AORTIC PROSTHETIC VALVE ENDOCARDITIS: ANALYSIS OF THE SOCIETY OF THORACIC SURGEONS DATABASE

Running Head: Aortic prosthetic valve endocarditis.

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Presentation at The Society of Thoracic Surgeons 2021 Annual Meeting

Word count: 4744

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ABSTRACT

Background

We sought to characterize the current U.S. experience of aortic prosthetic valve endocarditis (PVE) compared to native valve endocarditis (NVE).

Methods

The Society of Thoracic Surgeons Database was queried for entries of active aortic infective endocarditis (IE). Two analyses were performed: 1) Trends of surgical volume and operative mortality (2011 to 2019) and 2) Descriptive and risk-adjusted comparisons between PVE and NVE (2014 to 2019), using multivariable logistic regression.

Results

From 2011 to 2019, there was a yearly increase in the proportion of PVE (20.9% to 25.9%; p<0.001) with a concurrent decrease in operative mortality (PVE=22.5% to 10.4%; p<0.001; NVE=10.9% to 8.5%; p<0.001). From 2014 to 2019, active aortic IE was identified in 9,768 patients (NVE=6,842; PVE=2,926). Aortic root abscess (50.1% versus 25.2%; p<0.001), aortic root replacement (50.1% versus 12.8%; p<0.001), homograft implantation (27.2% versus 4.1%; p<0.001), and operative mortality (12.2% versus 6.4%; p<0.001) were higher in PVE. Following risk-adjustment, PVE (odds ratio [OR]=1.5; 95% confidence interval (CI):1.16-1.94; p<0.01), aortic root replacement (OR=1.49; 95% CI:1.15-1.92; p<0.001), staphylococcus aureus (OR=1.5; 95% CI:1.23-1.82; p<0.001), and unplanned revascularization (OR=5.83; 95% CI:4.12-8.23; p<0.001) or mitral valve surgery (OR=2.29; 95% CI:1.5-3.51; p<0.001) correlated with a higher operative mortality, while prosthesis type (p=0.68) was not an independent predictor.

Conclusions

IE in the U.S. has risen over the past decade. However, operative mortality has decreased for both PVE and NVE. PVE, extension of IE requiring aortic root replacement, and additional unplanned surgical interventions carry an elevated mortality risk. Prosthesis selection did not impact operative mortality.

Introduction

With the rapid implementation of transcatheter aortic valve replacement, aortic valve infective endocarditis (IE) will likely represent a growing segment in the surgical treatment of heart valve pathology; thus, it behooves the cardiac surgeon to understand accurately the risk profile of this evolving patient population.

Native valve endocarditis (NVE) and prosthetic valve endocarditis (PVE) are viewed as categories with disparate surgical risks. Earlier studies have reported operative mortality rates for PVE as high as 20% to 30%, distinctly higher than for NVE [1,2]; these findings have introduced further caution in the consideration of surgical treatment for PVE. However, this belief stems primarily from institutional reports with limited sample sizes, commonly spanning several decades in which operative and postoperative care have experienced considerable strides. Furthermore, larger studies often combine medical and surgical treatments of IE, include all heart valves, and lack relevant exclusion criteria. Contrastingly, various reports in the last decade have challenged this notion and have presented comparable outcomes with NVE [3,4].

Institutional studies generally do not accrue enough patients for a reliable analysis of this condition. Prior reports from the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD) have shown higher unadjusted mortality rates for IE in cases of reoperative surgery, however, without accurate discrimination between NVE and PVE [5,6]. Starting in 2011, STS ACSD version 2.73 added detailed entries to facilitate the identification of NVE and PVE, and data regarding illicit drug abuse, microbiology, and surgical reconstruction; thus, creating a more robust substrate from which to explore heart valve endocarditis.

The present study aimed at a twofold objective: 1. To characterize the trends in the surgical treatment of active aortic IE; 2. To conduct a risk-adjusted analysis of the current experience of active aortic endocarditis, with particular emphasis on the adjusted risk burden of PVE.

Material and Methods

Data Source

The STS ACSD was established in 1989 as a repository of clinical data for cardiac surgical procedures in North America and currently comprises at least 94% of the cardiac surgery practice [7]. The STS ACSD originated as an initiative to provide assessment of risk-adjusted outcomes to participants and to support quality improvement. Furthermore, through The STS Workforce on Research Development, STS ACSD serves as a versatile substrate for large-scale research endeavors. The data for this research were provided by The STS National Database Access and Publications (A&P) Research Program, and this manuscript was reviewed and approved by The STS A&P Task Force.

Study population

To assess the trends in volumes and outcomes of the surgical treatment of IE, STS ACSD was queried from July 2011 through September 2019 (versions 2.73, 2.81, 2.9). For the comparison between NVE and PVE, all relevant variables could not be consistently mapped to version 2.73; therefore, the comparative analysis was restricted from July 2014 through September 2019 (versions 2.81 and 2.9). Patient records of active aortic valve endocarditis were retrieved. Unplanned aortic valve procedures were excluded. To analyze the risk effect of unplanned concomitant procedures, all planned coronary artery bypass grafting (CABG) or other planned valve surgeries were excluded.

Variable and outcome definitions

Preoperative characteristics, operative data, and outcome endpoints were consistent with standard definitions from STS ACSD. Operative mortality is defined as (1) all deaths during the hospitalization in which the operation was performed, even if after 30 days; and (2) all deaths after discharge but before the 30th postoperative day [8]. Major morbidity or mortality is a composite endpoint defined as the occurrence of one or more of operative mortality, stroke, renal failure, prolonged ventilation or reintubation, reoperation (including insertion of permanent pacemaker), or deep sternal wound infection. The definitions for each endpoint have been previously published [8].

PVE was identified if a previous aortic valve replacement, either surgical or transcatheter, was present. Cases not meeting criteria for PVE were classified as NVE. Except for few cases of PVE following TAVR, reoperation is inherent to the definition of PVE, while only a small proportion of NVE had a reoperation. "Reoperation" could not be included in the risk model since it is a surrogate for PVE, which is already incorporated in the model. All reoperations in NVE were excluded since "reoperation" could not be considered as a variable in the model.

NVE and PVE were further separated into aortic valve replacement (AVR) and aortic root replacement (ARR) by clustering all the procedures that spared the aortic root as AVR. Aortic valve replacements with insertion of a supra-coronary non-valved conduit were classified as AVR. Aortic valve sparing operations were excluded. The remainder of the procedures comprised cases with implantation of aortic-valved conduits or homografts in the aortic position and were classified as ARR. The aortic prosthesis type was identified according to the Implant Model Number and Unique Device Identifier of the implanted prosthesis, and was classified as non-homograft biologic, mechanical, or homograft.

Statistical Analysis

The proportion of NVE and PVE and the corresponding operative mortality rates were plotted from 2011 to 2019, and trends were analyzed with the Cochran-Armitage trend test.

Preoperative characteristics, operative data, and outcomes were compared between NVE and PVE. Outcome endpoints were stratified by categories of clinical significance. Continuous variables are presented as medians and interquartile ranges [IQR] and categorical variables as percentages. Continuous variables were compared with the Wilcoxon rank-sum test and categorical variables with the x^2 test. A *P*-value less than 0.05 was considered statistically significant.

Variables of clinical significance in the surgical treatment of active aortic valve endocarditis were selected: PVE, valve prosthesis, ARR, root abscess, staphylococcus aureus, illicit drug abuse, and unplanned procedures (CABG, mitral valve surgery, or tricuspid valve surgery). The STS 2018 valve model was the basis for a multivariable analysis [8]. The standard variables of the STS 2018 valve model are listed in Supplemental Table 1. Considering the suspected collinearity between ARR, homograft

replacement, and annular abscess, the multivariable analysis was readjusted after excluding ARR. Risk models for operative mortality and for combined major morbidity or mortality were developed with generalized estimating equations to account for center variation and used independent working correlation to examine associations between variables of interest and outcomes.

Because the data accessed represent a limited data set (no direct patient identifiers) originally collected for nonresearch purposes, and the investigators are blinded to the identity of individual patients, the analysis was declared by the Duke University Health System Institutional Review Board as research not involving human subjects, and waiver of consent for use of de-identified data was obtained.

Results

From 2011 to 2019, 2,389,651 patients were identified in the STS ACSD, 24,262 of whom underwent AVR or ARR for active aortic valve endocarditis. PVE represented 20.9% of the cases in 2011, peaked to 26.3% in 2016, and leveled to 25.9% in 2019 (trend p<0.0001). The corresponding operative mortality decreased from 10.9% to 8.5% (trend p<0.001) for NVE and from 22.5% to 10.4% (trend p-value<0.0001) for PVE; Figure 1. The trends in volume of PVE and operative mortality were stratified by four standardized regions (Northeast, South, West, and Midwest). The trend in the volume of PVE and operative mortality appeared to be congruent with the nationwide pattern, except for the West.

From 2014 to 2019, 1,550,125 operative records were utilized for the comparison between NVE and PVE, and for the risk modeling of outcomes; active endocarditis was present in 33,516 and active aortic endocarditis in 17,371. Following the exclusion criteria, 9,768 patients remained for the analysis. Figure 2 illustrates the sequential exclusion of patient groups.

NVE was present in 70.1% (6,842/9,768) and PVE in 29.9% (2,926/9,768). AVR was performed in 77.6% (7,584/9,768) and ARR in 22.4% (2,184/9,768). Patients with PVE were older (62 versus 52; p<0.0001), more likely men (81.9% versus 77.18%; p <0.0001) and had diabetes (28.6% versus 25.0%; p<0.0001); less frequently had dialysis-dependent renal failure (10.4 versus 11.2%; p<0.0001), recent illicit drug use (11.2% versus 24.3%; p<0.0001), or moderate/severe aortic insufficiency (40.4% versus 90.7%-p<0.0001). Cardiopulmonary bypass and aortic-clamp times were longer in PVE. Intraoperative blood product transfusion, aortic root abscess, aortic root replacement, and homograft implantation were more prevalent in PVE. Table 1 and Table 2 list the preoperative and operative data, respectively, for NVE and PVE.

Operative mortality and combined major morbidity or mortality occurred more frequently in PVE (12.2% versus 6.4%; p<0.0001; 42.9% versus 30.5%; p<0.0001; respectively). All the morbidity endpoints were significantly more frequent in PVE. Of note, the permanent pacemaker rate was starkly higher in PVE (16.6% versus 5.6%; p<0.0001). Individual outcomes for NVE and PVE are listed in Supplemental Table 2. PVE following TAVR was identified in 86 patients, with an operative mortality of 14.0% (12/86).

Operative mortality according to prosthesis type was highest with homograft implantation; 10.2% in NVE and 14.5% in PVE. In the ARR group, the bioprosthetic category could only be stratified into stented valve composite graft (n=148) and stentless biologic full root (n=143) in version 2.9 (starting 2017), with operative mortalities of 13.9% and 15.4%, respectively. Supplemental Table 3 presents the outcomes according to prosthesis type.

Operative mortality was higher in ARR compared to AVR in NVE (11.8% versus 5.7%; p<0.0001) and PVE (14.7% versus 9.6%; p<0.0001). After stratifying the patient groups according to the extent of aortic valve surgery, PVE retained a higher operative mortality than NVE in AVR (9.6% versus 5.7%; p<0.0001) and, although less pronounced, in ARR (14.7% versus 11.8%; p=0.045). Unplanned CABG was present in 8.2% of ARR and 1.3 % in AVR, with mortality rates of 32.0% and 40.2%, respectively. Operative outcomes according to the extent of aortic valve surgery are listed in Supplemental Table 4.

In the univariable analysis, PVE, valve prosthesis (homograft greater than biologic and biologic greater than mechanical prosthesis), aortic root replacement, aortic root abscess, staphylococcus endocarditis, and unplanned CABG or unplanned concomitant surgery in the mitral or tricuspid valves correlated with a higher operative mortality. Of note, there were 16 patients in our cohort (n=9,768) who had both unplanned MV and unplanned CABG, with a mortality of 62.5% (10/16). Illicit drug abuse, recent or remote, did not have a significant effect. Table 3 summarizes the operative mortality for the selected variables of clinical relevance.

Following risk-adjustment, PVE compared to NVE remained as a risk factor for operative mortality, although the strength of the association was lower in the multivariable (OR=1.5; 95% CI:1.16-1.94; p=0.0019) compared to the univariable (OR=2.01; 95% CI:1.34-1.94; p=0.0019) analysis. Aortic root replacement (OR=1.49; 95% CI:1.15-1.92; p<0.001), staphylococcus aureus (OR=1.5; 95% CI:1.23-1.82; p<0.001), and unplanned CABG (OR=5.83; 95% CI:4.12-8.23; p<0.001) or mitral valve surgery (OR=2.29; 95% CI:1.5-3.51; p<0.001) correlated with an increased operative mortality. Prosthesis type (p=0.83) and remote or recent illicit drug abuse (p=0.84) were not associated with an increased operative mortality. To reduce the effect of collinearity, an iteration of the model excluding aortic root replacement

confirmed PVE as a significant predictor of operative mortality (OR=1.6; 95% CI:1.24-2.06; p<0.001). The risk model performed relatively well (c-stat 0.8203). Table 4 presents the results of the risk models for operative mortality and for any major morbidity in all the study patients. Supplemental Table 5 presents the results of the risk model restricted to patients with PVE.

Comment

Studies assessing the trends of IE have reported conflicting results. Few studies have addressed the incidence variation of IE, largely combining medical and surgical treatments. A study of the trends of IE in California and New York State showed that the standardized annual incidence remained stable from 1998 to 2013, but the proportion of PVE increased from 12.0% to 13.8% ($p<0.001$) [9]. A trend analysis from the National Inpatient Sample identified a downtrend in the risk-adjusted mortality of NVE from 16.7% in 2002 to 9.7% in 2016 ($p<0.01$) [10]. Contrastingly, registries from Denmark, Finland, and Germany have shown an uptrend of IE, without a specific variation in mortality rates. It appears that at least in the U.S., the incidence of IE has not varied significantly.

There is a paucity of reports regarding trends in the surgical treatment of IE. A recent analysis from STS ACSD found sustained growth in the surgical treatment of IE, primarily driven by an increase in drug-related cases, which accounted for 24% of operations, however, without specific data on trends of PVE or outcomes [11]. STS ACSD does not provide data regarding trends in the incidence of overall IE; however, our findings indicate that the relative surgical volume of PVE has slowly increased, and the operative mortality has declined for NVE and PVE in the last decade.

Outcomes of NVE and PVE have been compared in numerous studies, largely at single institutions with limited patient populations, not allowing a meaningful risk-adjusted analysis. Furthermore, most studies combine outcome endpoints for medical and surgical treatments, clustering different valves and active and treated endocarditis. STS ACSD reflects the nationwide practice of cardiac surgery and affords the versatility to focus on more homogeneous patient cohorts. In view of the expansion of transcatheter aortic valve replacement, aortic valve surgery may soon center heavily on IE; therefore, we decided to concentrate on cases of aortic valve endocarditis. Our inclusion and exclusion criteria centered on a patient group in the acute phase of the disease and at least suspected to be limited to the aortic valve, thus excluding cases with other planned valve procedures or planned CABG. The final study group represented patients with active aortic valve endocarditis and planned aortic valve surgery as the sole indication.

Our findings reveal that NVE and PVE show important differences. Notably, patients with PVE are older and had more comorbidities, although dialysis-dependent renal failure and illicit drug use were less prevalent. These findings are consistent with previous reports of older age and higher prevalence of comorbidities in PVE [12]. The extension of the infectious process in PVE was clearly more pronounced, as noted by higher rates of aortic root abscess and aortic root replacement. The surgical treatment of IE commonly involves aggressive surgical debridement and, particularly in PVE, often requires complex reconstructive strategies. Aortic root replacement and homograft implantation have been the preferred approach to PVE in various large institutional studies, with favorable outcomes [13].

The operative risk of PVE compared to NVE has been reported in univariable analyses [3,4,14,15], but few studies have presented risk-adjusted comparisons, which have been largely underpowered [14,16]. An increased risk of PVE versus NVE has been noted in few studies [14-16], however, has not been identified in others [3,4]. According to our findings, aortic valve surgery in PVE had a two-fold higher unadjusted operative mortality risk, which tempered to a 50% higher risk following risk-adjustment. Since reoperation is inherent to the definition of PVE, the multivariable analysis could not adjust for "reoperation"; therefore, NVE with prior cardiac surgery, which amounted to less than 9% of NVE, was excluded. The elevated operative risk of reoperations in isolated aortic valve surgery has been clearly documented from the STS ACSD (risk-adjusted OR:2.11; 95% CI:1.78, 2.49) [17]. It cannot be determined whether the higher operative risk in PVE versus NVE derives from a reoperation or the recurrence of the infectious process because reoperation is incorporated in the definition of PVE and is generally absent in NVE. Parallel to a higher operative mortality in PVE, the operative morbidity endpoints were significantly higher. Notably, permanent pacemaker implantation was over three-fold higher in PVE, which represent an ominous finding as it is a marker for decreased long term survival.

Other variables of clinical relevance were investigated. Prosthesis type and aortic root abscess lost statistical significance, while aortic root replacement and staphylococcus aureus endocarditis remained as significant risk factors. Illicit drug abuse did not show a higher operative mortality risk in the univariable or the multivariable analysis. PVE, aortic root abscess, homograft implantation, and aortic root

replacement are closely related and overlap each other. However, our risk-adjusted analysis shows that only PVE and aortic root replacement independently correlate with operative mortality. Our findings suggest that the elevated operative mortality risk in the surgical treatment of aortic IE hinges on the local extent of aortic valve disease, which often requires an aortic root replacement to control the infectious process. Therefore, it is likely that ARR and homograft implantation, which belongs to the ARR category, are surrogates for a more advanced infectious process. To our knowledge, a robust multivariable comparison between outcomes of NVE and PVE has not been previously conducted.

An increased mortality risk with additional cardiac procedures has been reported in few studies [18,19]. However, the risk significance of unsuspected findings requiring further cardiac procedures, namely CABG or other valve surgeries, has not been previously studied. In 2014, STS ACSD incorporated the dichotomous variable "planned/unplanned" for CABG and valve operations. Our study centered on the planned surgical treatment of active aortic valve endocarditis, excluding other planned valve surgeries but allowing the risk assessment of any unplanned procedures. According to our findings, an unplanned CABG or mitral valve operation carries nearly five- and three-fold increase in operative mortality risk, respectively. To our knowledge, a similar finding has not been previously reported. The rate of unplanned CABG was nearly eight-fold higher in ARR compared to AVR, which likely reflects challenges in coronary button reimplantation, inherent to ARR. Although a statistically significant difference was not identified in the operative mortality rates of unplanned CABG between ARR and AVR, the number of patients in these categories were very small, likely rendering the comparison underpowered.

There are several limitations to acknowledge. The STS ACSD is restricted to the surgical management of endocarditis and presents a biased substrate that excludes patients not offered surgical treatment, in particular the controversial patient with relapses in illicit drug use and commonly denied surgery for recurrent PVE. The definitions of NVE, PVE, AVR, and ARR in STS ACSD are precise but contingent upon the proper determination at participating institutions; therefore, coding errors are conceivable. The allocation to an "unplanned" procedure was determined by the surgical judgement of individual surgeons, without established criteria. The definition of illicit drug use lacks granularity and is all inclusive of

marijuana and drugs administered through injection or other routes. The data completeness of the STS ACSD is remarkable; nevertheless, up to 1% of missing entries can be found in various categories. The 2018 STS Valve Risk model was the basis for the multivariable analysis and has been extensively validated for valve surgery, however, this model is not optimized for IE. We attempted to enhance the model by including variables relevant to this patient population. Although the risk model developed performed well, there was not a predefined training/validation cohort as developing a prediction model was not the primary objective of the study

In summary, PVE relative to NVE in the surgical treatment of aortic IE has steadily increased over the last decade, while operative mortality has declined. Aortic root replacement, aortic root abscess, and homograft implantation are predominant in PVE, suggesting a more extensive aortic involvement. Following risk-adjustment, prosthesis type and aortic root abscess did not correlate with operative mortality. Contrastingly, PVE and ARR remained as independent risk factors. Unplanned CABG or mitral valve surgery carried a distinctly elevated operative risk. PVE showed a modest increase in the operative mortality risk, likely related to an inherent more extensive infectious process. PVE by itself should not deter surgical treatment, however, consideration to patient groups with higher risk profiles is necessary. Future studies that focus on contemporary and less heterogeneous patient groups of PVE are needed to optimize risk stratification and informed consent.

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Table 1. Preoperative characteristics

Characteristic	NVE (n=6842)	PVE (n=2926)	*P*-value
Age, years, median (IQR)	52 (40-62)	62 (50-71)	<.0001
Female	1554 (22.7)	531 (18.2)	<.0001
Diabetes	1706 (25.0)	833 (28.6)	0.0003
Hypertension	3747 (55.1)	2209 (75.7)	<.0001
Arrhythmia	954 (14)	1040 (35.7)	<.0001
Current smoker	2608 (38.7)	553 (19.2)	<.0001
Chronic lung disease (moderate/severe)	783 (12.0)	258 (9.0)	0.0018
Cerebrovascular disease	1984 (29.4)	1195 (41.1)	<.0001
Preoperative dialysis	764 (11.2)	173 (5.9)	<.0001
Endocarditis (culture)			
Staphylococcus aureus	1338 (20.7)	539 (19.6)	<.0001
Streptococcus species	2209 (34.1)	693 (25.16)	
Coagulase negative staphylococcus	227 (3.5)	186 (6.8)	
Enterococcus species	1245 (19.2)	440 (16.0)	
Other	532 (8.2)	371 (13.5)	
Culture negative	686 (10.6)	358 (13)	
Illicit drug use, recent	1711 (25.8)	297 (10.4)	<.0001
Previous CABG	0 (0)	580 (19.8)	<.0001
Previous valve procedure	0 (0)	2926 (100.0)	<.0001
First cardiovascular surgery	6837 (100)	0 (0.0)	<.0001
Ejection fraction	58 (53-63)	58 (53-63)	0.002
Aortic insufficiency (moderate/severe)	6158 (90.7)	1127 (40.4)	<.0001

Values are expressed as median (IQR) or n (%)

IQR=interquartile range

CABG=coronary artery bypass grafting

NVE=native valve endocarditis

PVE=prosthetic valve endocarditis

Table 2. Operative characteristics

Operative data	NVE (N=6842)	PVE (N=2926)	*P*-value
Cardiopulmonary bypass time, minutes, median (IQR)	105 (81-141)	189 (139-256)	<.0001
Aortic clamp time, minutes, median (IQR)	79 (61-107)	139 (100-184)	<.0001
Blood products intraoperatively	4104 (60.3)	2485 (85.3)	<.0001
Packed red blood cell units, median (IQR)	2 (1-3)	3 (1-5)	<.0001
Aortic root abscess	1691 (25.2)	1453 (50.1)	<.0001
Surgical procedure			
Aortic valve replacement	5966 (87.2)	1461 (49.9)	<.0001
Aortic root replacement	876 (12.8)	1465 (50.1)	
Valve implant type			
Homograft	277 (4.1)	790 (27.2)	<.0001
Mechanical	1174 (17.3)	297 (10.2)	
Bioprosthetic	5333 (78.6)	1822 (62.6)	
Unplanned CABG	112 (1.6)	177 (6.1)	<.0001
Unplanned MV repair	151 (2.2)	54 (1.9)	0.2516
Unplanned MV replacement	49 (0.7)	19 (0.7)	0.7139
Unplanned TV repair	32 (0.5)	20 (0.7)	0.1813
Unplanned TV replacement	9 (0.1)	1 (0.0)	0.1675

Values are expressed as median (IQR) or n (%)

IQR=interquartile range

CABG=coronary artery bypass grafting

MV=mitral valve

TV=tricuspid valve

NVE=native valve endocarditis

PVE=prosthetic valve endocarditis

Table 3. Unadjusted operative mortality: Selected categories

Category		Operative mortality (N=783/9616)	%	*P*-value
PVE	Yes	350/2880	12.2	<.0001
	No	433/6736	6.4	
Valve prosthesis	Homograft	141/1052	13.4	<.0001
	Mechanical	67/1456	4.6	
	Bioprosthetic	565/7036	8.0	
ARR	Yes	313/2297	13.6	<.0001
	No	470/7319	6.4	
Root abscess	Yes	390/3094	12.6	<.0001
	No	382/6374	6.0	
Staphylococcus	Yes	232/1846	12.6	<.0001
	No	502/7245	6.9	
Illicit drug abuse	Recent	150/1974	7.6	0.1198
	Remote	55/814	6.8	
	None	560/6553	8.6	
Unplanned CABG	Yes	107/286	37.4	<.0001

	No	676/9324	7.3	
Unplanned MV	Yes	51/267	19.1	<.0001
	No	731/9341	7.8	
Unplanned TV	Yes	10/62	16.1	0.0211
	No	772/9541	8.1	

PVE=prosthetic valve endocarditis

ARR=aortic root replacement

CABG=coronary artery bypass grafting

MV=mitral valve

TV=tricuspid valve

Table 4. Risk-adjusted analysis

	Operative Mortality		**Major Morbidity**	
Variable	aOR (95% CI)	*P*-value	aOR (95% CI)	*P*-value
PVE vs NVE	1.5 (1.16, 1.94)	0.0019	1.51 (1.31, 1.75)	<.0001
Valve prosthesis		0.8295		0.8859
Bioprosthetic (reference)	Reference		Reference	
Mechanical	0.9 (0.65, 1.25)		0.96 (0.82, 1.13)	
Homograft	0.96 (0.66, 1.4)		0.99 (0.79, 1.23)	
Aortic root replacement	1.49 (1.15, 1.92)	0.0023	1.45 (1.23, 1.7)	<.0001
Aortic root abscess	1.18 (0.96, 1.44)	0.1185	1.2 (1.06, 1.35)	0.0034
Staphylococcus aureus endocarditis	1.5 (1.23, 1.82)	<.0001	1.19 (1.05, 1.34)	0.006
Illicit drug abuse		0.8365		0.8378
None (reference)	Reference		Reference	
Remote	1.1 (0.8, 1.52)		0.95 (0.78, 1.15)	
Recent	1.03 (0.77, 1.39)		1 (0.85, 1.17)	
Unplanned CABG	5.83 (4.12, 8.23)	<.0001	1.46 (1.07, 2.01)	0.018
Unplanned MV	2.29 (1.5, 3.51)	0.0001	1.38 (1.03, 1.86)	0.0337
Unplanned TV	1.67 (0.82, 3.4)	0.1575	1.02 (0.58, 1.78)	0.9565

aOR=adjusted odds ratio

CI=confidence interval

NVE=native valve endocarditis

PVE=Prosthetic valve endocarditis

CABG=coronary artery bypass grafting

MV=mitral valve

TV=tricuspid valve

Figure 1. Trends (A) and outcomes (B) of native valve endocarditis (NVE) and prosthetic valve endocarditis (PVE) from 2011 to 2019.

Figure 2. Consort diagram of patient selection process. NVE=native valve endocarditis. PVE=prosthetic valve endocarditis

Figure-1

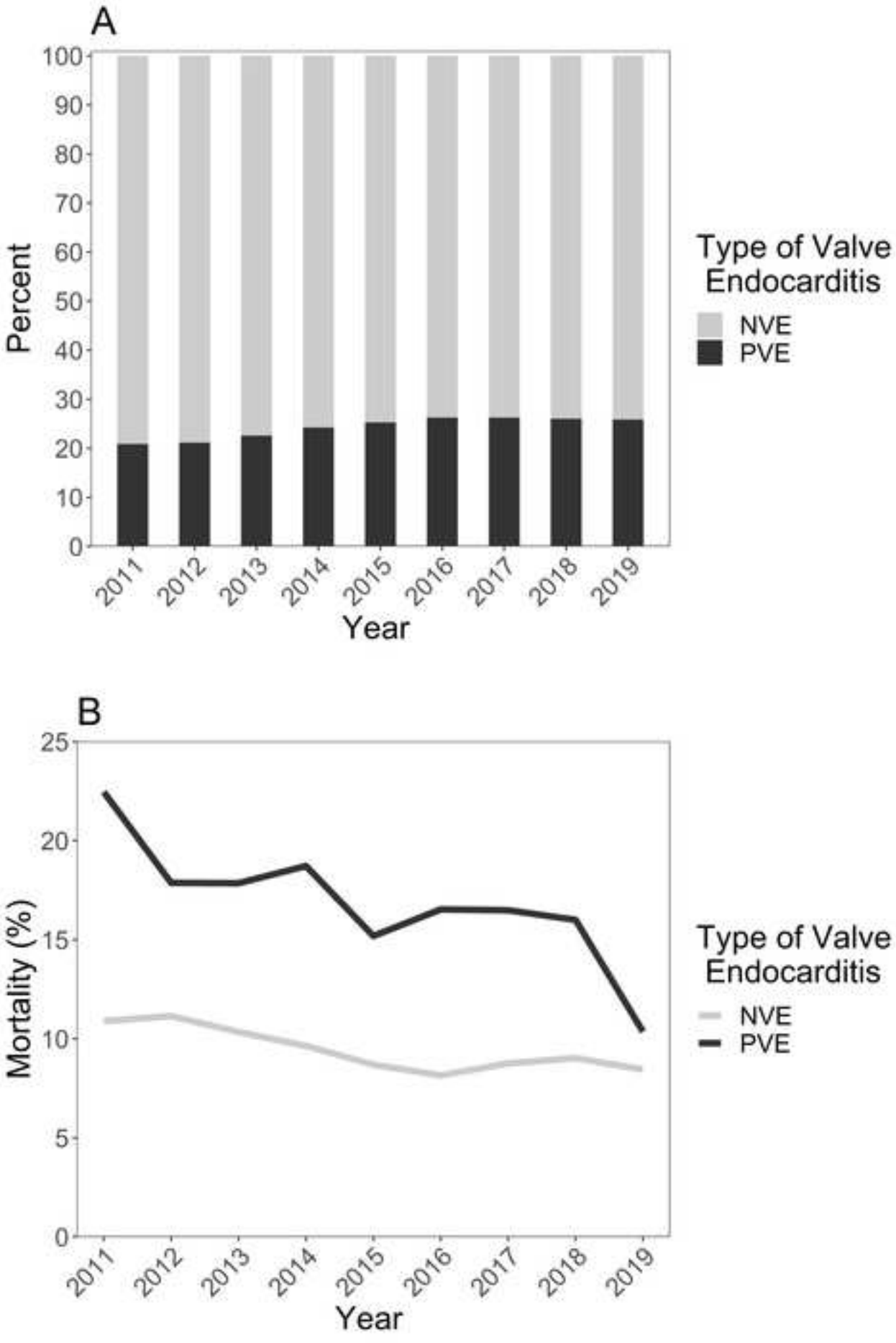
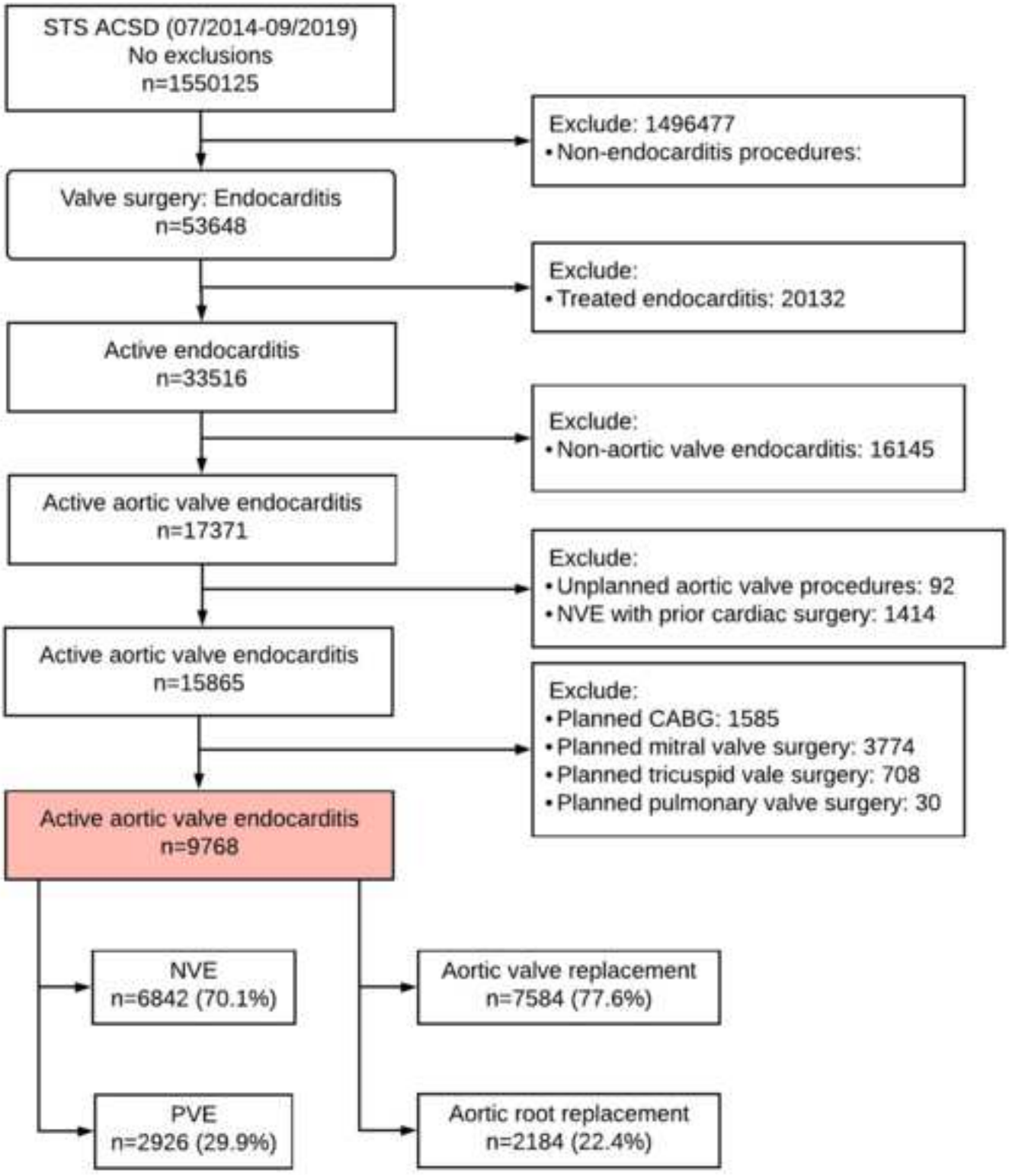

A
100
90
80
70
60
50
40
30
20
10
0
Percent
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year
Type of Valve Endocarditis
NVE
PVE
B
25
20
15
10
5
0
Mortality (%)
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year
Type of Valve Endocarditis
NVE
PVE

Figure-2


STS ACSD (07/2014-09/2019)
No exclusions
n=1550125
Exclude: 1496477
• Non-endocarditis procedures:
Valve surgery: Endocarditis
n=53648
Exclude:
• Treated endocarditis: 20132
Active endocarditis
n=33516
Exclude:
• Non-aortic valve endocarditis: 16145
Active aortic valve endocarditis
n=17371
Exclude:
• Unplanned aortic valve procedures: 92
• NVE with prior cardiac surgery: 1414
Active aortic valve endocarditis
n=15865
Exclude:
• Planned CABG: 1585
• Planned mitral valve surgery: 3774
• Planned tricuspid vale surgery: 708
• Planned pulmonary valve surgery: 30
Active aortic valve endocarditis
n=9768
NVE
n=6842 (70.1%)
Aortic valve replacement
n=7584 (77.6%)
PVE
n=2926 (29.9%)
Aortic root replacement
n=2184 (22.4%)