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Original Article

Impact of the Transcatheter Era on Outcomes of Surgical Aortic Valve Replacement with Biological Prostheses: A Temporal Cohort Study

Ahmed Benali[1]*, Karim Boudiaf[2], Samir Touati[1]

[1]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Algiers, Algiers, Algeria.
[2]Department of Clinical Oral Surgery, Faculty of Dental Medicine, University of Tunis El Manar, Tunis, Tunisia.

***E-mail** ✉ ahmed.benali@gmail.com

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ABSTRACT

For patients requiring treatment, surgical aortic valve replacement (SAVR) was the sole intervention capable of both relieving symptoms and extending life, until transcatheter aortic valve implantation (TAVI) emerged. Elderly and high-risk individuals were the initial target population for this newer option. Drawing on a sequential cohort of 2500 patients undergoing SAVR with a biologic heart valve (BHV) prosthesis, a comparison was undertaken of age, comorbid burden, procedural complexity, postoperative course, resource demands, and extended survival in eras both predating and following the availability of TAVI. The Carpentier-Edwards valve was the most commonly selected implant, though several additional BHV varieties were also evaluated for outcomes. Individuals receiving SAVR in isolation (i-SAVR) were evaluated separately from those receiving SAVR with another intervention (c-SAVR). The volume of patient referrals climbed steadily until 2016, a point after which TAVI reimbursement criteria were relaxed. Advancing age, a history of percutaneous coronary intervention, diabetes, and chronic kidney disease became increasingly prevalent across both groups over time; meanwhile, atrial fibrillation, urgent SAVR requirements, and various other comorbidities saw a significant rise exclusively in the c-SAVR group. Over the study period, both cohorts experienced greater frequencies of postoperative acute kidney injury, conduction disturbances, and hemorrhagic complications. Although the demand for renal replacement therapy escalated in both surgical populations, the increase was more striking in c-SAVR; a growing requirement for pacemaker insertion ($P < 0.001$), transfusion products, and reoperation was confined to the c-SAVR cohort. Thirty-day mortality displayed a modest, statistically nonsignificant upward trend over time in both groups. Furthermore, the arrival of TAVI did not modify the trajectory of long-term survival in either cohort. The Carpentier-Edwards Perimount prosthesis demonstrated robust durability over extended follow-up. The Perceval device, selected for more elderly patients, delivered favorable hemodynamic performance but was linked to a substantial rate of postoperative permanent pacemaker dependency. Collectively, the data appear to indicate that expanding TAVI reimbursement beyond the initial 2008 launch was justified. Still, as innovative SAVR technologies continue to emerge, the surgical approach will remain a cornerstone therapy for aortic valve disease.

Keywords: Surgical aortic valve replacement, Transcatheter aortic valve implantation, Concomitant procedures, Era, Postoperative complication rate, Mortality

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Introduction

Calcified aortic valve disease (CAVD), a disorder marked by progressive degeneration, predominantly manifests in older adults. Echocardiographic surveillance has captured a yearly rise of 0.49% in its incidence [1]. The condition's worsening trajectory proves particularly steep for those already carrying a severe diagnosis. A dire prognosis accompanies the

development of symptoms, most notably congestive heart failure (CHF), should no intervention be pursued [2]. The stepwise advancement of pathology—encroaching upon the left ventricle, the left atrium, the pulmonary vasculature, and eventually the right ventricle—further diminishes the outlook [3]. This pattern was evident during the first 12 months after surgical aortic valve replacement (SAVR) [4]. Similar findings emerged from the 5-year survival data among individuals with moderate aortic stenosis: after controlling for age, sex, and impaired left ventricular performance, both overall and cardiovascular mortality figures were markedly elevated [5]. Reversal of cardiac damage after SAVR was achievable in only a fraction of those treated [6]. In the era before transcatheter aortic valve implantation (TAVI) became available, SAVR constituted the exclusive therapy offering both prolonged survival and symptomatic relief for CAVD, applicable even to older patients carrying multiple comorbidities. Favorable outcomes achieved with the Carpentier-Edwards Perimount valve have been documented in our prior publications [7]. Iterative refinement transformed the Carpentier-Edwards device into the Magna and subsequently the Magna Ease (CEME) models. This evolution mirrors the progression seen with the Sapien balloon-expandable transcatheter platform, which advanced from the original device to the Sapien XT and, later, the Sapien 3 iterations. A unifying design goal across both lineages was to minimize the prosthesis profile to safeguard coronary ostial patency. One investigation, stratifying SAVR and TAVI recipients into septuagenarian and octogenarian subsets, applied the CEME prosthesis uniformly across the surgical arm and the successive Sapien models for the transcatheter arm. While the studied population closely resembled the present cohort concerning age, both coronary artery disease and concomitant CABG or any supplementary procedure were absent [8]. A recent publication highlighted that octogenarian patients surviving to hospital discharge could attain a 5-year survival exceeding 60% [9], lending further support to our longstanding perspective that chronological age, by itself, fails to serve as the principal driver of postoperative death [8]. Our earlier research also documented a rise in both age and comorbidity levels among referred patients between 1987 and 2007 [10], leading to the clinical introduction of TAVI, which launched in the Antwerp region of Belgium in 2008. The core motivation behind TAVI lies in reducing postprocedural adverse events and death, thereby furnishing an alternative pathway for individuals deemed to carry a heightened surgical risk [11]. One might reasonably predict that robust TAVI uptake would divert older, high-risk candidates away from SAVR, yielding observable gains in both short-term and long-term surgical outcomes. However, a contemporary Western report estimated that comorbid status prevented 30 to 40% of patients with an indication for SAVR from receiving any form of valve intervention [12]. Additionally, Belgian reimbursement standards for TAVI remained restrictive for several years after its introduction [13]. In light of this regulatory context, the following investigative questions concerning the introduction of TAVI as a parallel strategy to SAVR merit examination:

(1) How did the referral characteristics shift over time for isolated SAVR (i-SAVR) versus SAVR coupled with concomitant procedures (c-SAVR)?

(2) Over the study interval, how did the procedural complexity of c-SAVR evolve?

(3) What early and extended outcomes were observed with each of the two surgical approaches?

(4) Do the clinical results differ among the different BHV prosthesis designs used in this population?

Materials and Methods

This study is a retrospective review of clinical files covering a consecutive series of 2500 individuals who received a biological heart valve (BHV) prosthesis during SAVR at a general hospital, spanning the period from 1 January 1987 to 6 July 2017. Cardiologists referred patients based on the severity of symptoms and the echocardiographic or catheter-based extent of valve pathology. The overall cohort was split into two subsets: those whose surgery consisted exclusively of SAVR (i-SAVR, n = 867) and those whose SAVR was accompanied by at least one adjunctive intervention—for instance, CABG, mitral valve reconstruction, ascending aortic surgery, or a maze procedure (c-SAVR, n = 1613). Prostheses placed in any other valve position, as well as mechanical valves regardless of location, were not included. Left ventricular (LV) performance was evaluated by either echocardiographic imaging or contrast ventriculography. Electrocardiography served to document the presence of atrial fibrillation or any form of conduction disturbance. Biochemical marker evidence or ECG tracings confirmed a history of myocardial infarction. Clinical notes recorded previous episodes of CHF. Arterial hypertension was categorized as repeatedly measured blood pressure readings above 140/90 mmHg, or the continuous intake of antihypertensive medication. The modified Duke criteria were applied to establish a diagnosis of

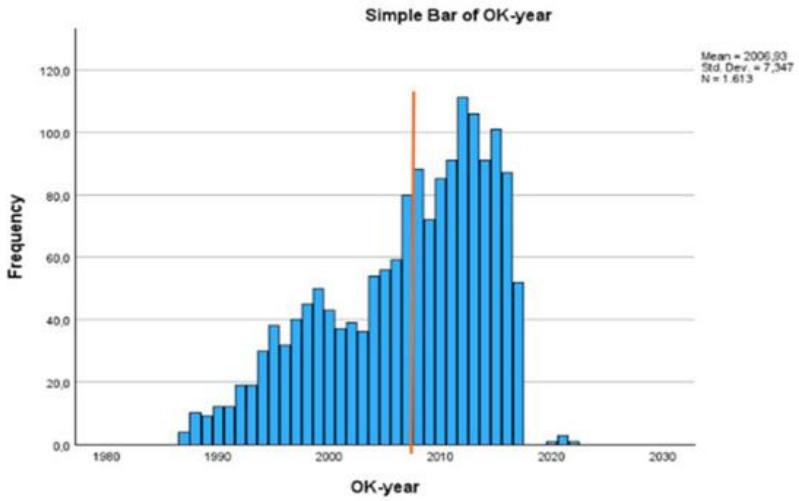
endocarditis. Significant coronary (CAD), peripheral, carotid, and left main stem disease were uniformly characterized by a luminal diameter reduction of 50% or greater, or by a prior revascularization requirement. An "urgent" classification required SAVR during the index hospitalization, when the aortic valve condition was first diagnosed. An "emergent" designation signified a need for surgical intervention within a window of less than 24 hours—a referral letter documented any previously confirmed malignancy based on histological findings. Diabetes was recorded when fasting plasma glucose exceeded 125 mg/dL or when a glucose-lowering regimen was prescribed. Chronic kidney disease (CKD) corresponded to an estimated glomerular filtration rate falling below 60 mL/min. A CVA was defined as the sudden onset of a focal neurological deficit lasting more than 24 hours, corroborated by imaging studies. Chronic obstructive pulmonary disease was recognized by an FEV_1 (forced expiratory volume in 1 second) of less than 80% of the predicted value. The following procedure-related details were captured: the implanted valve prosthesis model, whether CABG was performed, any mitral valve repair, any procedure addressing the ascending aorta, maze procedure execution, and the total cardiopulmonary bypass (CPB) duration.

In the years preceding TAVI availability, the Carpentier-Edwards Perimount valve constituted the sole prosthesis in use; starting in 2007, it was succeeded by the Carpentier-Edwards Magna Ease model. Because these two designs share a conceptual foundation, they were combined under the label CEP devices. The reduced basal stent profile of the Magna Ease iteration aimed to maximize clearance of the coronary ostia. After 2008, the selection among BHV types became a matter of individual surgeon preference within the department. The range of prostheses broadened to include Mitroflow, Mosaic Ultra, Crown, and Perceval valves. The Perceval device was specifically reserved for older and high-risk candidates and, together with the CEP valves, represented the sole option still in clinical use by the close of the recruitment window. Resource utilization was quantified by tallying transfused packed red cell units, plasma derivatives, or platelet concentrates administered, permanent pacemaker (PPM) insertions performed, and instances where renal replacement therapy was initiated. Comparisons of preoperative, operative, and early postoperative data—as well as measures obtained before and after the year 2008—were made separately for i-SAVR and c-SAVR using chi-square testing for categorical variables, reporting the resulting p-values. For continuous variables, Student's t-test was employed, yielding p-values along with Cohen's d effect sizes. The specific impact of valve type on the likelihood of PPM implantation was examined using logistic regression. Kaplan–Meier estimates alongside the log-rank test were used to analyze long-term survival. Cox proportional hazards regression was applied to isolate independent determinants of late mortality. The ZNA ethics committee approved protocol N° 2656.

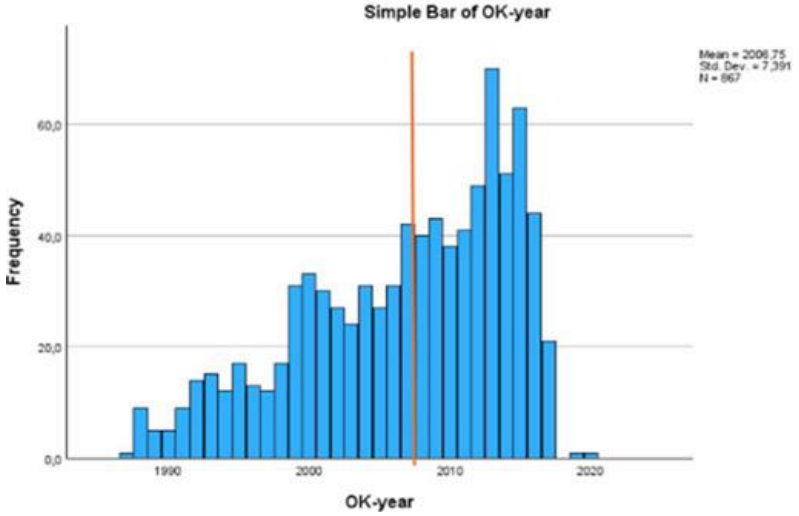
Results and Discussion

Temporal trends in referral, preoperative, and operative parameters

Figure 1a charts the temporal dynamics of referrals for c-SAVR; **Figure 1b** presents the corresponding trajectory for i-SAVR. The vertical marker denotes the introduction of TAVI in 2008. Individuals appearing in the 2019–2021 interval represent the subset of patients who returned to the operating room for reoperation prompted by structural valve degeneration (SVD).



a)



b)

Figure 1. (a) Temporal trend for referral of combined SAVR. The orange bar signals the launch of TAVI (OK-year stands for year of operation); (b) temporal trend for referral of isolated SAVR. The bar signals the launch of TAVI (OK-year stands for year of operation).

The first five entries in **Table 1** reveal a statistically significant temporal increase observed in both the isolated SAVR and the combined procedure cohorts. These characteristics are: age > 80 years, prior percutaneous coronary intervention, diabetes, renal impairment, and male sex. A significant reduction in hemodynamic lesion severity over time was also apparent in both operative groups: in the c-SAVR population, the aortic valve area (AVA) expanded from 71.2 ± 35.0 mm² to 79.5 ± 25.3 mm² (P < 0.001). Among i-SAVR recipients, the values shifted from 66.9 ± 32.3 mm² to 72.8 ± 17.9 mm² (P = 0.009). The 10 factors listed later in the table represent preoperative variables that increased significantly in the c-SAVR subgroup but remained stable in the i-SAVR subgroup. LVEF fell significantly over the decades for those who had c-SAVR (61.2 ± 16.9% vs. 59.1 ± 15.9%; P = 0.032). In the i-SAVR group, only a modest trend was observed (64.8 ± 14.7% vs. 62.6 ± 15.1%; P = 0.081). Peripheral artery disease was the sole variable to exhibit a significant temporal increase in the i-SAVR cohort. No significant shifts over time were detected for either surgical category regarding CHF, prior heart surgery, pre-existing PPM, pulmonary dysfunction, or a history of myocardial infarction. Regarding severe aortic regurgitation, the proportion recorded before 2008 among c-SAVR patients was 27/570 (4.7%) and afterward 22/477 (4.6%), an inconsequential difference (P = 0.920). For the i-SAVR group, the corresponding rates were 35/360 (6.9%) and 15/273 (5.5%), with P = 0.458. In short, these observations suggest that the patient population being referred for SAVR grew progressively older and clinically more compromised as time advanced. This worsening profile was more noticeable in those requiring c-SAVR than in those undergoing i-SAVR.

Table 1. Distribution of preoperative factors across the eras.

Variable	P-value	i-sAVR post (%)	i-SAVR Pre (%)	P-value	c-SAVR Post (%)	c-SAVR Pre (%)
Age > 80 years	< 0.001	130/421 (30.9)	85/446 (19.1)	< 0.001	285/803 (35.5)	175/810 (21.6)
Prior PCI	< 0.001	41/421 (9.7)	15/446 (3.4)	< 0.001	143/803 (17.8)	67/810 (8.3)
Diabetes mellitus	< 0.001	99/421 (23.5)	65/446 (14.6)	< 0.001	215/803 (26.8)	149/810 (18.4)
Chronic kidney disease	0.007	78/421 (18.5)	53/445 (11.9)	< 0.001	167/800 (20.9)	110/805 (13.7)
Male sex	0.007	217/421 (51.5)	189/446 (42.4)	< 0.001	539/803 (67.1)	475/810 (58.6)
Atrial fibrillation	0.210	106/421 (25.2)	96/445 (21.6)	< 0.001	233/803 (29.0)	168/807 (20.8)
Left main coronary artery involvement	0.967	1/142 (0.2)	1/446 (0.2)	< 0.001	153/803 (19.1)	105/810 (13.0)
Emergency SAVR	0.371	18/420 (4.3)	14/446 (3.1)	0.004	63/803 (7.8)	36/810 (4.4)
Treated malignancy	0.574	73/420 (17.4)	71/445 (16.0)	0.005	140/800 (17.5)	101/807 (12.5)
Arterial hypertension	0.078	302/420 (71.9)	294/433 (66.4)	0.008	614/800 (76.8)	574/809 (71.0)
Endocarditis	0.179	16/421 (3.8)	10/446 (2.2)	0.014	24/803 (3.0)	10/808 (1.2)

Conduction disturbances (all types)	0.115	227/421 (33.0)	125/445 (28.1)	0.016	277/803 (34.5)	232/803 (28.9)
AV block grade 1 or 2	0.254	27/403 (6.7)	21/432 (4.9)	0.047	63/767 (8.2)	44/779 (5.6)
Cerebrovascular accident	0.383	38/421 (9.0)	33/446 (7.4)	0.017	106/802 (13.2)	76/806 (9.4)
Peripheral artery disease	0.003	64/421 (15.2)	26/322 (8.1)	0.163	209/779 (26.2)	126/552 (22.8)

Abbreviations: AV = atrioventricular; LMCA = left main coronary artery; PCI = percutaneous coronary intervention; SAVR = surgical aortic valve replacement.

Changes over time in early postoperative results, resource utilization, and extended survival

Table 2 lays out how operative characteristics were distributed across the two time periods. Predictably, a growth in surgical intricacy is confined to the subset of individuals who received a combined intervention. The opening five operative variables in **Table 2** relate to the combined cohort. A rising proportion of cases involving more than two simultaneous procedures is apparent, driven chiefly by mitral valve repairs and other adjunctive interventions (most frequently maze operations targeting atrial fibrillation). Although the linkage between CABG and SAVR diminished significantly over time, its rate remained above 90% throughout the study window. Ascending aortic procedures showed no significant temporal shift (46/57 versus 58/801, P = 0.202). The pair of variables occupying the final rows of the table contrasts operative parameter trajectories between the two surgical subsets. A decline in the use of the smallest valve prosthesis diameter was observed in both cohorts, but this change did not reach statistical significance. The mounting complexity of the combined group is further evident in a significant increase in the fraction of cases requiring CPB for more than 120 minutes—a pattern absent in the i-SAVR experience.

Table 2. Distribution of operative factors across the eras.

Factor	P-value	i-SAVR Post (%)	i-SAVR Pre (%)	P-value	c-SAVR Post (%)	c-SAVR Pre (%)
CABG	NA	NA	NA	< 0.001	735/803 (91.5)	785/810 (96.9)
Mitral valve repair	NA	NA	NA	< 0.001	74/803 (9.2)	24/810 (3.0)
> 2 procedures	NA	NA	NA	< 0.001	125/803 (15.6)	68/810 (8.4)
Other concomitant procedures	NA	NA	NA	0.002	74/800 (9.3)	30/615 (4.9)
CPB time > 120 minutes	0.751	27/369 (7.3)	25/372 (6.7)	< 0.001	469/725 (64.7)	275/607 (45.3)
Use of the smallest valve size	0.132	8/420 (1.9)	16/446 (3.6)	0.080	14/801 (1.7)	25/810 (3.1)

Abbreviations: CABG = coronary artery bypass graft; CPB = cardiopulmonary bypass.

Over the full duration of patient accrual, a CEP device accounted for the largest share of implanted valves (n = 2153). Among the remaining prostheses, the Perceval rapid-deployment valve (n = 48) stands out as the most noteworthy. Introduced to clinical practice in 2013, it was purposefully selected for older patients with a heavier comorbid burden, and by the conclusion of the enrollment period, it had become the sole alternative to CEP devices still in active use. Every other prosthesis—the Mosaic Ultra (n = 122), Mitroflow (n = 101), and Crown (n = 77)—had been withdrawn at various junctures during the inclusion timeframe. When set against CEP devices, the Perceval valve was associated with markedly reduced cross-clamp duration (52.23 ± 22.9 min versus 68.4 ± 21.0 min, P < 0.001, effect size of moderate-to-large magnitude, Cohen's D = 0.763) and total cardiopulmonary bypass time (79.9 ± 29.9 min versus 121.7 ± 42.6 min, P < 0.001, effect size large, Cohen's D = 1.005). In contrast, the frequency of concomitant maneuvers—mitral valve reconstruction, CABG—remained statistically comparable between the two prosthesis types. Recipients of the Perceval device were, on average, considerably older (81.4 ± 4.1 years versus 75.0 ± 6.4 years, P < 0.001, effect size large, Cohen's D = 1.002). The EuroSCORE II estimate trended upward within the Perceval subset (8.0 ± 9.7% versus 6.3 ± 7.3%), but this disparity did not achieve significance (P = 0.230), and the accompanying effect size was small (Cohen's D = 0.230).

The consumption of postoperative hospital resources—covering extended dependence on mechanical ventilation or protracted ICU surveillance, the initiation of renal replacement measures, and the administration of packed erythrocytes or plasma products—proved broadly equivalent between patients receiving a CEP prosthesis and those treated with a Perceval valve. The sole divergence occurred in the domain of permanent pacemaker (PPM) insertion, where the Perceval cohort displayed a rate that was at least 4 times higher: 5/48 (10.4%) compared with 50/2148 (2.3%), P < 0.001. Furthermore, logistic

regression identified only two independent predictors of the need for postoperative PPM implantation. These were the presence of any preoperative conduction disturbance, yielding an odds ratio of 2.22 (1.29–3.82) and P = 0.004, and the deployment of a Perceval valve, which carried an odds ratio of 5.29 (1.99–14.01) and P < 0.001. Death within 30 days of Perceval implantation reached 5/48 (10.4%), a proportion that was double the rate recorded among those fitted with a CEP device (105/2152, or 4.9%). Nevertheless, owing to the limited number of Perceval recipients, this apparent excess remained statistically nonsignificant (P = 0.082). The multivariate model **(Table 3)** identifies the variables predictive of 30-day mortality. Perceval device use did not independently affect the likelihood of this event (odds ratio 1.03, P = 0.961). Yet the substantially older age profile of the patients who received a Perceval valve must be acknowledged as a relevant contextual factor. Peak transvalvular gradient readings (in mm Hg) proved significantly elevated for the Perceval device (22.9 ± 7.8 versus 18.6 ± 7.6 mm Hg, P = 0.001), while the mean transvalvular gradient showed only a modest, nonsignificant elevation (13.0 ± 5.7 versus 11.0 ± 4.3, P = 0.079).

Table 3. Predictors for 30-day mortality.

Predictor	P-value	95% CI	Odds ratio
Urgent SAVR	< 0.001	1.77–4.95	2.96
Chronic obstructive pulmonary disease	< 0.001	1.43–3.77	2.32
Chronic renal disease	0.002	1.31–3.46	2.13
Congestive heart failure	0.011	1.17–3.33	1.97
Age > 80 years	0.014	1.13–2.94	1.82

Table 4 maps the temporal evolution of unfavorable postoperative events and resource demands across the two surgical populations. A modest numerical increase in mortality is observed in both groups, but the trend is not statistically significant. By contrast, a clear and significant escalation in acute renal damage, de novo or progressive pre-existing conduction system disturbances, and clinically relevant bleeding emerged in each cohort. The incidence of postoperative endocarditis did not rise over time in either surgical category and remained below one percent overall. Application of renal replacement therapy became significantly more common across both groups as the eras progressed. The requirement for PPM insertion, the need to return to the operating theater for interventions linked to such reoperations, and the transfusion of plasma or platelet concentrates all increased significantly among c-SAVR patients; these same trends were absent in the i-SAVR group. This pattern implies that both conduction system compromise and hemorrhagic complications were of a milder nature in individuals who received isolated SAVR.

Table 4. Distribution of postoperative adverse events and need for resources across the eras.

Factor	P-value	i-SAVR Post (%)	i-SAVR Pre (%)	P-value	c-SAVR Post (%)	c-SAVR Pre (%)
Adverse event						
Mortality	0.479	18/420 (4.3)	15/446 (3.4)	0.111	57/803 (7.1)	42/809 (5.2)
Acute renal injury	< 0.001	88/420 (21.0)	32/446 (7.0)	< 0.001	250/801 (31.2)	92/809 (11.4)
Conduction defect	< 0.001	77/421 (18.3)	45/446 (10.1)	< 0.001	190/802 (23.7)	103/806 (12.8)
Bleeding	0.030	21/421 (5.0)	10/446 (2.2)	< 0.001	80/802 (10.0)	39/806 (4.8)
Acute myocardial infarction	0.954	2/421 (0.5)	2/446 (0.4)	0.119	14/802 (1.7)	7/809 (0.9)
Atrial fibrillation	0.461	66/421 (39.4)	165/446 (37.0)	0.508	328/802 (40.9)	317/807 (39.3)
Thromboembolism	0.931	10/421 (2.4)	11/446 (2.5)	0.783	33/802 (4.1)	31/806 (3.8)
Need for resources						
Renal replacement therapy	0.026	14/419 (3.3)	5.455 (1.1)	< 0.001	61/801 (7.6)	15/803 (1.9)
Permanent pacemaker implantation	0.887	14/421 (3.3)	14/446 (3.1)	< 0.001	32/803 (4.0)	9/805 (1.1)
Thrombocyte concentrate	0.924	28/412 (6.8)	6/92 (6.5)	0.005	128/791 (16.2)	15/187 (8.0)
Reintervention	0.460	15/421 (3.6)	12/446 (2.7)	0.012	36/803 (4.5)	18/810 (2.2)
Plasma transfusion	0.485	81/412 (19.7)	15/91 (16.5)	0.032	272/791 (34.4)	49/187 (26.2)
> 4 units packed cells	0.147	45/413 (10.9)	15/92 (16.3)	0.292	199/792 (25.1)	54/187 (28.9)

Abbreviations: PM = pacemaker; SAVR = surgical aortic valve replacement.

Table 5 provides survival estimates at the 1-, 5-, and 10-year landmarks for both operative groups, alongside the numbers of patients remaining under observation at those intervals. **Figure 2** presents a visual rendering of the identical dataset (upper graph, c-SAVR; lower graph, i-SAVR). Neither survival after isolated SAVR nor after the combined operation was materially influenced by the timing of surgery (P = 0.485).

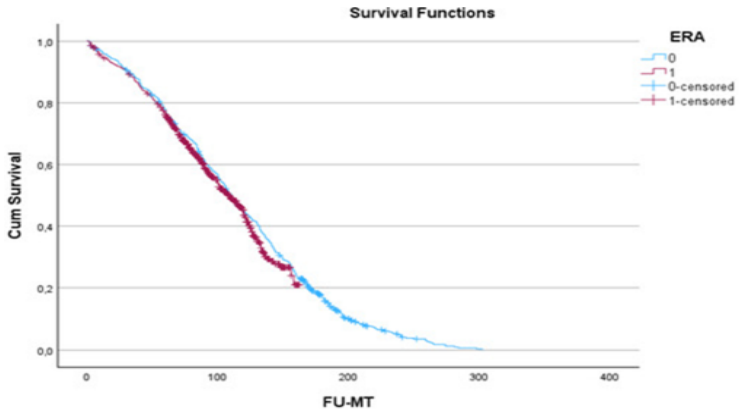
Table 5. Long-term survival for both surgical groups across the eras.

Survival (Years)	i-SAVR Post	n	i-SAVR Pre	n	c-SAVR Post	n	c-SAVR Pre	n
1 year	96.5% ± 0.9%	385	95.1% ± 1.0%	407	94.5% ± 0.8%	699	96.0% ± 0.7%	739
5 years	80.2% ± 2.0%	302	78.6% ± 2.0%	326	76.1% ± 1.6%	561	76.6% ± 1.5%	593
10 years	49.4% ± 3.2%	74	43.6% ± 2.3%	129	43.6% ± 2.3%	129	44.6% ± 1.8%	340

n: number of patients at risk.

Survival at five years was more favorable among patients who had been implanted with a CEP device (78.5% ± 0.9%). A lower rate was recorded for recipients of the Perceval prosthesis (66.7% ± 7.3%). This gap satisfied the threshold for statistical significance (P = 0.003), yet the Perceval-treated subgroup was, on average, six years older. Structural valve degeneration (SVD) linked to the Perimount design was captured echocardiographically in 135 of 2153 instances (6.3%), after a mean postoperative interval of 112 (114–131) months. A subsequent valvular reintervention—either repeat SAVR or TAVI—was required for 54 patients (2.5%), at a mean interval of 113 months (46–149). The long-term durability of the Mitroflow prosthesis, with 11 SVD events occurring at a mean of 73 (65–81) months, and the Crown prosthesis, with 10 events at a mean of 48 (38–57) months, proved substantially poorer; both were consequently abandoned. For the Perceval device, the tally of observations was too sparse to support a reliable assessment of SVD. This constraint may partially reflect the patients' advanced age and correspondingly shorter anticipated survival. Mortality may be viewed as a competing risk for the development of SVD.

Figures 2a and 2b for all devices combined:



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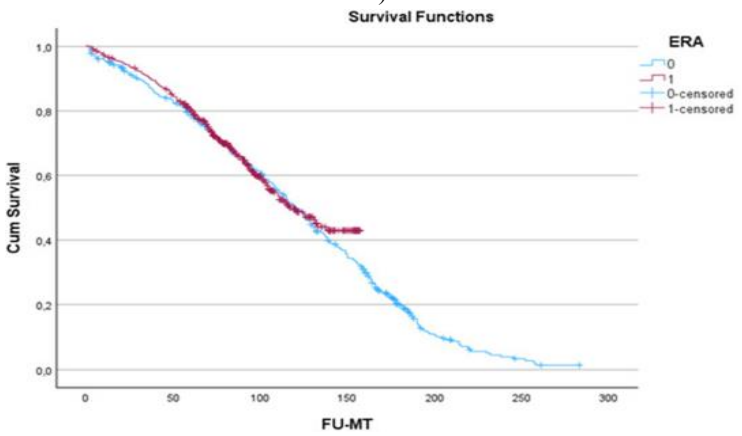

b)

Figure 2. FU-MT: follow-up in months; blue line: era before 2008 labeled as '0'; red line: era after 2008, labeled as '1'. Cum: cumulative. (a) top c-SAVR; (b) bottom i-SAVR.

Table 6 enumerates the factors independently associated with late mortality, with analyses conducted separately for the two eras. An age of 80 years or more is the foremost predictor in both the period preceding and the period following 2008. Chronic kidney dysfunction, chronic lung disease, a recorded history of malignancy, and peripheral arterial occlusive disease feature as determinants shared across the two time frames. Diabetes mellitus, atrial fibrillation, and atrioventricular block emerge as significant predictors only in the post-2008 era. Across the series as a whole, the specific BHV prosthesis type implanted is not recognized as a driver of long-term survival.

Table 6. Predictors for long-term mortality in the early and later era.

Early era				**Later Era**		
Predictor	**P**	**95% CI**	**Odds ratio**	**P**	**95% CI**	**Odds ratio**
Age over 80 years	< 0.001	2.28–3.31	2.75	< 0.001	1.66–2.38	1.99
COPD	< 0.001	1.23–1.86	1.51	< 0.001	1.15–1.78	1.35
CKD	< 0.001	1.23–1.89	1.52	< 0.001	1.42–1.89	1.53
Diabetes mellitus	< 0.001	1.37–2.05	1.67	-	-	-
Atrial fibrillation	< 0.001	1.28–1.91	1.56	-	-	-
AV block 1 or 2	0.003	1.18–2.22	1.62	-	-	-
Malignancy	0.004	1.11–1.75	1.40	0.013	1.06–1.60	1.30
Peripheral artery disease	0.006	1.08–1.62	1.32	0.010	1.05–1.53	1.23
CPB time > 120 min	0.012	1.06–1.53	1.27	0.007	1.07–1.57	1.27
Urgent/emergent SAVR	0.021	1.07–2.23	1.54	0.007	1.03–1.57	1.27

The present data reveal a trajectory marked by increasing referral numbers, older patient age, accumulating comorbidities, mounting procedural challenges, a rising frequency of untoward postoperative events, and increasing demand for hospital resources—all of which are exaggerated within the c-SAVR subgroup. Before 2008, no valve other than the CEP prosthesis was selected. Once the latter period commenced, a wider array of BHV designs was adopted, but, aside from CEP devices, only the Perceval valve continued to be used for isolated SAVR without root surgery until the final patient was enrolled. The 30-day death rate did not shift to a significant degree, and long-term survival proved nearly indistinguishable when the pre- and post-2008 periods were placed side by side, whether examining i-SAVR or c-SAVR. Additionally, the findings reveal differential performance among the various implanted valve types.

Surgical referral activity

A particularly noteworthy pattern emerging from this consecutive series is the expansion in patient volume directed to both i-SAVR and c-SAVR once TAVI entered clinical practice in 2008. Growth continued up to 2016, the inclusion window having been closed in June 2017. Far from being an isolated observation, this trend extends a pattern previously flagged within our own institution [10] and has been recapitulated among narrower subgroups, such as those aged 80 or older or those with a prior cancer diagnosis [9, 14, 15]. Members of either subgroup might logically be viewed as well-suited for TAVI, whether because of a heightened operative risk or an abbreviated anticipated lifespan. At some centers, reaching the eighth decade of life has effectively become an automatic indication for transcatheter referral [16]. The broadened uptake of SAVR, captured in this report, finds strong echoes across multiple independent cohorts [12, 17-28], with the numerical upswing spanning both older and younger age strata [2, 29]. One explanatory framework invokes a “halo effect”—the notion that the mere accessibility of a TAVI program stimulates higher SAVR activity by drawing in patients who, after multidisciplinary deliberation, are ultimately judged more suitable for open surgery [2, 26, 27]. On balance, this phenomenon may be interpreted as a salutary development, especially in light of historical evidence that aortic valve replacement, regardless of the approach, was deployed too sparingly [26, 30]. It must be acknowledged, nonetheless, that the post-TAVI referral pattern for SAVR has been anything but uniform [31]. One study detected volume expansion exclusively at sites where TAVI was not performed [32]. Unchanged SAVR caseloads were chronicled in several additional reports [16, 19, 33, 34], whereas five other analyses documented a contraction [35-39]. A very recent dataset demonstrated that, from 2016 through 2019, SAVR referrals dwindled across all age categories examined (< 65 years, 65–80 years, < 80 years), even as TAVI deployment rose for those same age groups.

Age trends and comorbidity burden

Inseparably woven together with the first observation is the substantial growth in the contingent aged 80 years and older, a finding that held for both i-SAVR and c-SAVR alike. That surgical candidates were becoming progressively older was already detectable before the transcatheter era commenced [10], a pattern reaffirmed by a host of more recent publications, which generally point to a mean age increase of no less than one year after the introduction of TAVI [17, 21, 24, 26, 27, 36, 40-43] or to a disproportionate expansion of the octogenarian fraction [44]. Yet the literature does not speak with a single voice. A mean age decrement of at least one year was registered in several other series [25, 32, 38, 42, 45], while still others observed no meaningful temporal shift [12, 20, 28, 33]. One longitudinal account described an early peak in octogenarian referrals for SAVR that subsequently reversed [46], and, in one series, the most pronounced decline in surgical cases was concentrated among the over-80s [39]. Age has recently been identified as a dominant driver of treatment allocation: a recent analysis showed that SAVR utilization declined to approximately 3%, with transcatheter replacement becoming all but the exclusive default for octogenarians [22].

The third key observation concerns the accompanying disease burden. EuroSCORE II was excluded from the current analysis because pulmonary artery hypertension data were inconsistently collected during earlier years. Even without formal scoring, it stands to reason that the risk estimate would have been lower before 2008, since the later period witnessed unmistakable rises in age, diabetes prevalence, chronic renal impairment, peripheral artery disease incidence, the proportion of urgent cases, and the intricacy of the operations themselves. That pre-2008 mortality was non-significantly lower among both i-SAVR and c-SAVR recipients offers indirect corroboration of this assumption. Reports in the existing literature diverge on this matter. A higher risk profile among SAVR referrals after the advent of TAVI has been substantiated by numerous groups [20, 21, 24, 26-28, 32, 44, 47], including institutions with robust TAVI throughput [32], implying that transcatheter therapy does not invariably siphon off every high-risk candidate. In contrast, other investigators have documented a decline in SAVR risk scores over the years [2, 12, 30, 32, 33, 37-39], consistent with the notion that high-risk patients were increasingly steered toward transcatheter management. A further six analyses identified no statistically significant temporal drift in risk scores [12, 20, 28, 29, 32, 48].

Growing procedural complexity and bioprosthetic valve use

The fourth pattern warranting emphasis is the progressive increase in technical difficulty among recipients of c-SAVR, driven by a mounting need for mitral valve reconstruction, ascending aortic surgery, or maze procedures. This shift had its objective correlate in a statistically significant increase in cardiopulmonary bypass duration in the c-SAVR group—a change absent among i-SAVR patients. Notably, the frequency with which CABG accompanied SAVR did not climb across the study interval. Because the bulk of earlier investigations confined their analyses to i-SAVR, the literature is largely silent on temporal trends in operative complexity [18-20, 24, 25, 32-34, 36, 37, 40-42, 44, 46, 49]. For older or high-risk individuals confronting the prospect of SAVR combined with CABG, a hybrid strategy pairing transcatheter valve deployment with percutaneous coronary intervention may offer an alternative pathway. Roughly 60% of patients in our previous surgical publications harbored CAD [7, 9], a figure broadly consistent with a review documenting CAD in 40% to 75% of TAVI populations [50]. How best to sequence interventions when severe aortic valve disease and CAD coexist remains an open and actively debated question, with only observational series available and the ever-present possibility of selection bias [51, 52].

The growth in absolute numbers within our cohort may also reflect a second, broader secular trend: the steady displacement of mechanical valves (MHVs) by biological prostheses (BHVs) over the years. Earlier comparative studies have shown superior short-term results following BHV versus MHV implantation [18, 26]. For younger BHV recipients, however, the specter of SVD necessitates planning for a future secondary intervention, most plausibly a valve-in-valve TAVI procedure. This consideration makes it imperative to insert the largest possible prosthesis at the time of the index operation. A drift away from the smallest valve dimensions was indeed perceptible in the present dataset, though confounding by the concurrent rise in male sex cannot be excluded. While a preemptive strategy anticipating eventual valve-in-valve TAVI may be considered [12, 47], long-term durability data for this approach are not yet available [53]. Moreover, evidence suggests that surgeons working in high-volume environments have gravitated toward implanting larger-diameter prostheses [28, 47], a practice expected to lower the probability of a clinically important residual transvalvular gradient should a future valve-in-valve procedure be required—

such gradients being a potent predisposing factor for SVD. Despite the introduction of valve-in-valve solutions, the frequency of redo SAVR has not decreased. Repeat sternotomy with surgical re-replacement remains a well-established course of action with acceptable outcomes [24] for patients whose anatomic substrate is ill-suited to transcatheter within-a-valve deployment [47]. The CEP device has consistently demonstrated excellent durability, both in the present material and in previously published reports. For the Perceval valve, the question of long-term degeneration takes on a different character, given that the typical recipient was 81 years old, suggesting that most such patients are unlikely to survive their bioprosthesis. In SVD analyses, mortality may appropriately be treated as a competing risk.

Early postoperative death, complications, and resource consumption

A fifth finding worth highlighting is the statistically nonsignificant increase in 30-day mortality in our cohort, observed after both i-SAVR and c-SAVR. The bulk of published series, by contrast, have charted a temporal decline in 30-day death rates [2, 16-18, 20, 21, 23, 24, 26, 32-34, 38-40, 44], even amid rising risk scores, with the greatest reductions concentrated at centers running high-volume TAVI programs. Such an improvement would be anticipated if transcatheter therapy were effectively diverting the highest-risk individuals away from surgery. Indeed, those carrying the most extreme risk profiles derived the largest absolute mortality benefit over time [34]. Once risk was accounted for, enhanced surgical technique was credited with driving better results [24]. Elsewhere, however, a nonsignificant upward drift in 30-day mortality has been recorded [29, 45, 48, 49, 54, 55]. Several series noted that a rising risk score did not translate into higher mortality, though this dissociation appeared to hold solely for i-SAVR [18, 24, 26, 32, 43].

A sixth observation pertains to resource utilization, a proxy for the gravity of postoperative morbidity. Our data reveal a highly significant increase in the use of renal replacement therapy after both operative modalities, indicating a temporal rise in acute kidney injury across the two groups. This pattern was likewise captured in an octogenarian-focused series that compared surgical outcomes before and shortly after the launch of TAVI [33]. A recent publication explored in considerable depth the determinants of acute renal injury following SAVR and the subsequent emergence of CKD during longitudinal surveillance. Of particular interest was the influence of baseline CKD stage on the tempo of acute renal injury. The severity of pre-existing CKD, along with CPB and cross-clamp durations, emerged as independent predictors—a finding consonant with our observation that acute kidney injury occurs less frequently after i-SAVR than after SAVR coupled with other interventions. The postoperative incidence of acute renal injury climbed over time, mirroring temporal increases in preoperative CKD (in both surgical cohorts) and CPB duration (exclusive to the combined surgery group). Concomitant procedures are expected to prolong operative time. It is also noteworthy that, while advanced age was identified as a significant contributing factor, acute renal injury post-SAVR is not confined to older adults; it also poses a concern among younger recipients (mean age 66 ± 11 years), a proportion of whom received mechanical prostheses [56].

The requirements for PPM insertion, reoperation, and blood product transfusion likewise showed significant temporal increases, though these were considerably more pronounced after c-SAVR. A disproportionate demand for PPM was particularly evident after Perceval device implantation, corroborating earlier multicenter experience [57]. High-grade atrioventricular block and clinically significant hemorrhage appeared to be more severe in the c-SAVR population, as reflected by greater reliance on pacemaker insertion, plasma derivatives, platelet concentrates, and surgical re-exploration. Another report found no temporal worsening of postoperative morbidity or mortality and documented a shorter hospital stay, despite an increasing comorbidity burden [20]. Early mortality rates observed in the present study for the Perimount, Mosaic Ultra, Mitroflow, and Perceval prostheses did not differ significantly. Deaths were most frequent among Perceval recipients, a finding attributable to older age and broadly consistent with postoperative outcomes reported in octogenarian populations [10]. The abbreviated CPB duration conferred by the Perceval valve may partially offset the adverse impact of advanced age on in-hospital mortality.

Extended survival and late adverse events

Long-term survival in our cohort proved unaffected by the surgical era: the curves for both i-SAVR and c-SAVR were nearly superimposable. The most recently treated subset, by necessity, contributed a shorter follow-up window. A limited number of other publications have addressed extended survival. One-year survival following i-SAVR improved significantly over time [2, 12, 30], with octogenarians benefiting to a particularly notable degree [43].

Because the Perimount device was employed throughout the study, it yielded large patient numbers and ample follow-up. Its earliest implantations date back to early 1987, a choice motivated by specific design features. The absence of contact between the leaflet tissue and the suture line reduced the likelihood of leaflet injury.

Furthermore, friction zones over the Dacron-covered stent were eliminated [7]. These attributes underpinned a strong institutional preference for the device, although surgeons retained the freedom to select alternative biologic prostheses. One such alternative was the Perceval valve, introduced in 2013 and in continuous use until enrollment closed. Patients fitted with this prosthesis had shorter survival, a finding explained by their higher mean age. Moreover, only a single instance of valve failure requiring explantation was documented. In the analysis of Perceval SVD, death may legitimately be treated as a competing event. One modest single-center series reported the use of multiple biologic valve designs [42] but did not extend the analysis to era- or outcome-based comparisons. Another report [47] cataloged the deployment of various prostheses, noting that Perimount and Hancock valves dominated throughout most of the study window, whereas Mitroflow usage gained ground in later years; no inter-device outcome comparisons were undertaken. Of greater consequence was the trend toward implanting larger-diameter prostheses, a strategy intended to preserve the feasibility of future valve-in-valve TAVI interventions.

The carpentier-edwards valve and possible alternatives

The Carpentier-Edwards Perimount valve has an extensive, well-substantiated record of durability. Its leaflets are fashioned from bovine pericardium treated to prevent calcification, thereby enhancing longevity. The Magna Ease iteration features a reduced profile that facilitates both insertion and aortic closure. Designed for supra-annular seating, it yields optimal hemodynamic performance and incorporates a narrower sewing cuff. Not long after TAVI entered the clinical arena, the sutureless, rapid-deployment Perceval device was introduced. This BHV prosthesis can be placed with considerably shorter cross-clamp and bypass intervals. Within our practice, it was predominantly reserved for older individuals with elevated EuroSCORE estimates, a selection bias that likely explains the absence of a 30-day mortality advantage relative to Perimount recipients. The device also lends itself to minimally invasive SAVR approaches, including partial sternotomy or right anterior mini-thoracotomy [56], the latter of which remains technically demanding. A meta-analysis concluded that the Perceval valve performs comparably to sutured valves and proves superior to TAVI with respect to paravalvular leak, permanent pacemaker requirement, postoperative stroke, and myocardial infarction [58]. That said, the rate of postoperative PPM insertion among our Perceval-treated patients was substantial. Only two independent predictors emerged: the prosthesis itself and preoperative conduction abnormalities. Careful candidate selection for Perceval implantation is therefore essential, as the subsequent need for PPM is far from innocuous. A separate, comparatively small but very recently published series reported higher early postoperative gradients in the Perceval group [59]; these differences attenuated over time—a phenomenon we also observed—suggesting that the long-term consequences of this finding are unlikely. A second rapid-deployment valve, not employed in the current cohort, is the Intuity device, which builds upon the CEME frame [60]. The Intuity Elite variant shares these attributes while also enabling dry storage and handling, achieving a high technical success rate [61]. Only three guiding sutures are required. A cloth-covered, balloon-expandable frame can be deployed within the left ventricular outflow tract (LVOT), widening it and thereby enhancing hemodynamic properties [56]; nevertheless, the PPM requirement remains elevated [61]. Another noteworthy parallel innovation is the Inspiris Resilia valve, likewise mounted on the Carpentier-Edwards Magna Ease frame. Its tissue undergoes glycerolation, enabling dry storage and handling. To facilitate future TAVI procedures, the frame has been made expandable by incorporating a cobalt–chromium alloy band; during a valve-in-valve TAVI, radial force can be applied to achieve uniform, predictable expansion. The perforated polyester band of the Inspiris Resilia valve is designed to expand at all three commissures without the necessity of high-pressure stent fracture, thereby diminishing the risk of stroke and other procedural complications. The recently published COMMENCE trial reported encouraging results, exhibiting low 30-day mortality, a low rate of adverse event-driven reoperation, and a favorable hemodynamic profile, with these outcomes sustained at five years [62]. A meta-analysis found no differences in outcomes compared with the conventional Carpentier-Edwards valve, although extended follow-up studies remain necessary [63].

The Shifting Paradigm for Surgical Bioprosthetic Valve Placement in Younger Populations

Thinking around the elective insertion of a biologic prosthesis into younger adults is far from static. A thought-provoking paper addressed a cluster of issues, cataloging adverse event frequencies, the likelihood of cooperative surgery, and diminished longevity after aortic valve procedures performed on relatively young individuals. Because these patients remain at risk for valve-related complications over a considerably extended horizon, such untoward outcomes could be reduced by adopting repair-oriented strategies, performing the Ross operation, or inserting tissue-engineered constructs [64]. By contrast, the cases assembled for this study are markedly older, face a far more constrained remaining lifespan, and overwhelmingly present with degenerative, stenotic aortic valve pathology. These features make valve repair or the Ross technique—the latter involving the pulmonary valve as well—clinically unsuitable. Equally, no large-animal chronic model of a tissue-engineered valve is currently at hand. Although mechanical prostheses were specifically excluded from the present cohort, one should note that life years are lost after aortic valve implantation with any prosthetic valve; the deficit is greater with biologic than with mechanical substitutes. Biologic replacements also carry a higher cumulative risk of reintervention. Valve-in-valve transcatheter deployment holds theoretical appeal on this score, but confirmatory evidence drawn from extended follow-up is still missing [65]. A separate question concerns stentless aortic bioprostheses in patients with a narrow annulus. In our hands, these were not standard implants. Stentless designs deliver more favorable hemodynamics under physical load, yet they entail greater technical demands and are more often followed by permanent pacemaker dependency. Such characteristics render them less appropriate for older patients with circumscribed exertional capacity. In one published report, the stentless cohort was appreciably younger than the population we describe (mean age, 61 ± 12 years) and had a substantially higher proportion of reoperative cases (31%). Active infective endocarditis before surgery was also more prevalent (27%). Cross-clamp and perfusion intervals were markedly longer—an undesirable feature in older adults. No long-term gains in survival, freedom from adverse events, or reoperation rate were found when stented and stentless devices were compared. The excess of permanent pacemaker insertions in the stentless arm [66] constituted one of the justifications for our reluctance to adopt such designs as a default solution for small annular diameters.

Anticipating the road ahead

Spanning a 30-year continuum, the present series reveals a distinct increase in the stream of patients referred to both i-SAVR and c-SAVR. The temporal accumulation of preoperative comorbid conditions was disproportionately concentrated among those receiving a combined operation rather than an isolated one. For the c-SAVR subset, technical operative difficulty grew in parallel. It seems plausible that these dynamics are mechanistically tied to a rising incidence of postoperative adverse events, a burden that fell most heavily on the c-SAVR category. Escalation in the consumption of hospital resources tracked an analogous course. A numerically small and statistically nonsignificant drift upward in 30-day death was observed across both surgical classifications. The extended survival trajectories from the pre- and post-TAVI intervals were practically superimposable for each group. Reimbursement conditions can significantly shape referral flows for SAVR once a transcatheter program is established. The Belgian regulatory stance [13] was exceptionally restrictive through at least 2017: earlier guidance actively discouraged public funding of TAVI for symptomatic aortic valve disease, even in the presence of major comorbidity and heightened operative risk. The authors of that guidance maintained that such individuals should proceed with SAVR, reserving transcatheter therapy solely for those whose anatomy rendered surgery prohibitive. This posture diverged sharply from that seen in countries like Germany, where the combined volume of aortic valve procedures expanded over time across all age bands, most strikingly among the over-80s. In that environment, TAVI volumes pulled ahead of SAVR, even as surgical activity contracted to a moderate extent [39]. Cases complicated by significant CAD add another layer of complexity, since agreement on when PCI should be performed relative to TAVI has not yet crystallized.

One particularly noteworthy, newly published analysis showed that octogenarian patients whose initial evaluation led to a TAVI referral but who were subsequently switched to SAVR achieved better outcomes than octogenarian patients referred to SAVR from the outset. Preoperative multidisciplinary deliberation by a heart team, applied to octogenarians, correlated with reduced hospital death and fewer postoperative complications after SAVR. Despite the fairly limited case numbers, propensity score matching strengthened the inference [67]. Collectively, these data, along with a series of recent surgical publications [2, 14, 15, 21-25, 29, 33, 44, 45], buttress our own conclusion that SAVR can still secure acceptable

extended survival even among elderly and high-risk subjects, with the acknowledged potential for downstream events such as SVD. The open surgical option seems likely to preserve a competitive niche for the foreseeable future, relevant to both older and younger adults. Perimount valves have affirmed their merits in this respect [63]. Rapid-deployment prostheses, exemplified by the Perceval BHV, delivered through a minimally invasive corridor, look well-suited to the older segment of the spectrum; the Inspiris Resilia valve, in contrast, can be extended to younger counterparts. Because this newer device was conceived with future valve-in-valve TAVI in mind, the emergence of SVD in patients who have by then grown older and frailer could be met with a planned transcatheter solution. Coronary sequelae—myocardial infarction and grave patient–prosthesis mismatch—will still need to be vigilantly anticipated. For younger, lower-risk individuals, reoperative SAVR may well represent the superior choice, given the more established safety and efficacy, despite the current lack of long-term data. Considered holistically, the wave of innovations—miniaturized access, rapid-deployment and sutureless technologies, expandable frames—broadcasts that SAVR has a durable future ahead. These surgical refinements deserve integration into an all-encompassing therapeutic algorithm for aortic valve disease, complementing TAVI, particularly when sequential interventions such as redo SAVR or valve-in-valve TAVI are envisioned. The participation of a multidisciplinary heart team and the potential reassignment of patients from the transcatheter to the surgical arm reinforce this outlook.

Conclusion

Surgical aortic valve replacement remains a valid therapeutic option for the foreseeable future. The Carpentier-Edwards Perimount prosthesis has a well-documented legacy of durability and hemodynamic performance. In carefully chosen elderly or high-risk individuals, the Perceval device continues to represent an available choice, though concern regarding the necessity for postoperative permanent pacing persists. The more recent emergence of additional rapid-deployment, expandable BHV platforms, developed with the express intention of facilitating later valve-in-valve TAVI, opens up further credible surgical avenues.

Limitations

Spanning a three-decade enrolment window inevitably means that evolutionary refinements in perioperative and postoperative management could influence the observed outcomes. Conventional protracted mechanical ventilation gave way to a fast-track anesthetic protocol in 1996, after which both intensive care unit residency and total hospital stay were curtailed as a matter of routine. These variables were therefore not amenable to direct comparison and were excluded from the analysis. From the year 2000 onward, reliance on opioid-based analgesia was progressively scaled back. Pulmonary artery pressure was not systematically measured during the earliest years, precluding the incorporation of EuroSCORE II as a study parameter. Analogous progress has been achieved on the transcatheter front, where the indications for TAVI have steadily broadened to encompass lower-risk cohorts. Unavoidably, the follow-up interval for the more recent era is considerably shorter. The selection of a particular biologic prosthesis was left to the operating surgeon's individual judgment, meaning that no element of randomization governed device assignment.

Moreover, over a thirty-year timeframe, the composition of the surgical team did not remain static. Only the Perimount prosthesis was continuously used from the outset to the close of the study. The Perceval valve was introduced later, but continued to be implanted until recruitment was completed. Despite the small absolute numbers for this device, the observations of elevated rates of permanent pacemaker insertion and a satisfactory hemodynamic profile are clinically relevant. A head-to-head comparison between the Perceval device and conventional biologic prostheses would ideally rest on propensity score matching. Given the limited sample size available here, such an exercise would be unlikely to generate meaningful inferences. Logistic regression analysis, however, offers a robust alternative. This approach identified age in excess of 80 years, chronic renal impairment, chronic pulmonary disease, congestive heart failure, and the necessity for urgent SAVR as independent determinants of 30-day mortality. Perceval device implantation was found to have no independent bearing whatsoever on the risk of death. One may reasonably infer that the abbreviated operative times characteristic of Perceval deployment serve to counterbalance the adverse prognostic weight of age exceeding 80 years. It is also reasonable to conclude that Perceval utilization should be avoided in individuals who have previously undergone SAVR. Modest patient numbers likewise represented the remaining valve types, and their long-term data are curtailed owing to their eventual discontinuation. The principal strengths of this investigation lie in the scale of the cohort, the extended duration of surveillance,

and the granularity with which resource consumption was documented.

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