TAVR protocol, technical success rates up to 97% are reported nowadays (3).

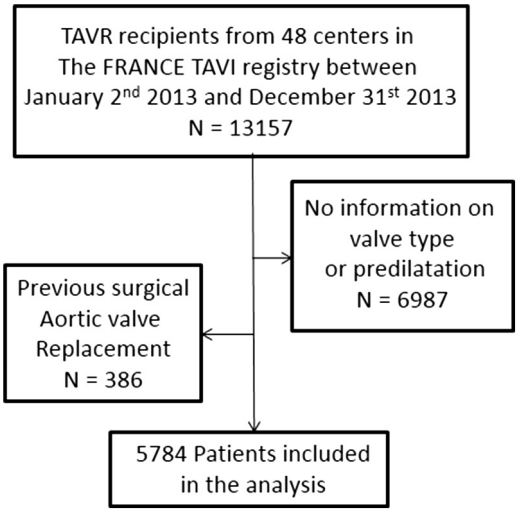
A systematic step of aortic valve pre-dilatation before valve deployment has been mandatory from the early days (4). Balloon aortic valvuloplasty (BAV) is supposed to facilitate the delivery system, help in sizing the device, and optimize valve implantation and expansion (4). However, BAV has been associated with hemodynamic disturbance, acute aortic regurgitation, renal failure, increased risk of stroke, and pacemaker implantation (5-8).

SEE PAGE 1966

Feasibility of the TAVR procedure without systematic BAV has been described in the literature, for both self-expanding and balloon-expanding devices (9,10). Therefore, the necessity of systematic BAV has been debated in recent years and is now avoided by most teams.

Therefore, on the basis of the large FRANCE TAVI (Registry of Aortic Valve Bioprostheses Established by Catheter) registry, we describe the current practices and compare patient outcomes according to pre-dilatation performed during the TAVR procedure.

**FIGURE 1** Flowchart

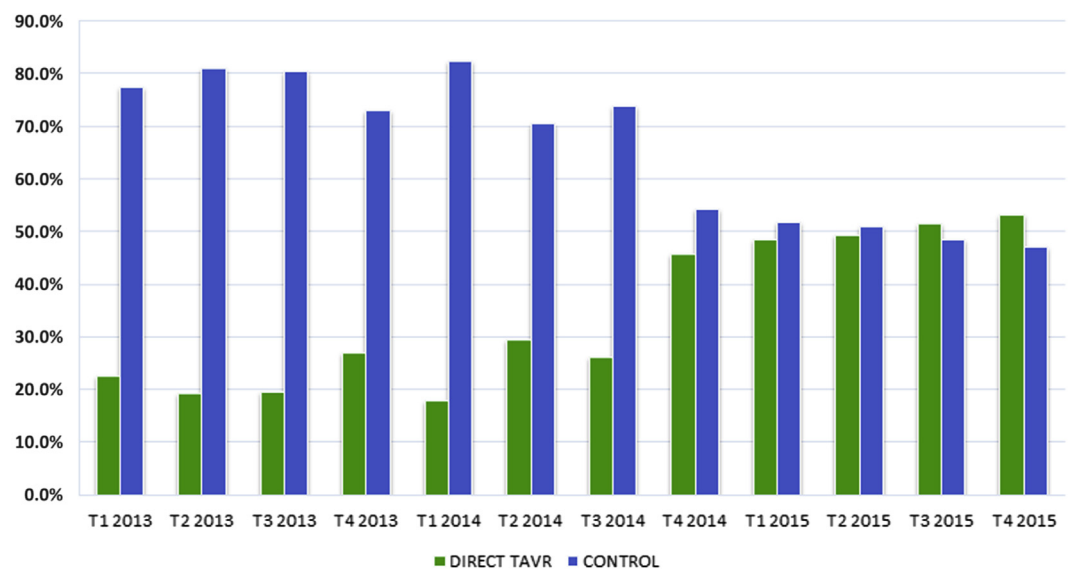



Patients with previous aortic valve replacement, no information regarding the type of valve implanted, or pre-dilatation status were excluded from the analysis. TAVR = transcatheter aortic valve replacement.

## METHODS

Launched in January 2013, FRANCE TAVI is an initiative of the working group of interventional cardiology of the French Society of Cardiology with the participation of the French Society of Thoracic and

**FIGURE 2** Direct TAVR Evolution Between 2013 and 2015




The rate of Direct TAVR increased during the time period and became the most frequent TAVR procedure in mid-2015. T = trimester; TAVR = transcatheter aortic valve replacement.

**TABLE 1 Baseline Clinical and Echocardiographic Characteristics**

| | Direct TAVR (n = 2,579) | Control (n = 3,205) | p Value |
|---|---|---|---|
| Male | 1,291 (50.1) | 1,553 (48.5) | 0.23 |
| Age, yrs | 83.1 ± 7.6 | 84.0 ± 6.6 | <0.01 |
| Body mass index, kg/m$^2$ | 26.4 ± 5.3 | 26.6 ± 5.3 | 0.20 |
| Logistic EuroSCORE | | | 0.12 |
| Mean | 17.2 ± 11.7 | 16.6 ± 11.3 | 0.05 |
| <10 | 726 (28.8) | 913 (29.4) | |
| 10–20 | 999 (39.6) | 1,294 (41.6) | |
| 20–40 | 687 (27.2) | 760 (24.4) | |
| >40 | 111 (4.4) | 143 (4.6) | |
| NYHA functional class III or IV | 1,616 (66.1) | 2,072 (68.0) | 0.13 |
| ≥APE within previous year | 350 (14.8) | 389 (12.8) | 0.03 |
| Clinical history | | | |
| Coronary artery disease | 988 (41.0) | 1,300 (42.8) | 0.18 |
| Previous MI <90 days | 50 (1.9) | 55 (1.7) | 0.53 |
| Previous CABG | 273 (10.6) | 317 (9.9) | 0.37 |
| Permanent pacemaker | 370 (14.4) | 414 (12.9) | 0.11 |
| Atrial fibrillation | 462 (22.1) | 705 (25.2) | 0.01 |
| Previous stroke/TIA | 277 (10.8) | 348 (10.9) | 0.88 |
| Diabetes mellitus | 683 (26.6) | 838 (26.3) | 0.80 |
| Peripheral vascular disease | 720 (28.1) | 605 (19.0) | <0.01 |
| Chronic pulmonary disease | 510 (19.8) | 540 (16.9) | 0.01 |
| Serum creatinine ≥200 μmol/l | 129 (5.2) | 142 (4.56) | 0.26 |
| Renal dialysis | 45 (1.8) | 45 (1.4) | 0.30 |
| Life expectancy <1 yr | 114 (4.6) | 82 (2.6) | <0.01 |
| Critical state preoperative | 208 (8.2) | 188 (5.9) | <0.01 |
| Ejection fraction | 54.4 ± 13.7 | 56.6 ± 13.2 | <0.01 |
| Aortic valve area | 0.72 ± 0.31 | 0.68 ± 0.19 | <0.01 |
| Aortic annulus | 24.0 ± 2.7 | 23.6 ± 2.7 | <0.01 |
| Aortic mean gradient | 45.6 ± 15.0 | 48.7 ± 15.6 | <0.01 |
| Moderate or severe AR | 354 (18.3) | 534 (20.7) | 0.04 |
| Moderate or severe MR | 448 (22.9) | 605 (22.8) | 0.92 |
| Severe PH (sPAP >60 mm Hg) | 212 (11.4) | 290 (12.24) | 0.65 |

Values are n (%) or mean ± SD.

APE = acute pulmonary edema; AR = aortic regurgitation; CABG = coronary artery bypass graft; MI = myocardial infarction; MR = mitral regurgitation; NYHA = New York Heart Association; PAP = pulmonary artery pressure; PH = pulmonary hypertension; TAVR = transcatheter aortic valve replacement; TIA = transient ischemic attack.

Cardiovascular Surgery. Device manufacturers partly funded the registry but had no role in data collection or analysis or in manuscript preparation.

Designed as an all-comers registry, it prospectively includes data on all patients who underwent TAVR for severe AS in 48 of 50 active TAVR centers in France and who volunteered to participate. The decision to perform TAVR and the choice of approach and device used were made on the basis of assessment by a multidisciplinary heart team at each participating center, as previously described (11). Procedures and post-procedural management were performed in accordance with each site's routine protocol. A 30-day follow-up was recommended in the case report form and was performed either on site or by telephone contact with the patient and the patient's physician depending on each site's protocol. Patients included in the registry provided written informed consent for the procedure and for anonymous processing of their data. The registry was approved by the Institutional Review Board of the French Ministry of Higher Education and Research and by the National Commission for Data Protection and Liberties. FRANCE TAVI is supported by the French Society of Cardiology. The FRANCE TAVI dataset was collected using a dedicated web-based interface from the French Society of Cardiology. All data, including in-hospital complications and follow-up, were site reported according to the definitions within the national dataset (11). The database was managed by the French Society of Cardiology, which implemented regular data quality checks, including range checks and assessments of internal consistency. In cases of missing, extreme, or inconsistent values, centers

**TABLE 2 Procedural and Echocardiographic Outcomes**

| | Direct TAVR (n = 2,579) | Control (n = 3,205) | p Value |
|---|---|---|---|
| General anesthesia | 968 (37.9) | 1,292 (40.9) | 0.02 |
| TEE guidance | 449 (20.5) | 644 (22.6) | 0.07 |
| Approach | | | <0.01 |
| Transfemoral | 2,139 (82.9) | 2,759 (86.1) | |
| Transapical | 111 (4.3) | 63 (1.97) | |
| Subclavian | 32 (1.24) | 110 (3.43) | |
| Others | 297 (11.5) | 273 (8.5) | |
| Valve type | | | 0.47 |
| Edwards Sapien | 1,788 (69.3) | 2,175 (67.9) | |
| Medtronic CoreValve | 779 (30.2) | 988 (30.8) | |
| Contrast load | 131.5 ± 61.6 | 141.6 ± 61.5 | <0.01 |
| Radiation (Kerma) | 608.9 ± 576.3 | 667.0 ± 631.3 | <0.01 |
| Fluoroscopy duration | 17.2 ± 9.1 | 18.5 ± 8.8 | <0.01 |
| Need for a second valve | 46 (1.8) | 41 (1.3) | 0.12 |
| Conversion to surgery | 11 (0.44) | 8 (0.25) | 0.24 |
| Device success | 2,495 (97.3) | 3,117 (97.6) | 0.40 |
| Aortic valve area | 1.78 ± 0.51 | 1.75 ± 0.53 | 0.29 |
| Aortic mean gradient | 10.2 ± 5.5 | 10.3 ± 5.9 | 0.34 |
| Moderate to severe AR | 175 (8.3) | 342 (12.2) | <0.01 |
| Moderate to severe MR | 303 (16.8) | 363 (15.2) | 0.16 |
| Ejection fraction | 56.0 ± 12.3 | 57.5 ± 11.9 | <0.01 |

Values are n (%) or mean ± SD.
TEE = transesophageal echocardiography; other abbreviations as in Table 1.

were contacted and asked to verify and modify records as appropriate.

**STUDY GROUP AND ENDPOINTS.** For the purposes of this analysis, all patients included from January 2, 2013, to December 31, 2015, in FRANCE TAVI database were screened. Detailed methodology and definitions used in this registry have been published elsewhere (3,11). Patients with missing data on valve type or approach (n =353) were excluded from the analysis. Following this step, patients without information regarding the pre-dilatation were excluded (n = 6,634). Then, we excluded patients with previous surgical aortic valve replacement (n = 386) (Figure 1). They represent a specific group with almost exclusive use of Medtronic CoreValve device (Santa Ana, California) and large majority of aortic regurgitation. We separated the patients into 2 cohorts according to pre-dilatation performed (Control) or no pre-dilatation (Direct TAVR).

The primary endpoint of the study was device success comparison between the 2 cohorts. Secondary endpoints were defined as procedural endpoints (fluoroscopic time, contrast load, radiation dose, need for a second valve, and conversion to surgery), and clinical endpoints (in-hospital complications of mortality, permanent pacemaker implantation, annular rupture, stroke, tamponade, acute renal failure). Pre-procedural and post-procedural echocardiographic parameters were also compared.

**STATISTICAL ANALYSIS.** Quantitative variables are expressed as mean ± SD or as median (interquartile range), and qualitative data as absolute values and percentages. Baseline clinical and echocardiographic characteristics of included patients were described for the 2 groups (Control vs. Direct TAVR) and compared. For quantitative variables, Student's *t*-tests were performed when valid, and Mann-Whitney *U* tests were performed otherwise. For qualitative variables, chi-square tests were performed when valid, and Fisher exact tests were performed otherwise.

Outcomes were compared between the 2 groups using the same statistical tests as described previously. Multivariate regression models were then built, to assess the independent association between BAV and each outcome with a forced adjustment for the following variables: age, EuroSCORE, baseline ejection fraction, heart failure, atrial fibrillation, peripheral vascular disease, chronic pulmonary disease, life expectancy <1 year, critical sate preoperative, moderate or severe aortic regurgitation at baseline, general anesthesia, and TAVR approach. No variable selection was performed on statistical criteria. Multivariate linear regression models were built for quantitative outcomes to estimate adjusted beta coefficients with their 95% confidence intervals. Multivariate logistic regression models were built for binary qualitative outcomes to estimate adjusted odds ratios with their 95% confidence intervals.

Statistical analysis was performed using R software version 3.4.1. All tests were 2-sided at the 0.05 significance level.

## RESULTS

Between January 2013 and December 31, 2015, a total of 5,784 patients have been included in our analysis, corresponding to 2,579 (44.6%) patients in Direct TAVR group and 3,205 (55.4%) patients in Control group (Figure 1). We did not have information regarding BAV in 6,634 patients and 386 had a TAVR following surgical aortic replacement.

We observed a progressive decline of the use of BAV over time, starting in 2013 with 78% of procedures to 49% in the last trimester of 2015 (Figure 2).

**BASELINE CLINICAL AND ECHOCARDIOGRAPHIC CHARACTERISTICS.** We observed significant differences between the 2 groups (Table 1). Patients with

Direct TAVR were younger (83.1 ± 7.6 vs. 84.0 ± 6.6) and frailer with higher rates of critical preoperative state before procedure (8.2% vs. 5.9%), chronic obstructive pulmonary disease (19.8% vs. 16.9%), and peripheral arterial disease (28.1% vs. 19.0%). Patients having a Direct TAVR had lower ejection fraction (54.4 ± 13.7 vs. 56.6 ± 13.2) and less severe AS with lower gradients (45.6 ± 15.0 vs. 48.7 ± 15.6) and higher area (0.72 ± 0.31 vs. 0.68 ± 0.19).

**PROCEDURAL CHARACTERISTICS.** No differences in valve type (Direct TAVR 69.3% Edwards [Irvine, California] Sapiens and 30.2% Medtronic CoreValve vs. Control 67.9% Edwards Sapiens and 30.8% Medtronic CoreValve) was observed between the 2 groups ($p = 0.55$). The transfemoral route was more often used in the Control group (86.1% vs. 82.9%).

Direct TAVR was associated with procedural simplification. Fluoroscopy time (17.2 ± 9.1 min vs. 18.5 ± 8.8 min), radiation dose (608.9 ± 576.3 vs. 667.0 ± 631.3), and contrast load (131.5 ± 61.6 vs. 141.6 ± 61.5) were lower in the Direct TAVR cohort (Table 2). Those results were maintained after adjustment ($p < 0.01$ for contrast load and fluoroscopic time; $p = 0.04$ for radiation dose).

**ECHOCARDIOGRAPHIC RESULTS.** After the TAVR, patients who underwent a Direct TAVR procedure had lower post-operative ejection fraction and similar aortic surface and mean gradient. However, the rate of aortic regurgitation >2 was significantly increased in case of pre-dilatation (8.3% vs. 12.2%; $p < 0.01$ after adjustment) (Table 2).

**PRIMARY ENDPOINT AND CLINICAL OUTCOMES.** The primary endpoint did not differ between the 2 groups (device success: 97.3% Direct TAVR vs. 97.6% Control; $p = 0.40$). Stroke, permanent pacemaker implantation, acute kidney injury, and annular rupture were not significantly different between the 2 groups. However, tamponade was more frequently noted in case of pre-dilatation (1.5% vs. 2.3%; $p = 0.04$) (Table 3). This association was not significant after multivariable adjustment ($p = 0.25$).

Results according to the type of valve (Edwards Sapiens and Medtronic CoreValve) are presented in Tables 4 and 5.

**TABLE 3 Clinical Outcomes**

| | Direct TAVR (n = 2,579) | Control (n = 3,205) | p Value | OR (95% CI)* | p Value* |
|---|---|---|---|---|---|
| In-hospital outcomes | | | | | |
| Time from hospital to discharge | | | 0.12 | | |
| Median | 7 (5–9) | 7 (5–10) | | | |
| 1–5 | 780 (30.1) | 903 (28.4) | | | |
| 6–9 | 115 (45.3) | 1,447 (45.5) | | | |
| ≥10 | 619 (24.2) | 831 (26.1) | | | |
| Complications | | | | | |
| Death | | | | | |
| All cause | 92 (3.6) | 101 (3.2) | 0.38 | 0.94 (0.62–1.43) | 0.76 |
| Cause of death | | | | | |
| CV death | 62 (67.4) | 70 (32.3) | | | |
| Non-CV death | 22 (23.9) | 27 (26.7) | | | |
| Unknown | 8 (8.7) | 4 (4.0) | | | |
| Annulus rupture | 9 (0.4) | 9 (0.3) | 0.64 | 1.59 (0.36–9.62) | 0.56 |
| Aortic dissection | 6 (0.2) | 10 (0.3) | 0.58 | 0.78 (0.20–3.07) | 0.71 |
| Valve migration | 29 (1.2) | 30 (0.95) | 0.46 | 0.68 (0.36–1.29) | 0.24 |
| Tamponade | 39 (1.5) | 73 (2.3) | 0.04 | 1.38 (0.80–2.36) | 0.25 |
| Stroke | 52 (2.1) | 58 (1.8) | 0.55 | 1.10 (0.67–1.84) | 0.70 |
| STEMI | 3 (0.1) | 3 (0.1) | 1.0 | 0.51 (0.08–2.55) | 0.40 |
| Permanent pacemaker implantation | 407 (18.9) | 483 (17.6) | 0.26 | 0.83 (0.69–1.01) | 0.06 |
| Pulmonary embolism | 1 (0.04) | 5 (0.2) | 0.24 | 3.54 (0.34–610.6) | 0.35 |
| Renal failure | 74 (2.9) | 118 (3.7) | 0.09 | 1.37 (0.92–2.06) | 0.12 |
| Renal dialysis | 8 (0.3) | 16 (0.5) | 0.27 | 2.61 (0.80–10.67) | 0.12 |

Values are n (%), unless otherwise indicated. *Multivariate regression models were then built to assess the independent association between balloon aortic valvuloplasty and each outcome, with a forced adjustment for the following variables: age, EuroSCORE, baseline ejection fraction, heart failure, atrial fibrillation, peripheral vascular disease, chronic pulmonary disease, life expectancy <1 year, critical state preoperative, moderate or severe aortic regurgitation at baseline, general anesthesia, and TAVR approach.

CI = confidence interval; CV = cardiovascular; OR = odds ratio; STEMI = ST-elevation myocardial infarction; TAVR = transcatheter aortic valve replacement.

## DISCUSSION

Our results show that BAV, as an initial step during TAVR, is nowadays performed in <50% of procedures in France and reserved for patients with more severe AS. Moreover, Direct TAVR is associated with procedural simplification and a similar success rate. This approach could lead to improved outcomes with lower aortic regurgitation >2 and tamponade rates.

**EVOLUTION OF TAVR PROCEDURE, SIMPLIFICATION, AND FEASIBILITY.** Increasing evidence demonstrates TAVR as an alternative to surgical aortic valve implantation in selected patients with symptomatic severe AS. This procedure benefited from continuous and multiple simplifications related to material development over the past 15 years.

The main purpose of BAV is to facilitate the AS crossing with the new valve by fracturing calcified nodules, separating fused commissures, stretching the aortic annulus, and reducing the radial counterforce. Therefore, device expansion should be facilitated. There are some additional aspects, including balloon sizing and exclusion of coronary artery obstruction, that can be assessed during the initial BAV. On the other hand, BAV has been associated with inherent risks, including thromboembolic complications, conduction disorders, annular rupture, acute severe aortic regurgitation, and transient

**TABLE 4 Procedural, Echocardiographic, and Clinical Outcomes in the Medtronic CoreValve Cohort**

| | Direct TAVR (n = 779) | Pre-Dilatation (n = 988) | p Value | OR* | p Value* |
|---|---|---|---|---|---|
| General anesthesia | 284 (37.1) | 466 (47.5) | <0.01 | | |
| TEE guidance | 90 (14.9) | 174 (20.7) | <0.01 | | |
| Approach | | | <0.01 | | |
| Transfemoral | 643 (82.5) | 791 (80.1) | | | |
| Transapical | 1 (0.1) | 0 | | | |
| Subclavian | 24 (3.1) | 102 (10.3) | | | |
| Others | 111 (14.3) | 95 (9.6) | | | |
| Contrast load | 154.0 ± 67.3 | 159.6 ± 61.5 | 0.09 | | 0.77 |
| Radiation (Kerma) | 670.0 ± 626.4 | 723.7 ± 627.0 | 0.13 | | 0.90 |
| Fluoroscopy duration | 20.5 ± 9.7 | 20.0 ± 9.2 | 0.32 | | 0.01 |
| Need for a second valve | 30 (3.9) | 26 (2.6) | 0.15 | 0.51 | 0.01 |
| Conversion to surgery | 1 (0.1) | 2 (0.20) | 0.99 | 1.20 | 0.85 |
| Device success | 742 (95.6) | 939 (95.3) | 0.77 | 1.35 | 0.99 |
| Aortic valve area | 1.89 ± 0.57 | 1.78 ± 0.61 | 0.04 | | 0.54 |
| Aortic mean gradient | 8.6 ± 6.2 | 8.4 ± 6.1 | 0.66 | | 0.23 |
| Moderate to severe AR | 99 (15.9) | 154 (17.9) | 0.31 | 1.00 | 0.99 |
| Moderate to severe MR | 96 (19.0) | 110 (15.7) | 0.13 | 0.85 | 0.99 |
| Ejection fraction | 56.6 ± 12.6 | 56.5 ± 12.1 | 0.86 | | 0.16 |
| In-hospital outcomes | | | | | |
| Complications | | | | | |
| Death | | | | | |
| All cause | 30 (3.9) | 43 (4.4) | 0.13 | 1.31 | 0.48 |
| Cause of death | | | | | |
| CV death | 21 (70.0) | 32 (74.4) | | | |
| Non-CV death | 7 (23.3) | 10 (23.3) | | | |
| Unknown | 2 (6.7) | 1 (2.3) | | | |
| Annulus rupture | 1 (0.1) | 0 | 0.44 | 0.60 | 0.82 |
| Aortic dissection | 4 (0.5) | 4 (0.4) | 0.74 | 0.16 | 0.13 |
| Valve migration | 16 (2.1) | 15 (1.5) | 0.39 | 0.55 | 0.16 |
| Tamponade | 10 (1.3) | 21 (2.2) | 0.18 | 1.06 | 0.99 |
| Stroke | 16 (2.1) | 23 (2.4) | 0.70 | 1.58 | 0.31 |
| STEMI | 2 (0.3) | 1 (0.1) | 0.59 | 0.48 | 0.46 |
| Permanent pacemaker implantation | 178 (28.1) | 238 (28.0) | 0.96 | 0.91 | 0.57 |
| Pulmonary embolism | 1 (0.1) | 2 (0.2) | 0.99 | 1.19 | 0.90 |
| Renal failure | 26 (3.4) | 35 (3.6) | 0.82 | 1.01 | 0.93 |
| Renal dialysis | 4 (0.5) | 3 (0.3) | 0.71 | 0.39 | 0.28 |

Values are n (%) or mean ± SD. *Multivariate regression models were then built to assess the independent association between balloon aortic valvuloplasty and each outcome, with a forced adjustment for the following variables: age, EuroSCORE, baseline ejection fraction, heart failure, atrial fibrillation, peripheral vascular disease, chronic pulmonary disease, life expectancy <1 year, critical state preoperative, moderate or severe aortic regurgitation at baseline, general anesthesia, and TAVR approach.

Abbreviations as in Tables 1, 2, and 3.

hemodynamic instability during the rapid pacing, which leads to increased risk of systemic inflammatory response syndrome and acute kidney injury (5-8,12). The feasibility of Direct TAVR without pre-dilatation has been suggested in small cohorts for the self-expanding Medtronic CoreValve prosthesis and for the balloon-expandable Edwards Sapiens XT valve for both transapical and transfemoral access routes (9,10,13-18). Our data confirm the fast adoption of Direct TAVR procedure in France, which has become the more common TAVR protocol in the latest 2015. Similar success rates are observed independently of anatomic selection. Remaining challenges are to determine which clinical and anatomic features would favor BAV as part of TAVR procedure.

**A WAY TO REDUCE COMPLICATIONS ASSOCIATED WITH TAVR.** Our cohort is the largest published so far and therefore evaluation of procedural complications is essential. Confirming previous data from small cohort, we showed that Direct TAVR is associated with lower contrast delivery with inherent benefit on kidney function. Moreover, avoiding BAV makes the procedure quicker and simpler, with lower fluoroscopy duration and radiation dose.

The rate of paravalvular regurgitation after device placement seems to be lower with avoidance of BAV. This has been already reported in small cohort and may be explained by a more accurate positioning of the valve in those cases, related to stability conferred by the calcifications in the absence of separated fused commissures (8,10,17,19). It is well known that aortic regurgitation, mostly paravalvular, is one of the relatively frequent complications after TAVR with adverse impacts on short- and long-term survival (20). Interestingly, in our analysis according to the type of valves (self-expanding vs. balloon expandable), we found that the device success rate was similar in the 2 groups while the lowering in aortic regurgitation was observed only with balloon-expanding valves. Therefore, the use of a balloon-expandable valve could be even more favorable for Direct TAVR.

Tamponade remains a complication of BAV, and we observed lower rates of its incidence with Direct TAVR protocol.

Embolic migration is an inherent complication of calcified aortic valve manipulations, and BAV has been correlated to higher risk of stroke. However, data in the literature are in favor of higher risk of subclinical strokes in cases of Direct TAVR versus TAVR including BAV. Bijuklic et al. (21) showed, in a study using diffusion-weighted magnetic resonance imaging post-TAVR, higher incidence of silent embolic events in case of Direct TAVR with balloon-expandable valves. Moreover, Pagnesi et al. (22) found higher rates of stroke in the non-pre-dilatation group with both valves type. Confirming the most recent meta-analysis, our data are reassuring and showed low stroke rates with no differences between both groups (23). Those conclusions were reported with both types of valves, despite remaining more pronounced on self-expanding prosthesis (9,13).

**STUDY LIMITATIONS.** One limitation of the current work is that outcomes associated with the decision to use BAV were studied in a retrospective fashion. Our design does not capture the reasons why or how each BAV was conducted. Importantly, the decision of whether or not to pre-dilate was made at the discretion of the TAVR team operator and may relate to the complexity of the valve anatomy and the operator's perception of successful valve delivery; therefore, it is possible that BAV was undertaken in more complex and challenging cases. This is of particular importance because a high correlation between the volume of calcification and the severity of paravalvular leaks has been previously demonstrated (24). It is probable that physician experience and device improvement (Edwards Sapiens 3 version replacing Edwards Sapiens XT has been launched in March 2015) may have played a cofounder role in aortic regurgitation reduction. However, those data were missing from reporting in our registry. Moreover, the trend regarding adoption of Direct TAVR in each separate center is not available.

A large proportion of patients did not have any details regarding pre-dilatation status and have been excluded. There is a concern that avoiding BAV will increase post-dilatation, which has inherent risk (valve migration, annular rupture, and cerebral embolism). However, those data were not available in our cohort and, therefore, it remains a limitation to our work. In Fiorina et al. (10) and Conradi et al. (17), Direct TAVR procedures were not associated with increased frequency of post-dilatation. Three ongoing studies (SIMPLIFY TAVI [Transcatheter Aortic Valve Implantation Without Pre-dilation] [NCT01539746], EASE-IT [Balloon Expandable Transcatheter Aortic Valve Implantation Without Predilation of the Aortic Valve] [NCT02127580], and DIRECTAVI [Implantation of the Transcatheter Aortic Prosthesis SAPIEN 3 With or Without Prior Balloon Predilation] [NCT02729519]) will provide more information.

**TABLE 5 Procedural, Echocardiographic, and Clinical Outcomes in the Edwards Sapiens Cohort**

| | Direct TAVR (n = 1,788) | Pre-Dilatation (n = 2,175) | p Value | OR* | p Value* |
|---|---|---|---|---|---|
| General anesthesia | 672 (37.8) | 812 (38.0) | 0.90 | | |
| TEE guidance | 359 (22.8) | 469 (23.7) | 0.53 | | |
| Approach | | | <0.01 | | |
| Transfemoral | 1,491 (83.4) | 1,926 (88.6) | | | |
| Transapical | 109 (6.10) | 63 (2.90) | | | |
| Subclavian | 8 (0.45) | 8 (0.37) | | | |
| Others | 180 (10.1) | 178 (8.2) | | | |
| Contrast load | 121.9 ± 56.6 | 133.2 ± 59.6 | <0.01 | | 0.01 |
| Radiation (Kerma) | 580.9 ± 551.1 | 636.2 ± 615.8 | 0.01 | | 0.03 |
| Fluoroscopy duration | 15.7 ± 8.3 | 17.7 ± 8.3 | <0.01 | | 0.01 |
| Need for a second valve | 16 (0.89) | 14 (0.64) | 0.12 | | 0.55 |
| Conversion to surgery | 10 (0.57) | 4 (0.19) | 0.05 | | 0.17 |
| Device success | 1,741 (98.0) | 2,140 (98.8) | 0.05 | 1.78 | 0.09 |
| Aortic valve area | 1.72 ± 0.46 | 1.74 ± 0.50 | 0.48 | | 0.11 |
| Aortic mean gradient | 10.8 ± 5.0 | 11.1 ± 5.6 | 0.10 | | 0.36 |
| Moderate to severe AR | 75 (5.1) | 184 (9.6) | 0.03 | 2.67 | 0.01 |
| Moderate to severe MR | 205 (15.9) | 249 (14.9) | 0.46 | 0.97 | 0.83 |
| Ejection fraction | 55.8 ± 12.2 | 57.9 ± 11.8 | <0.01 | | 0.06 |
| In-hospital outcomes | | | | | |
| Complications | | | | | |
| Death | | | | | |
| All cause | 62 (3.5) | 57 (2.6) | 0.12 | 0.71 | 0.20 |
| Cause of death | | | | | |
| CV death | 41 (66.1) | 37 (64.9) | | | |
| Non-CV death | 15 (24.2) | 17 (29.8) | | | |
| Unknown | 6 (9.7) | 3 (5.3) | | | |
| Annulus rupture | 8 (0.5) | 9 (0.4) | 0.86 | 1.66 | 0.52 |
| Aortic dissection | 2 (0.1) | 6 (0.3) | 0.31 | 1.17 | 0.86 |
| Valve migration | 13 (0.7) | 14 (0.7) | 0.74 | 0.77 | 0.60 |
| Tamponade | 28 (1.6) | 49 (2.3) | 0.13 | 1.38 | 0.33 |
| Stroke | 36 (2.1) | 33 (1.5) | 0.22 | 0.87 | 0.67 |
| STEMI | 1 (0.1) | 2 (0.1) | 0.99 | 0.82 | 0.86 |
| Permanent pacemaker implantation | 227 (15.0) | 236 (12.7) | 0.06 | 0.69 | 0.01 |
| Pulmonary embolism | 0 | 3 (0.1) | 0.26 | 2.21 | 0.54 |
| Renal failure | 45 (2.6) | 82 (3.8) | 0.03 | 1.60 | 0.06 |
| Renal dialysis | 4 (0.2) | 13 (0.6) | 0.77 | 14,397 | 0.01 |

Values are n (%) or mean ± SD. *Multivariate regression models were then built to assess the independent association between balloon aortic valvuloplasty and each outcome, with a forced adjustment for the following variables: age, EuroSCORE, baseline ejection fraction, heart failure, atrial fibrillation, peripheral vascular disease, chronic pulmonary disease, life expectancy <1 year, critical state preoperative, moderate or severe aortic regurgitation at baseline, general anesthesia, and TAVR approach.

Abbreviations as in Tables 1 to 3.

## CONCLUSIONS

A Direct TAVR procedure is commonly performed in France and proved to be safe. This procedure is associated with benefits in terms of procedural simplifications and may be associated with improved outcomes related to lower rates of residual aortic regurgitation and tamponade. Therefore, this strategy should be validated in a dedicated randomized trial.

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## PERSPECTIVES

**WHAT IS KNOWN?** A systematic step of aortic valve pre-dilatation before valve deployment has been mandatory during TAVR. BAV is supposed to facilitate the delivery system, help in sizing the device, and optimize valve implantation and expansion. However, BAV has been associated with hemodynamic disturbance, acute aortic regurgitation, renal failure, increased risk of stroke, and pacemaker implantation. Feasibility of TAVR procedure without systematic BAV has been described in the literature, for both self-expanding and balloon-expanding devices.

**WHAT IS NEW?** We confirmed in a large cohort that avoidance of BAV represents most TAVR procedures nowadays. This technique is associated with procedural simplification, including decreased fluoroscopy time, radiation dose, and contrast used. The success rate is similar than TAVR with BAV. We observed that Direct TAVR is associated with lower rates of post-procedural aortic regurgitation and tamponade.

**WHAT IS NEXT?** Those data should be confirmed in a large randomized trial evaluating Direct TAVR versus TAVR with BAV. A separate trial should be designed and performed for both types of valves (i.e., self-expanding vs. balloon expandables).

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**KEY WORDS** aortic regurgitation, balloon aortic valvuloplasty, transcatheter aortic valve replacement


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