

Transcatheter Aortic Valve Implantation: General Anesthesia using Transesophageal Echocardiography Does Not Decrease the Incidence of Paravalvular Leaks Compared to Sedation Alone

Abstract

Background: Transcatheter aortic valve implantation (TAVI) is a valid option for patients with severe aortic stenosis judged to be at high surgical risk. For this procedure, there is no agreement on the appropriate type of anesthesia. Sedation offers several advantages, but general anesthesia (GA) leads to less paravalvular leaks (PVLs) probably because of the transesophageal echocardiography (TEE) guidance. The objective was to compare the incidence of PVL among patients receiving conscious sedation (TAVI-S) and patients receiving GA (TAVI-GA). We made the hypothesis that a referral center does not necessitate TAVI-GA to reduce the incidence of moderate-to-severe PVL. **Aim:** The primary outcome was the incidence of moderate-to-severe PVL at 30 days after the implantation. **Design and Setting:** This study design was a retrospective observational trial in a university hospital. **Methods:** The TAVI-S group underwent the procedure under conscious sedation. In the TAVI-GA group, an endotracheal tube and a TEE probe were inserted. After the valve deployment, PVL was assessed by hemodynamic and fluoroscopic measurements in the TAVI-S group. TEE was also used in the TAVI-GA group to evaluate the presence of PVL. When PVL was moderate or severe according to the Valve Academic Research Consortium criteria. **Results:** TAVI-S and TAVI-GA were accomplished in 168 (67.5%) and 81 (32.5%) patients, respectively. Our results show no difference between the two groups regarding the incidence and grade of PVL. **Conclusion:** Performing TAVI under GA with TEE guidance is not associated with a lower incidence of moderate and severe PVL.

Keywords: *Conscious sedation, general anesthesia, paravalvular leaks, transcatheter aortic valve replacement, transesophageal echocardiography*

Introduction

The population is aging and concomitantly patients present an increasing number of comorbidities.^[1] For this frail population, the risk related to the surgical procedure might outweigh the benefit of the surgical intervention.^[2] This restriction applies in particular for aortic valve replacement.^[3] However, transcatheter aortic valve implantation (TAVI) has been proposed as a valid alternative to surgical aortic valve replacement for patients with severe aortic valve stenosis deemed to be at high surgical risk^[4] and more recently, at intermediate surgical risk.^[5,6] Although many trials have shown the efficacy of a TAVI over a surgical replacement for these patients, no agreement on the most suitable type of anesthesia has been advocated yet.^[4] Sedation for TAVI presents several advantages such as fewer episodes of significant hypotension, lower intraoperative

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vasoconstrictor use, faster turnover, central nervous system assessment to determine the occurrences of strokes, and finally, more rapid postoperative recovery.^[4,7] In contrast, general anesthesia (GA) has been advocated to be associated with significantly less paravalvular leaks (PVLs) compared to sedation.^[8] Such difference is probably related to the insertion of a transesophageal echocardiography probe (TEE) during GA that guides the correct valve deployment and detects PVL requiring postimplantation dilation.^[9] The presence of PVL is of paramount importance because it has been stated that PVL is associated with increased short- and long-term mortality post-TAVI.^[10] It should be underlined that PVL grading post-TAVI lacks harmonization across institutions^[11] although standardized end point definitions for TAVI have been suggested in that respect through the Valve

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Academic Research Consortium.^[12] To the best of our knowledge, only one recent study investigated the impact of PVL severity after TAVI on long-term mortality as the primary outcome using the Valve Academic Research Consortium (VARC)-2 criteria.^[13] This trial showed that increased long-term mortality was observed only in patients with moderate-to-severe PVL.^[14] In an effort to determine whether conscious sedation for TAVI without TEE guidance could be performed deprived of increased incidence of postimplantation PVL that could have an impact on long-term mortality, we conducted the present study. The objective of the current observational investigation was to compare the incidence of PVL using the VARC-2 criteria between patients receiving GA (TAVI-GA) with TEE guidance during the procedure and patients receiving local anesthesia infiltration plus sedation without TEE guidance (TAVI-S). We hypothesized that, in an experienced center, defined as a center that have performed more than 200 TAVI procedures for 3 consecutive years, TAVI-GA with TEE guidance is not associated with a lower incidence of moderate-to-severe PVL compared to TAVI-S alone.

Methods

Patients

This single-center retrospective observational trial conducted in the Department of Cardiac Anesthesia and Coronary Care Unit is an ancillary study. Data were collected prospectively for the French Aortic National CoreValve and Edwards 2 France TAVI registry, for which the Ethics Review Board allowed a waiver of the written informed consent because the investigation is under the provisions governing biomedical and routine care research. After approval for the present ancillary study from our institutional ethics committee (Comité de Protection des Personnes Sud-Ouest et Outre Mer III, Bordeaux, France/agreement number DC 2016/101) and agreement from the Commission Nationale de l'Informatique et des Libertés (registration number 912,449), we analyzed data from all patients with severe aortic stenosis scheduled to undergo a TAVI in Bordeaux University Hospital from January 2013 to December 2014. Patients included in the study were 18 years old or over were scheduled to undergo a valve change by transcatheter implantation and gave explicit consent for this procedure. We excluded patients undergoing a GA without TEE guidance and patients undergoing a TAVI under sedation with the insertion of a TEE.

Perioperative management-anesthesia and procedure

A detailed transthoracic echocardiography (TTE) and a multisliced computed tomography with iodine contrast media injection were performed in all patients before the procedure. Then, a heart team constituted of interventional cardiologists, cardiac surgeons, and cardiac anesthesiologists determined the valve type to implant, the access route,

and the type of anesthesia depending on patients' characteristics. Most cases were performed percutaneously through a transfemoral approach. The heart team opted for the transcarotid implantation when the femoral approach was impeded by the anatomy or the atherosclerotic vascular disease severity affecting the lower limbs. All procedures took place in a hybrid room. One hour before the intervention, anesthesiologists prescribed 0.1 mg/kg of oral midazolam. Before the procedure, cardiologists prescribed aspirin and clopidogrel. This combination of antithrombotic drugs was continued for 6 months after the implantation if no contraindication was found. Upon arrival in the hybrid operating room, patients were transferred to the operating table. Then, they were monitored with a 2-channel electrocardiogram, an arterial line, a pulse oximeter, and a bispectral index (BIS). Two IV lines were inserted in all patients. One was devoted for anesthetic drugs infusion only, while the other large bore one was dedicated to other drugs' administration and rapid fluid administration. The TAVI-S group received a facial mask for O₂ delivery. This group also received an injection of 30–40 cc of lidocaine 1% at the site of procedural sheaths insertion and propofol administration using a target-controlled infusion technique for conscious sedation with spontaneous breathing with BIS values maintained around 65. In contrast, the TAVI-GA received a total intravenous anesthesia-technique using target-controlled infusion models for both remifentanyl and propofol. Cisatracurium 0.15 mg/kg was administered to facilitate endotracheal intubation. After the intubation, lungs were ventilated at normocapnia with a 50% FiO₂. After induction, anesthetic drugs' infusion rates were changed if necessary to maintain BIS values within 40 and 60. A TEE probe was inserted immediately after intubation and connected to an ultrasound machine (Vivid9, GE Healthcare device, Chalfont St Giles, UK). The bioprostheses implanted were either the self-expandable CoreValve valve (Medtronic, Minneapolis, MN, USA) or the balloon-expandable Edwards Sapien XT heart valve system (Edwards Lifesciences, Irvine, CA). The procedure was performed by same set of physician. The details of the TAVI procedure have been thoroughly described previously.^[3] Valves were deployed under fluoroscopic guidance in the TAVI-S group and by fluoroscopy and TEE in the TAVI-GA group. In the TAVR-S group, PVL was graded through hemodynamic^[15] and fluoroscopic measures.^[11] In the TAVR-GA group, PVL was graded also using intraoperative TEE measurements accomplished by a certified echocardiographer (S. L.). A postdilation was performed when PVL was deemed moderate or severe.

Details concerning the echocardiographic assessment

TTE was systematically performed and analyzed by the same set of experts in echocardiography before TAVI, in coronary care unit right after the procedure, at 5 days and finally, at 30 days after the implantation. After the valve implantation, only TTE was used to assess PVL,

which were graded using the VARC-2 criteria described in Table 1.^[12] Patients were categorized into two groups according to the grade of PVL: none to mild and moderate to severe. Left ventricular ejection fraction was measured using the Simpson biplane methods. Mitral regurgitation was also assessed at baseline, at 5 days, and at 30 days after the implantation according to the recommendations of the American Society of Echocardiography.^[16]

Data collection and statistical analysis

Demographic, clinical, and echocardiographic patients' characteristics, procedural findings, postprocedure echocardiographic patients' characteristics, intra- and postprocedure complication related, as well as, endpoints data were prospectively collected for the France TAVI database and analyzed for the present ancillary trial. Clinical follow-up was carried out at 30 days in clinical visits and then through telephone contact at 12 months after the valve implantation. The primary outcome of the study was the incidence of moderate-to-severe PVL at 30 days after the procedure. The secondary outcomes were the incidence of moderate-to-severe PVL immediately after the procedure, and at 5 days, the all-cause mortality in-hospital, at 30 days and at 1 year after the procedure, as well as, the incidence of procedure-related complications such as conversion to open surgery, coronary obstruction, new permanent pacemaker, postprocedural myocardial infarction, tamponade, major stroke, major vascular access-site bleeding, life-threatening bleeding, postimplantation infection, acute kidney injury Stage 3, renal replacement therapy rate, and finally, the length of hospital stay. Patients lost to follow-up were not included in the analysis. Determination of the sample size was calculated to show a difference between the incidences of PVL having an impact on the long-term survival in an experienced center, and the one reported nationwide. According to the French registry, the national incidence of moderate-to-severe PVL that could have an impact on long-term survival is 17.1% at 30 days after

the implantation.^[17] The aim of our investigation was to detect a 75% proportion difference on the incidence of PVL between an experienced center and the incidence of moderate-to-severe PVL at 30 days after the implantation of the French TAVI registry. An alpha error of 0.05 and a power of 0.8 were chosen, resulting in a sample size of 50 patients for each group. Considering a potential loss to follow-up into account, at least sixty patients per group were planned. Data collected were analyzed using the Statistical Package for the Social Sciences (IBM, SPSS Statistics 20, Chicago, IL, USA). Results are presented as mean with standard deviation for continuous variables and as number and percentage (%) for categorical data. Comparisons of continuous variables were performed using the Student's *t*-test. Comparisons for categorical data were performed using the Fisher's exact test. *P* = 0.05 was considered statistically significant. To reduce the impact of anesthesia procedure-selection bias on study outcomes, a propensity score approach was performed for the procedural findings and the postprocedural findings of interest using a logistic statistical model including the baseline covariates found to be significantly different between the two groups. Study end points of interest were then analyzed using an ANCOVA (for continuous endpoints) or a regression (for categorical endpoints) model adjusting for propensity score as a continuous covariate.

Results

From the January 1, 2013, to December 31, 2014, 268 patients were scheduled to undergo a TAVI in Bordeaux University Hospital. Fifteen patients were excluded from the analysis in the TAVI-GA group because no TEE probe was inserted. Two patients were excluded in the TAVI-S group because they had a TEE probe inserted during the procedure to rule out the presence of a cardiac tamponade. Finally, 234 patients were included for final analysis. Of those, 168 were implanted under sedation and 66 under GA. The flowchart of the investigation is depicted in Figure 1. Twenty-two patients did not show up for the clinical visit at 30 days, and 12 patients were lost to follow-up at 1 year. Patients' preoperative characteristics are presented in Table 2. Both groups were similar, except for histories of diabetes mellitus, peripheral vascular disease, previous mitral valve surgery, and concomitant significant coronary artery disease, which were more frequent in the TAVI-GA group. Procedural findings are shown in Table 3. No significant differences were found between the two groups except for the duration of fluoroscopy, and the absolute quantity of contrast-medium injected. However, when the latter was indexed to the body surface area, both groups were similar.

When adjusted with a propensity score the intraoperative variables found to be significantly different the results were analogous [Table 3]. The number of valve malpositioning implantations was higher in the TAVI-S

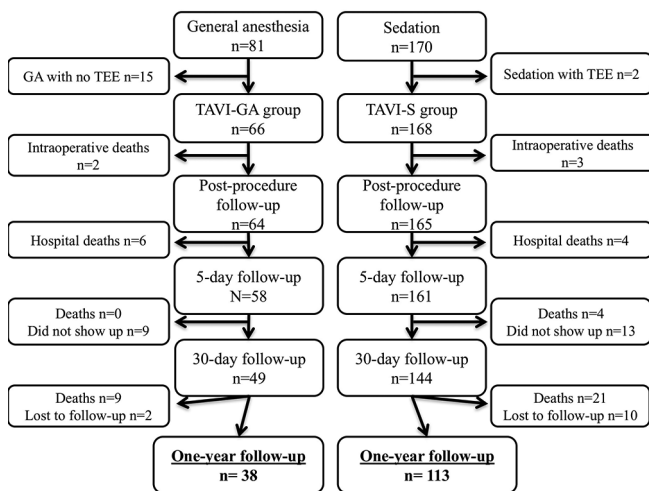


Figure 1: Flowchart of the trial

Table 1: Valve Academic Research Consortium-2 criteria for prosthetic aortic valve regurgitation

Classification of the regurgitation severity	Mild	Moderate	Severe
Semi-quantitative parameters			
Diastolic flow reversal in the descending aorta with pulsed wave Doppler	Absent or brief early diastolic	Intermediate	Prominent, holodiastolic
Circumferential extent of prosthetic valve PVL (%)	<10	10-29	≥30%
Quantitative parameters			
Regurgitant volume (mL/beat)	< 30	30-59	≥60
Regurgitant fraction (%)	<30	30-49	≥50%
EROA (cm ²)	0.10	0.10-0.29	≥0.30
EROA: Effective regurgitant orifice area			

group, but no significant difference was found between the two groups. All the ectopic valves implanted were self-expandable ($P = 0.008$). The procedure success rates according to the VARC 2 criteria were similar and superior to 90% in both groups.

Clinical outcomes

In a center of reference, the incidence of moderate-to-severe PVL after the implantation is rare. At 30 days after the implantation, no moderate-to-severe PVL was detected [Table 4]. No differences regarding the incidence of moderate-to-severe PVL were observed after the procedure and at 5 days after the implantation between TAVI-GA and TAVI-S [Table 4]. The baseline covariates found to be significantly different between the two groups that were inserted in the statistical model were diabetes, concomitant significant coronary artery disease, and PVD. When adjusted with a propensity score, the incidence of moderate-to-severe PVL at 5 days was not different either ($P = 0.528$; 95% Wald confidence limits [0.06–4.06]). The others echocardiographic outcome data of interest are presented in Table 4. Five patients (2.1%) died during the procedure. Two of them were in TAVI-GA group while three of them were from TAVI-S group ($P = 0.623$). Ten patients died during the hospital stay after the implantation: 6 in the TAVR-GA group (3 because of cardiogenic shocks leading to multiple organ failures, 2 because of cardiorespiratory arrests, and 1 because of a respiratory failure). In contrast, four patients died in the TAVR-S group (two patients died because of a septic shock, one patient because of a cardiorespiratory arrest, and one patient died after a stroke). Hence, the hospital mortality rate was higher in the TAVI-GA group compared to the TAVR-S group (12.5% vs. 4.2%, $P = 0.036$). Such statistical difference did not persist neither at 30 days after the procedure (12.5% vs. 6.7%, $P = 0.183$) nor at 1 year (26.6% vs. 19.4%, $P = 0.372$). The type and rate of procedure-related complications are presented in Table 5. Only postimplantation life-threatening bleedings occurred significantly more often in the TAVI-GA group ($P = 0.021$). The mean length of hospital stay was 13.4 ± 7.7 days with no significant difference between the two groups ($P = 0.385$).

Discussion

The main findings of this retrospective observational investigation demonstrated that, in an experienced center, the incidence of moderate-to-severe PVL right after the implantation and at 30 days is exceptional. In addition, our findings showed that the implantation under conscious sedation without TEE does not increase the incidence of PVL associated with long-term mortality compared to GA with TEE guidance for the correct valve deployment and to detect PVL requiring postimplantation dilation. The type of anesthesia for patients scheduled to undergo a TAVI might be of concern to anesthesiologists performing conscious sedation without TEE guidance since this anesthesia technique has been associated with an increased incidence of PVL according to the last French TAVI registry including 2326 patients^[8] and to a recent literature review including 5919 patients.^[18] The legitimacy of this concern is justified because lowering the incidence of PVL is crucial. The latter is associated with increased short- and long-term mortality post-TAVI.^[11] Initially, a reanalysis of the PARTNER trial data has shown that mild-to-severe PVL could increase short- and long-term mortality.^[10] However, the PARTNER trial did not use the VARC-2 criteria to assess PVL. The rate of PVL and its impact on mortality change significantly from one study to another.^[11] This is probably secondary to a lack of harmonization to grade PVL after TAVI^[11] although clear criteria have been proposed in that respect.^[12] Jerez-Valero *et al.*^[14] were the first to conduct a trial to determine the effect of PVL on outcomes using the VARC-2 criteria. They enrolled 1735 patients and showed that long-term mortality was significantly more frequent in patients with moderate-to-severe PVL. Based on our results, anesthesiologists performing TAVI under conscious sedation without TEE guidance in an experienced center should not be alarmed since this anesthesia technique does not lead to higher rate of moderate-to-severe PVL neither immediately after the procedure nor 30 days after the procedure. Our investigation also shows a decrease in the rate of moderate-to-severe PVL over time. This trend is well described in the literature and seems to be endorsed by the remodeling of the aortic root and caused by to the death of the patients with the most

Table 2: Pre-implantation patients' characteristics

Patients' characteristics	Total (n=234)	TAVI-GA (n=66)	TAVI-S (n=168)	P
Clinical characteristics				
Age (years)	81.3±8.2	80.2±7.5	81.8±8.4	0.177
Female (%)	118 (50.4)	32 (48.5)	86 (51.2)	0.772
Body Mass Index (kg.m ⁻²)	26.8±5.8	26.0±5.8	27.1±5.8	0.184
NYHA functional status (%)				
I/II	98 (41.9)	27 (40.9)	71 (42.8)	0.119
III	123 (52.6)	38 (57.6)	85 (51.2)	
IV	11 (4.7)	1 (1.5)	10 (6.0)	
COPD (%)	72 (30.8)	22 (33.3)	50 (29.8)	0.638
Diabetes (%)	56 (23.9)	22 (33.3)	34 (20.2)	0.042
PVD (%)	67 (28.6)	37 (56.1)	30 (17.9)	<0.001
Chronic atrial fibrillation (%)	81 (34.6)	24 (36.4)	57 (33.9)	0.761
Concomitant significant coronary artery disease (%)				
None	127 (54.3)	26 (39.4)	101 (60.1)	<0.020
One territory	51 (22.2)	16 (24.2)	35 (20.8)	
Two territories	40 (17.1)	16 (24.2)	24 (14.3)	
Three territories	11 (4.7)	5 (7.6)	6 (3.6)	
Four territories	5 (2.1)	3 (4.5)	2 (1.2)	
MI occurring within 90 days before the implantation (%)	9 (3.9)	4 (6.1)	5 (3.0)	0.275
History of PCI (%)	97 (41.5)	31 (47.0)	66 (39.3)	0.304
History of CABG (%)	39 (16.7)	10 (15.2)	29 (17.3)	0.846
History of MVSx (%)	5 (2.1)	4 (6.1)	1 (0.6)	0.023
History of AVSx (%)	21 (9.0)	7 (10.6)	14 (8.3)	0.614
Stroke (%)	18 (7.7)	4 (6.1)	14 (8.3)	0.786
Creatinine (mg.dL ⁻¹)	113.2±86.6	112.0±65.8	113.7±93.6	0.891
eGFR (ml.min ⁻¹)	50.8±21.8	50.2±25.7	51.0±27.3	0.848
Chronic renal failure (%)	184 (78.6)	51 (77.3)	133 (79.2)	0.727
Pacemaker (%)	48 (20.4)	12 (18.2)	36 (21.4)	0.719
Logistic EuroSCORE 1 (%)	22.6±12.3	25.0±11.8	21.6±12.5	0.065
Logistic EuroSCORE 2 (%)	7.2±5.3	8.1±5.4	6.8±5.2	0.085
STS-PROM Score (%)	7.6±3.7	7.8±3.4	7.5±3.8	0.519
Echocardiographic characteristics				
LVEF (%)	52.2±13.9	52.0±14.8	52.3±13.5	0.882
Aortic mean gradient (mmHg)	44.7±17.0	44.1±17.5	44.9±16.8	0.743
Indexed aortic valve area (cm ² .m ⁻²)	0.7±0.4	0.8±0.4	0.7±0.4	0.506
Aortic regurgitation, n (%)				
None	114 (48.7)	33 (50.0)	81 (48.2)	0.109
Trace	88 (37.6)	20 (30.3)	68 (40.5)	
Mild	20 (8.6)	9 (13.6)	11 (6.5)	
Moderate	8 (3.4)	4 (6.1)	4 (2.4)	
Severe	4 (1.7)	0 (0.0)	4 (2.4)	
Mitral regurgitation, n (%)				
None	48 (20.7)	10 (15.2)	38 (22.9)	0.260
Trace	117 (50.4)	37 (56.1)	80 (48.2)	
Mild	58 (25.0)	16 (24.2)	42 (25.3)	
Moderate	8 (3.5)	3 (4.5)	5 (3.0)	
Severe	1 (0.4)	0 (0.0)	1 (0.6)	
Systolic pulmonary artery pressure >60 mmHg, n (%)	30 (12.8)	13 (19.7)	31 (18.5)	0.133

Data are expressed as mean (standard deviation) for quantitative variables and as number (percentages) for categorical variables. The *P* refers to comparison between groups. TAVI-AG: TAVI under general anesthesia; TAVI-S: TAVI under conscious sedation; NYHA: New York Heart Association functional status; COPD: chronic obstructive pulmonary disease; PVD: perivascular disease; LVEF: left ventricular ejection fraction; MI: myocardial infarction; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; MVSx: mitral valve surgery; AVSx: aortic valve surgery; eGFR: estimated glomerular filtration ratio; EuroSCORE: European System for Cardiac Operative Risk Evaluation; STS: Society of Thoracic Surgeons predicted risk of mortality; LVEF: left ventricular ejection fraction

Table 3: Procedural findings

Procedural data	Total (n=234)	TAVI-GA (n=66)	TAVI-S (n=168)	P	P adjusted*	95% confidence interval
Approach, n (%)						
Transfemoral	184 (78.6)	18 (27.3)	166 (98.8)	<0.001		
Transcarotid	23 (9.8)	23 (34.9)	0 (0.0)	<0.001		
Subclavian	6 (2.6)	6 (9.1)	0 (0.0)	<0.001		
Transaortic	16 (6.8)	14 (21.2)	2 (1.2)	<0.001		
Transapical	5 (2.1)	5 (7.6)	0 (0.0)	0.002		
Number of patients who received a pre-dilation, n (%)	205 (87.6)	55 (83.3)	150 (89.3)	0.269		
Number of patients who received a post-dilation	34 (14.5)	6 (9.1)	28 (16.7)	0.155		
Success of the procedure**, n (%)	219 (93.6)	61 (92.4)	158 (95.2)	0.767		
Two valves implanted, n (%)	9 (3.8)	2 (3.0)	7 (4.2)	1		
Type of valve implanted, n (%)						
Self-expandable	121 (51.7)	37 (56.1)	84 (50.0)	0.56		
Balloon-expandable	109 (46.6)	29 (43.9)	80 (47.6)			
Valve malpositioning**, n (%)	8 (3.4)	1 (1.5)	7 (4.2)	0.447	0.475	(0.2, 20.4) [†]
Amount of contrast-medium injected (ml)	136.2±64.5	113.8±59.3	143.0±64.6	0.006	0.004	(-53.9, -10.3) [‡]
Contrast-medium adjusted to BMI (ml/kg ¹ /m ²)	90.4±85.6	80.5±84.4	93.4±86.0	0.372	0.367	(-43.9, 16.3) [‡]
Length of fluoroscopy (min)	24.7±11.1	20.5±11.8	26.0±10.6	0.002	0.022	(-8.1, -0.6) [‡]

Data are expressed as mean (standard deviation) for quantitative variables and as number (percentages) for categorical variables. The P refers to comparison between groups. TAVI-AG: TAVI under general anesthesia; TAVI-S: TAVI under conscious sedation; Asterisks definition: *the P value refers to comparison between groups adjusted with a propensity score as a continuous covariate; **procedural assessment based on the VARC-2 classification; [†]95% Wald confidence limits; [‡]95% Confidence limits of the difference

severe PVL.^[11] Hospital mortality rate was greater in the TAVI-GA group. Patients of this group presented more comorbidities (diabetes, peripheral vascular disease, mitral valve repair, and coronary artery disease) compared to TAVI-S group. This difference could explain the higher hospital mortality rate in the TAVI-GA group. In this group, most of the deaths had a cardiovascular etiology, whereas, in the TAVI-S group, hospital deaths had mainly an extracardiac origin (stroke and sepsis). In contrast, the mortality rate at 30 days and at 1 year were similar between the two groups. These results are in line with a recent literature review aiming to compare the safety between locoregional anesthesia with sedation and GA for TAVI procedure.^[19] The differences between the two groups regarding medical history might explain the significantly higher rate of life-threatening bleedings in the TAVI-GA group along with the technically more difficult procedural approach (less transfemoral approach but more transcarotid, subclavian, transaortic, and transapical approach). Interestingly, the TAVI-GA group had a significantly lower length of fluoroscopy and volume of contrast-medium injected. These differences were significant even after propensity-matched comparison. Such differences could be explained by the TEE guidance during the valve deployment in the TAVI-GA group. Lowering the volume of contrast-medium injected could be of particular interest to reduce the incidence of acute kidney injury, especially in patients with chronic kidney disease. However, contrast-induced nephropathy after TAVI is controversial and it is still not known whether this nephropathy is associative or causative.^[20] Our results did not reveal

disparities in the incidence of acute kidney injury Stage 3 and requirement for renal replacement therapy between the two groups. Thus, considering that the implantation under sedation is associated with a faster procedure time, a shorter length of critical care unit stay, and a lower requirement of vasoconstrictor drugs,^[19] it could be claimed that the procedure under sedation is preferable compared to GA with TEE guidance. On the other hand, Maas *et al.*^[18] literature review reports that locoregional anesthesia with or without sedation is associated with an increased risk of new permanent pacemaker implantation with a risk ratio of 1.23. Dissimilarly, we did not find a significant difference in that respect. Such difference could be explained by the fact that their review included trials with centers starting to perform TAVI under sedation, which were not used to patients not being completely immobile. These conditions could have augmented the rate of inadvertent device implantation too low in the outflow tract, which could compress the conduction tissue causing atrioventricular blocks.^[21] Another important discrepancy of our investigation compared to Maas *et al.* meta-analysis is that we did not find a difference in the length of stay between the two study groups.^[18] It could be advocated that, during the transition period from GA to sedation, no practice changes occurred in discharge planning in our institution. This circumstance might have affected the time of discharge from hospital although the eligibility to be discharged may have been reached earlier in the sedation group.

There are several limitations to the present study. First, the power of the sample size was not calculated to make

Table 4: Echocardiographic outcome data

Transthoracic echocardiographic assessment	Total	TAVI-GA	TAVI-S	P
At the end of the procedure (n=229)	n=229	n=64	n=165	
PVL, n (%)				
None to mild	222 (97.0)	62 (96.9)	160 (97.0)	1.000
Moderate to severe	7 (3.0)	2 (3.1)	5 (3.0)	
At 5-day (n=221)	n=221	n=60	n=161	
PVL, n (%)				
None to mild	216 (97.7)	58 (96.7)	158 (98.1)	0.615
Moderate to severe	5 (2.3)	2 (3.3)	3 (1.9)	
Aortic mean gradient (mmHg)	8.7±5.0	8.7±4.0	8.7±5.3	0.936
Indexed aortic valve area (cm ² .m ²)	1.7±0.6	1.8±0.7	1.7±0.5	0.245
LVEF (%)	53.9±12.9	53.0±12.9	54.3±12.9	0.515
Mitral regurgitation, n (%)				
None	59 (26.7)	15 (25.0)	44 (27.3)	0.579
Mild	109 (49.3)	31 (51.7)	78 (48.5)	
Moderate	41 (18.6)	12 (20.0)	29 (18.0)	
Severe	12 (5.4)	2 (3.3)	10 (6.2)	
Systolic pulmonary hypertension non measurable (%)	17 (7.7)	6 (10.1)	11 (6.8)	0.409
Systolic pulmonary hypertension (%)	58 (28.4)	15 (27.8)	43 (28.7)	0.978
None (<31 mmHg)	135 (66.2)	36 (66.7)	99 (66.0)	
Moderate (31-60 mmHg)	11 (5.4)	3 (5.6)	8 (5.3)	
Severe (> 60 mmHg)				
At 30-day (n=193)	n=193	n=49	n=144	
PVL, n (%)				
None to mild	193 (100.0)	49 (100.0)	144 (100.0)	1.000
Moderate to severe	0 (0.0)	0 (0.0)	0 (0.0)	
Aortic mean gradient (mmHg)	7.6±4.4	8.1±5.1	7.5±4.1	
Indexed aortic valve area (cm ² .m ²)	1.8±0.5	1.8±0.6	1.8±0.5	0.370
LVEF (%)	55.4±11.8	54.1±12.5	55.8±11.6	0.816
Mitral regurgitation, n (%)				0.391
None	35 (18.2)	9 (18.4)	26 (18.2)	
Mild	115 (59.9)	32 (65.3)	83 (58.0)	
Moderate	35 (18.2)	7 (14.3)	28 (19.6)	0.327
Severe	7 (3.7)	1 (2.0)	6 (4.2)	
Systolic pulmonary hypertension non measurable, n (%)	14 (7.3)	5 (10.2)	9 (6.3)	0.351
Systolic pulmonary hypertension, n (%)				
None (<31 mmHg)	61 (34.1)	16 (36.3)	45 (33.3)	0.565
Mild (31-60 mmHg)	108 (60.3)	25 (56.8)	83 (61.5)	
Severe (> 60 mmHg)	10 (5.6)	3 (6.8)	7 (5.2)	

Data are expressed as mean (standard deviation) for quantitative variables and as number (percentages) for categorical variables. The P refers to comparison between groups. TAVI-AG: TAVI under general anesthesia; TAVI-S: TAVI under conscious sedation; PVL: Paravalvular leak; LVEF: left ventricular ejection fraction

a comparison between TAVI-GA and TAVI-S. However, the results provide clinical hints of important value for the anesthesiologist. Second, the trial was not randomized leading to an imbalance between groups in terms of patients' medical history creating a potential selection bias. However, the differences in comorbidities could not influence the incidence of PVL, and a propensity-matched comparison was performed for the intraoperative parameters found to be significantly different. Another limitation of our study was the missing echocardiographic data in 10.2% of the patients alive at 30-day follow-up. Finally, the effect over time of PVL on left ventricular ejection function could

have been misjudged since no TTE data were collected after the 30-day follow-up.

Conclusion

Our study demonstrates that, in a center of reference that masters the TAVI procedure, the rate of PVL is very low compared to the overall incidence reported in the literature. GA with TEE guidance is not associated with a lower rate of moderate-to-severe PVL compared to local anesthesia plus sedation alone. An experienced center that is proficient in hemodynamic and fluoroscopic assessment does not need a GA with TEE guidance for the correct valve deployment

Table 5: Procedure related complications and all-cause mortality rate

Procedure related complications	Total (n=229)	TAVI-GA (n=64)	TAVI-S (n=165)	P
Conversion to open surgery, n (%)	4 (1.7)	3 (4.7)	1 (0.6)	0.067
Unplanned use of CPB, n (%)	1 (0.4)	1 (1.6)	0 (0)	0.279
Coronary obstruction, n (%)	0 (0)	0 (0)	0 (0)	1.000
New permanent pacemaker, n (%)	37 (16.1)	13 (20.3)	24 (14.5)	0.319
Tamponade, n (%)	5 (2.2)	3 (4.7)	2 (1.2)	0.135
Major stroke, n (%)	6 (2.6)	1 (1.6)	5 (3.3)	1.000
Myocardial infarction, n (%)	2 (0.9)	2 (3.1)	0 (0)	0.077
Major vascular access-site bleeding, n (%)	21 (9.2)	3 (4.7)	18 (10.9)	0.202
Life-threatening bleedings, n (%)	3 (1.3)	3 (4.7)	0 (0)	0.021
Post-implantation infection, n (%)	22 (9.6)	6 (9.4)	16 (9.7)	1.000
Acute kidney injury stage 3, n (%)	9 (3.9)	3 (4.7)	6 (3.6)	0.712
Renal replacement therapy, n (%)	3 (1.3)	1 (1.6)	2 (1.2)	1.000

Data are expressed as number (percentages). The *P* refers to comparison between groups. TAVI-AG: TAVI under general anesthesia; TAVI-S: TAVI under conscious sedation; PVL: Paravalvular leak; LVEF: left ventricular ejection fraction; CPB: cardiopulmonary bypass

and to deem the necessity for postimplantation dilation. Thus, when these conditions are met anesthesiologists could perform a TAVI procedure under local anesthesia plus sedation without increasing the incidence of PVL known to be associated with greater short- and long-term mortality.

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Conflicts of interest

There are no conflicts of interest.

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