Influence of concomitant ablation of nonparoxysmal atrial fibrillation during coronary artery bypass grafting on mortality and readmissions

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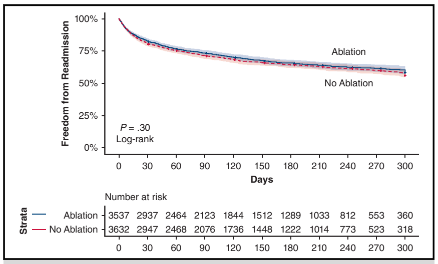
ABSTRACT

Objective: We determined the utilization rate of surgical ablation (SA) during coronary artery bypass grafting (CABG) and compared outcomes between CABG with or without SA in a national cohort.

Methods: The January 2016 to December 2018 Nationwide Readmissions Database was searched for all patients undergoing isolated CABG with preoperative persistent or chronic atrial fibrillation by using the International Classification of Diseases, 10th Revision classification. Propensity score matching and multivariate logistic regressions were performed to compare outcomes, and Cox proportional hazards model was used to assess risk factors for 1-year readmission.

Results: Of 18,899 patients undergoing CABG with nonparoxysmal atrial fibrillation, 78% (n = 14,776) underwent CABG alone and 22% (n = 4123) underwent CABG with SA. In the propensity score-matched cohort (n = 8116), CABG with SA (n = 4054) (vs CABG alone [n = 4112]) was not associated with increased in-hospital mortality (3.4% [139 out of 4112] vs 3.9% [159 ut of 4054]; *P* = .4), index-hospitalization length of stay (10 days vs 10 days; *P* = .3), 30-day readmission (19.1% [693 out of 3362] vs 17.2% [609 out of 3537]; *P* = .2), or 90-day readmission (28.9% [840 out of 2911] vs 26.2% [752 out of 2875]; *P* = .1). Index hospitalization costs were significantly higher for those undergoing SA ($52,556 vs $47,433; *P* < .001). Rates of readmission at 300 days were similar between patients receiving SA (43.8%) and no SA (42.8%; log-rank *P* = .3). The 3 most common causes of readmission were not different between groups and included heart failure (24.3% [594 out of 2444]; *P* = .6), infection (16.8% [411 out of 2444]; *P* = .5), and arrhythmia (11.7% [286 out of 2444]; *P* = .2).

Conclusions: In patients with nonparoxysmal atrial fibrillation, utilization of SA during CABG remains low. SA during CABG did not adversely influence mortality or short-term readmissions. These findings support increased use of SA during CABG. (JTCVS Open 2023;16:355-69)



One-year readmission after CABG in patients with nonparoxysmal atrial fibrillation.

CENTRAL MESSAGE

Despite its safety, surgical ablation in patients with nonparoxysmal atrial fibrillation undergoing coronary artery bypass grafting has a low utilization rate in the United States.

PERSPECTIVE

Despite a Class I indication, use of concomitant ablation in patients with nonparoxysmal atrial fibrillation undergoing coronary artery bypass grafting is low. Its use may be limited by concerns of the influence on operative outcomes. Using a large national database, we found that surgical ablation did not adversely influence in-hospital mortality or 1-year readmissions.

See Discussion on page 370.

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Abbreviations and Acronyms

AF	= atrial fibrillation
CABG	= coronary artery bypass grafting
ICD-10-CM	= International Classification of Diseases, 10th Revision Clinical Modification
LOS	= length of stay
NRD	= Nationwide Readmissions Database
SA	= surgical ablation
STS	= Society of Thoracic Surgeons

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Atrial fibrillation (AF) is the most common adult arrhythmia worldwide and is associated with increased rates of stroke, heart failure, and mortality.[1-4] Over the past 2 decades, numerous studies have demonstrated that patients with AF undergoing cardiac surgery have decreased long-term survival if the AF is not treated.[1,5,6] Progression to chronic or persistent AF is more common with nonparoxysmal AF than with paroxysmal AF and is associated with increased adverse events, including heart failure hospitalization and systemic embolization.[7-9] Surgical ablation (SA) is a safe and effective treatment modality for patients undergoing cardiac surgery because it restores normal sinus rhythm and improves quality of life.[2,10] Furthermore, SA is preferred for those with nonparoxysmal AF because it is associated with long-term maintenance of normal sinus rhythm.[11,12] Concomitant SA is recommended for patients with AF who are undergoing coronary artery bypass grafting (CABG) with a Class I recommendation.[13] However, adoption of SA may be limited due to concerns of the influence on operative outcomes, especially in closed atrial operations.[14]

Although several studies have demonstrated the benefit of SA in patients with AF undergoing CABG, the national utilization rate of SA in patients with nonparoxysmal AF undergoing CABG is currently unknown.[5,15] Additionally, the influence of SA on hospital readmissions up to 1 year postoperatively has not been assessed in an all-payer cohort. The aims of the present study were to determine the utilization rate of concomitant SA and compare short-term outcomes in patients with nonparoxysmal AF undergoing CABG with or without SA in a large national cohort.

METHODS

Data Source

The Nationwide Readmissions Database (NRD) is the largest publicly available all-payer database of hospital readmissions in the United States.[16] The NRD uses a complex survey design with clustering and poststratification that enables national estimates of outcomes using survey-based statistics. Due to its ability to provide reliable linkage between different admissions, the NRD is an optimal data source for assessing readmissions. The NRD contains de-identified demographic, clinical, cost-related, and hospital-specific information on more than 35 million discharges annually. The survey-based design was accounted for in all aspects of the study, and survey-adjusted variances were used to calculate statistics. This methodology has been validated and used extensively in the literature.[17] Because patient and hospital information contained in the NRD is de-identified to comply with Health Insurance Portability and Accountability Act guidelines, this study was classified as exempt, and institutional review board approval was waived by the Baylor College of Medicine. Informed written consent for the publication of the study data was not required.

Study Cohort

We searched the NRD from January 2016 to December 2018 for patients with nonparoxysmal AF undergoing CABG by using the *International Classification of Diseases, 10th Revision, Clinical Modification* (ICD-10-CM) diagnosis codes I48.1 and I48.2. Patients undergoing CABG were identified using ICD-10 procedure codes 0201, 0211, 0212, and 0213. Table E1 includes all inclusion and exclusion ICD-10-CM codes. We then stratified patients by those who underwent concomitant SA (ICD-10-CM procedure code: 02560ZZ, destruction of right atrium, open approach; 02570ZZ, destruction of left atrium, open approach; 02580ZZ, destruction of conduction mechanism, open approach) and those who underwent isolated CABG without SA. All admissions, classified as elective or nonelective, were included. Additionally, in-hospital deaths were excluded from calculations other than inpatient mortality, as previously described.[18,19] A sensitivity analysis of only patients who were receiving preoperative oral anticoagulation therapy was performed.

Patient and Hospital Characteristics

We extracted patient characteristics from the database, including age, sex, payer, and median household income quartile. Comorbidity burden was assessed with the Elixhauser comorbidity index as defined by the Agency for Healthcare Research and Quality using the *comorbidity* R package.[20] Elective admission was examined as an admission characteristic. Hospital characteristics were teaching status, bed size (small, medium, or large), and urban location as defined by the NRD.

Index Hospitalization and Readmission Event Outcomes

The outcomes assessed in this study include index-hospitalization mortality, length of stay (LOS), cost, and 30-day, 90-day, and calendar-year readmission. Causes for readmission were determined by the principal cause of readmission listed for each diagnosis (ICD-10-CM codes) and were grouped into clinically relevant categories as previously described.[19] In-hospital mortality and LOS were evaluated for each discharge record. Hospital cost was calculated from total charges using the cost-to-charge ratio, a method established via the Health Care Cost and Utilization Project.[17]

Kaplan-Meier Readmission Analysis

A Kaplan-Meier analysis was performed to assess freedom from readmission over a calendar year. All discharges were assumed to occur on the last day of the month, and patients whose index procedure occurred in December were excluded because the NRD solely reports discharge month.[21] The significance between curves was assessed via a survey-adjusted log-rank test.

Propensity Score-Matched Analysis

Propensity score matching was performed to minimize the influence of confounding factors such as age, sex, elective status, and comorbidities (per the *comorbidity* R package) on CABG readmission comparisons, as previously described.[21,22] Propensity scores were evaluated using documented concomitant SA as a dependent variable in a survey-adjusted binomial logistic regression. Cohorts were matched using 1-to-1 nearest neighbor propensity score matching without replacement and a 0.05 caliper (*MatchIt* [version 4.2] R package). A graphical propensity overlay, standardized mean differences, and statistical differences between comorbidities were used to confirm match balance. Acceptable matching was determined via the absolute standardized mean difference < .05 (Figure E1).

Risk-Adjusted Analysis

Multivariable logistic regressions were used to determine risk factors associated with SA. With the use of area under the curve-guided regression variable selection among variables significant between cohorts and/or present in >5% of the cohorts, 80% of patients served as a training set, whereas the remaining 20% was used as independent data for model validation. Additionally, a Cox proportional hazard model was generated to identify the adjusted risk of readmission over a calendar year.

Statistical Analysis

We used R version 4.1 for all statistical analyses. To account for the sampling design of the NRD, we accounted for survey clustering and stratification by using the *survey* package in R. Outcomes of patients undergoing concomitant ablation and isolated CABG were assessed by using $\chi 2$ tests with the Rao and Scott adjustment for survey-based data for categorical variables. Continuous variables that were nonnormally distributed were compared by using Kruskal-Wallis analysis of variance. The results were presented as the frequency and percentage or as median values with the interquartile range, as appropriate. Less than 1% of values were missing in any category in our cohort; missing values were handled by replacing continuous values with the median of that variable for the overall cohort and replacing categorical values with the mode of that variable for the overall cohort. The matched nature of the data was accounted for in the after-propensity-score matching analysis.

RESULTS

Preoperative Characteristics

Between January 2016 and December 2018, 18,899 patients with nonparoxysmal AF underwent CABG: isolated CABG in 78.2% (n = 14,776) and CABG with concomitant SA in 21.8% (n = 4123) (Figure 1). Patients undergoing CABG with SA were younger (median age, 71 vs 73 years; $P < .001$) (Table 1) and more likely to undergo an elective operation (56.9% vs 50.3%; $P < .001$). Patients in the SA cohort had higher rates of valve disease (41.0% vs 31.5%; $P < .001$) and long-term anticoagulation use (66.4% vs 63.7%; $P = .04$) (Table 1), but lower rates of peripheral artery disease (15.1% vs 20.9%; $P < .001$), chronic obstructive pulmonary disease (24.4% vs 27.1%; $P = .022$), and renal disease (28.0% vs 33.1%; $P < .001$). Hospital characteristics were similar between the groups (Table 2). In the propensity score-matched cohort (n = 8116), 4054 patients underwent CABG with SA, and 4112 underwent isolated CABG. Rates of permanent pacemaker implantation were higher in patients undergoing isolated CABG in the unmatched cohorts (1335 out of 14,776 [9.0%] CABG-alone vs 271 out of 4123 [6.6%] CABG-SA; $P = .001$), but were not different after propensity score matching (333 out of 4054 [8.2%,] CABG-alone vs 271 out of 4112 [6.6%]; $P = .067$). However, we were unable to confirm if implantation was done pre-

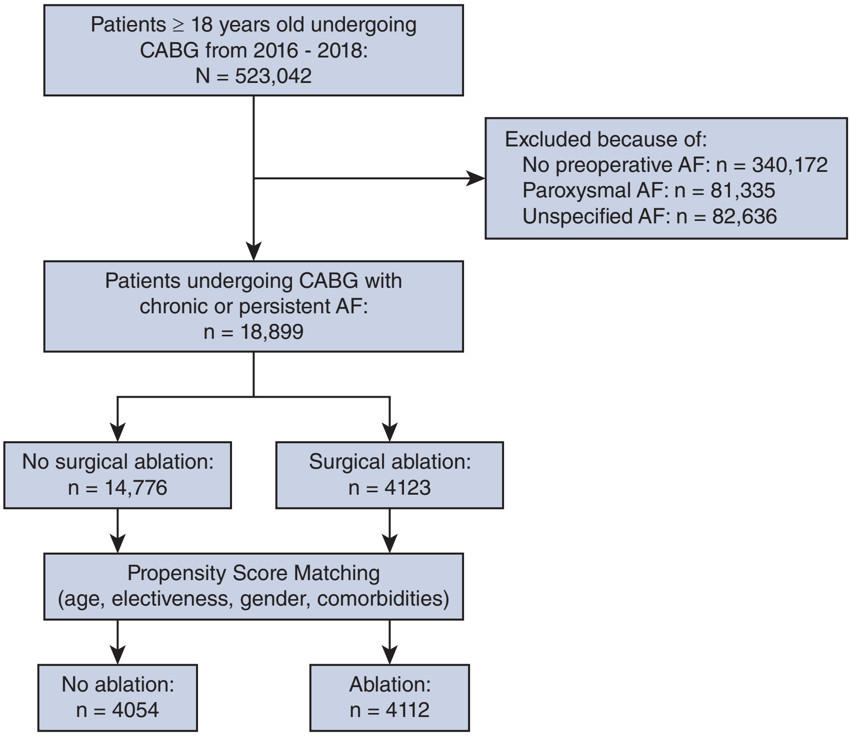

FIGURE 1. Flow diagram detailing the application of inclusion and exclusion criteria and the final cohort for analysis. *CABG*, Coronary artery bypass grafting; *AF*, atrial fibrillation.

TABLE 1. Characteristics and comorbidities of patients with chronic or persistent atrial fibrillation undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

Characteristic	Before propensity score matching CABG-only (n = 14,776)	CABG-SA (n = 4123)	P value*	Propensity score matched CABG-only (n = 4054)	CABG-SA (n = 4112)	P value*
Age (y)	73 (67-78)	71 (66-76)	<.001	71 (65-77)	71 (66-76)	.5
Age breakdown (y)			<.001			.034
<50	86 (0.6)	45 (1.1)		45 (1.1)	39 (0.9)	
50-64	2413 (16.3)	766 (18.6)		820 (20.2)	765 (18.6)	
65- 80	9251 (62.6)	2830 (68.6)		2615 (64.5)	2830 (68.8)	
> 80	3026 (20.5)	481 (11.7)		574 (14.2)	478 (11.6)	
Female	2663 (18.0)	794 (19.3)	.3	784 (19.3)	794 (19.3)	1.0
Elective	7439 (50.3)	2346 (56.9)	<.001	2307 (56.9)	2339 (56.9)	1.0
Income quartile			.4			.8
1	3714 (25.1)	955 (23.2)		985 (24.3)	953 (23.2)	
2	4385 (29.7)	1275 (30.9)		1227 (30.3)	1271 (30.9)	
3	3912 (26.5)	1091 (26.5)		1089 (26.8)	1087 (26.4)	
4	2765 (18.7)	802 (19.4)		754 (18.6)	802 (19.5)	
Primary payer			.023			.6
Medicaid	432 (2.9)	128 (3.1)		153 (3.8)	128 (3.1)	
Medicare	11,634 (78.7)	3115 (75.6)		3019 (74.5)	3111 (75.7)	
Private insurance	2183 (14.8)	746 (18.1)		729 (18.0)	740 (18.0)	
Self-pay	122 (0.8)	29 (0.7)		33 (0.8)	29 (0.7)	
Elixhauser score	18 (9-28)	17 (9-27)	.3	18 (9-27)	17 (9-27)	.9
Congestive heart failure	8684 (58.8)	2494 (60.5)	.2	2434 (60.0)	2483 (60.4)	.8
Arrhythmia	14,776 (100.0)	4123 (100.0)		4054 (100.0)	4112 (100.0)	
Valve disease	4652 (31.5)	1692 (41.0)	.001	1657 (40.9)	1685 (41.0)	1.0
Long-term anticoagulation use	9410 (63.7)	2736 (66.4)	.04	2593 (64.0)	2730 (66.4)	.12
Pulmonary circulation disorder	2088 (14.1)	634 (15.4)	.2	573 (14.1)	631 (15.3)	.3
Peripheral artery disease	3092 (20.9)	623 (15.1)	<.001	618 (15.2)	620 (15.1)	.9
Hypertension	13,507 (91.4)	3712 (90.0)	.055	3668 (90.5)	3701 (90.0)	.6
Chronic obstructive pulmonary disease	4009 (27.1)	1005 (24.4)	.022	1013 (25.0)	1002 (24.4)	.7
Diabetes mellitus	7279 (49.3)	1947 (47.2)	.1	1918 (47.3)	1947 (47.4)	1.0
Renal disease	4884 (33.1)	1154 (28.0)	<.001	1199 (29.6)	1150 (28.0)	.3
Liver disease	751 (5.1)	160 (3.9)	.052	148 (3.6)	160 (3.9)	.7
Coagulopathy	3876 (26.2)	1267 (30.7)	<.001	1227 (30.3)	1261 (30.7)	.8
Alcohol abuse	587 (4.0)	238 (5.8)	.001	221 (5.4)	232 (5.6)	.8
Drug abuse	186 (1.3)	65 (1.6)	.3	52 (1.3)	65 (1.6)	.4
Depression	1250 (8.5)	333 (8.1)	.6	271 (6.7)	330 (8.0)	.1

Values are presented as median (interquartile range) or n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation. *Kruskal-Wallis rank-sum test for complex survey samples; χ^2 test with Rao and Scott second-order correction.

or postoperatively. Patient characteristics and comorbidities were not different between the matched groups (Table 1). In assessing patients on preoperative oral anticoagulation therapy, patient characteristics and comorbidities were not different between matched groups (Tables E2 and E3).

Index Hospitalization Outcomes

In the propensity score-matched cohort, patients undergoing CABG alone or CABG with SA had similar rates of in-hospital mortality (3.9% CABG-alone vs 3.4% CABG-SA; P = .4) (Table 3) and index-hospitalization LOS (10 vs 10 days; P = .3). Index-hospitalization costs were significantly higher for those undergoing SA ($47,433 CABG-alone vs $52,556 CABG-SA; P < .001). Rates of left atrial appendage closure were higher in patients undergoing SA (5.4% CABG-alone vs 10.7% CABG-SA; P < .001). Outcomes were similar between groups in our analysis of patients who were receiving oral anticoagulation therapy (Table E4).

Predictors of SA

On multivariate regression analysis, patients with preoperative congestive heart failure (odds ratio [OR], 1.16; 95% CI, 1.02-1.32; P = .022) and those treated in a rural hospital

TABLE 2. Hospital characteristics of patients with chronic or persistent atrial fibrillation undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

	Before propensity score matching			Propensity score matched		
Comorbidity	CABG only (n = 14,776)	CABG-SA (n = 4123)	P value*	CABG only (n = 4054)	CABG-SA (n = 4112)	P value*
Bed size			.6			.7
Large	9828 (66.5)	2691 (65.3)		2667 (65.8)	2681 (65.2)	
Medium	3583 (24.3)	1007 (24.4)		1011 (24.9)	1007 (24.5)	
Small	1365 (9.2)	424 (10.3)		376 (9.3)	424 (10.3)	
Teaching			.4			.5
Metro nonteaching	2539 (17.2)	668 (16.2)		727 (17.9)	668 (16.3)	
Metro teaching	11,732 (79.4)	3344 (81.1)		3213 (79.2)	3337 (81.1)	
Nonmetro	505 (3.4)	110 (2.7)		115 (2.8)	107 (2.6)	
City size			.4			.2
Large metropolitan	7605 (51.5)	2135 (51.8)		2102 (51.8)	2132 (51.8)	
Micropolitan	461 (3.1)	110 (2.7)		101 (2.5)	107 (2.6)	
Nonurban residual	44 (0.3)	0 (0.0)		14 (0.3)	0 (0.0)	
Small metropolitan	6666 (45.1)	1878 (45.5)		1838 (45.3)	1873 (45.5)	

Valueas are presented as n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation. *Kruskal-Wallis rank-sum test for complex survey samples; chi-squared test with Rao and Scott second-order correction.

(OR, 1.32; 95% CI, 1.07-1.62; $P = .009$) were more likely to undergo CABG with SA (Figure 2). Patients older than age 65 years (OR, 0.79; 95% CI, 0.66-0.94; $P = .007$), those undergoing nonelective operations (OR, 0.80; 95% CI, 0.71-0.91; $P < .001$), and those with preoperative peripheral vascular disease (OR, 0.75; 95% CI, 0.64-0.88; $P < .001$) or renal disease (OR, 0.87; 95% CI, 0.75-0.99; $P = .04$) were less likely to undergo concomitant SA. Low-income patients, defined as those in the lowest income quartile, appeared to be less likely to receive SA (OR, 0.87; 95% CI, 0.75-1.002; $P = .053$); however, this trend did not reach statistical significance.

Readmission Rates at 30 and 90 Days

In the propensity score-matched cohort, patients undergoing CABG with SA had similar rates of 30-day (17.2%

TABLE 3. Outcomes of patients with chronic or persistent atrial fibrillation undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

	Before propensity score matching			Propensity score matched		
Outcome	CABG only (n = 12,839)	CABG-SA (n = 3643)	P value*	CABG only (n = 3537)	CABG-SA (n = 3632)	P value*
In-hospital mortality	636/14,776 (4.3)	139/4123 (3.4)	.1	159/4054 (3.9)	139/4112 (3.4)	.4
LOS (d)	10 (7-16)	10 (7-16)	.2	10 (7-15)	10 (7-16)	.3
Cost ($)	48,044 (35,650-67,652)	52,628 (40,310-71,870)	<.001	47,433 (35,572-67,878)	52,556 (40,296-71,843)	<.001
Left atrial appendage occlusion	743 (5.0)	440 (10.7)	<.001	221 (5.4)	440 (10.7)	<.001
Disposition			.1			.4
Home health care	5147 (40.1)	1441 (39.5)		1451 (41.0)	1438 (39.6)	
Routine	3257 (25.4)	1035 (28.4)		960 (27.1)	1030 (28.4)	
SNF or ICF	4294 (33.4)	1136 (31.2)		1092 (30.9)	1133 (31.2)	
30-d readmissions	2370 (18.5)	695 (19.1)	.6	609 (17.2)	693 (19.1)	.2
90-d readmissions	2961/10,463 (28.3)	841/2920 (28.8)	.7	752/2875 (26.2)	840/2911 (28.9)	.1
Died on readmission	173/14,776 (1.2)	51/4123 (1.2)	.8	20/4054 (0.5)	51/4112 (1.2)	.008
Readmission LOS (d)	4 (2-7)	4 (2-8)	.2	4 (2-7)	4 (2-8)	.3
Readmission cost ($)	9280 (5221-18,092)	9664 (5514-18,463)	.3	9360 (5147-17,382)	9665 (5510-18,542)	.3
Elective readmission	509/14,776 (3.4)	155/4123 (3.8)	.5	135/4054 (3.3)	155/4112 (3.8)	.5

Values are presented as n/N (%), median (interquartile range), or n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation; *LOS*, length of stay; *SNF*, skilled nursing facility; *ICF*, intermediate care facility. *Kruskal-Wallis rank-sum test for complex survey samples; χ^2 test with Rao and Scott second-order correction.

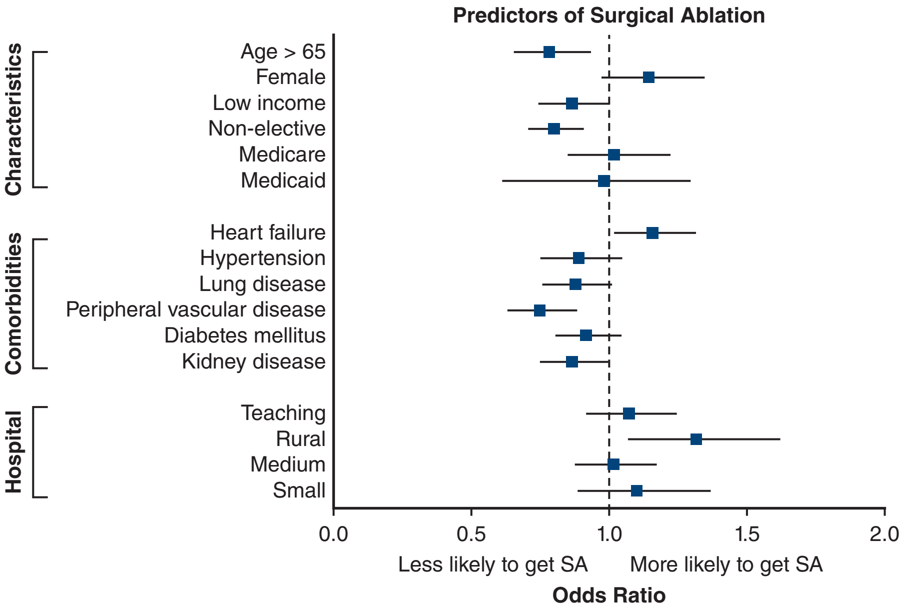

FIGURE 2. Forest plot depicting predictors of receiving surgical ablation during coronary artery bypass grafting. *SA*, Surgical ablation.

CABG-alone vs 19.1% CABG-SA; $P = .2$) and 90-day readmissions (26.2% CABG-alone vs 28.9% CABG-SA; $P = .1$) (Table 3) compared with patients undergoing isolated CABG. Patients receiving SA had significantly higher rates of mortality during readmission (0.5% CABG-alone vs 1.2% CABG-SA; $P = .008$) than patients who did not receive SA.

Readmission Up to 1 Year

Rates of readmission at 300 days were similar between patients receiving SA (43.8%) and no SA (42.8%; log-rank $P = .3$) (Figure 3). The 3 most common causes of readmission were similar between groups and included heart failure (24.3% [594 out of 2444]; $P = .6$), infection (16.8% [411 out of 2444]; $P = .5$), and arrhythmia (11.7% [286 out of 2444]; $P = .2$) (Figure 4). Other predictors of readmission up to 1 year on the Cox proportional hazards model included renal disease (adjusted hazard ratio [aHR], 1.38; 95% CI, 1.28-1.49; $P < .001$), chronic pulmonary disease (aHR, 1.33; 95% CI, 1.21-1.45; $P < .001$), female sex (aHR, 1.25; 95% CI, 1.14-1.38; $P < .001$), congestive heart failure (aHR, 1.21; 95% CI, 1.11-1.31;

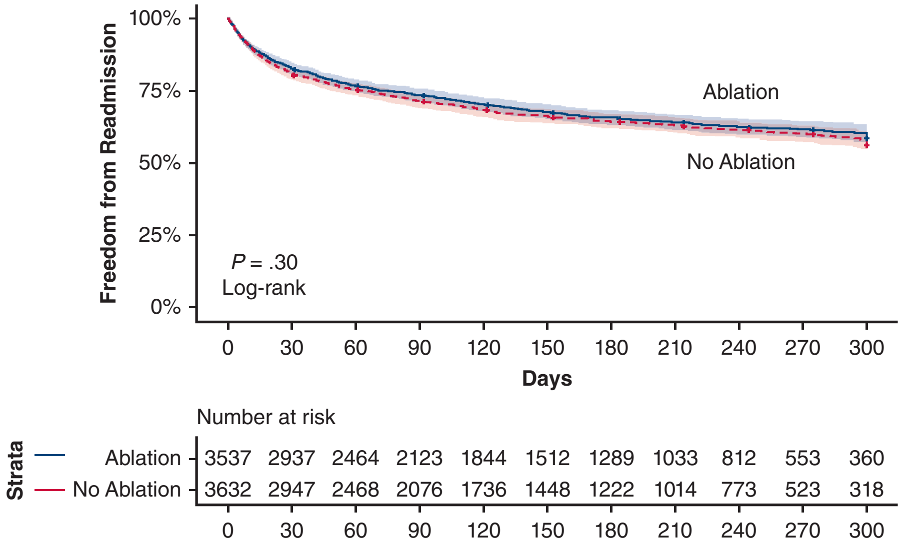

FIGURE 3. Kaplan-Meier estimates of readmission of patients with nonparoxysmal atrial fibrillation undergoing coronary artery bypass grafting with or without surgical ablation. Freedom from readmission within 1 year was similar between groups ($P = .3$, long-rank test). *Shaded areas* represent 95% CI.

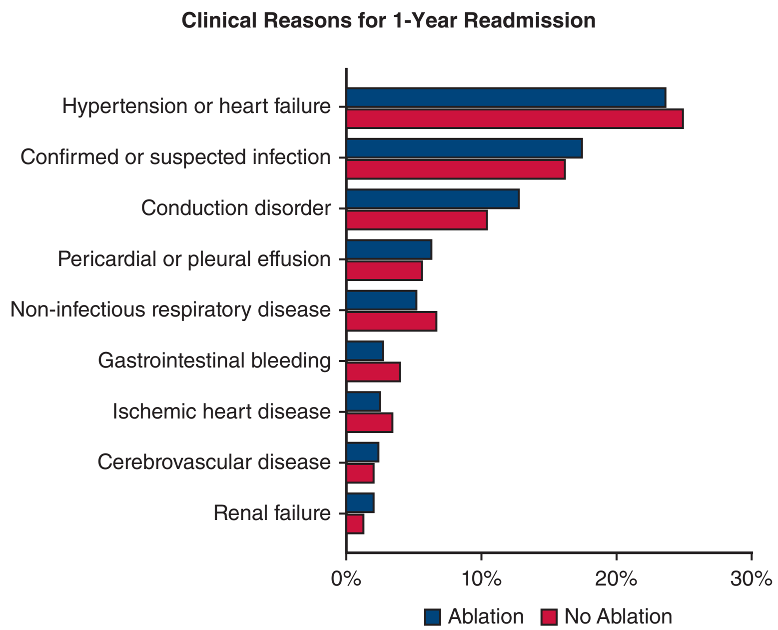

FIGURE 4. Clinical reasons for 1-year readmission for nonparoxysmal atrial fibrillation patients with or without concomitant surgical ablation.

$P < .001$), diabetes mellitus (aHR, 1.18; 95% CI, 1.08-1.28; $P < .001$), peripheral vascular disease (aHR, 1.13; 95% CI, 1.03-1.23; $P = .007$), pulmonary circulatory disorder (aHR, 1.11; 95% CI, 1.01-1.23; $P = .038$), and nonelective surgery (aHR, 1.09; 95% CI, 1.03-1.20; $P = .009$).

DISCUSSION

This study utilized propensity score matching and multivariable analysis with a large, all-payer database to assess the influence of concomitant SA on outcomes and 1-year readmissions in patients with nonparoxysmal AF undergoing CABG. Using this large, all-payer database, we found that the utilization of SA during CABG remains low despite a Class I recommendation. In our propensity score-matched analysis, SA during CABG did not influence in-hospital mortality, LOS, readmissions up to 1 year postoperatively, or causes of readmission but was associated with increased index-hospitalization costs. There was a trend of decreased SA utilization in low-income patients. These findings further support that concomitant SA is safe at the time of CABG.

There is robust evidence that survival is decreased in patients with AF who undergo cardiac surgery if AF is left untreated.[1,5,6] Our cohort mortality of 4% was higher compared with an all-comers isolated CABG cohort because our study group included only patients with preexisting AF. The presence of AF in patients undergoing CABG also substantially reduces long-term survival, with up to 24% greater 10-year mortality compared with those without AF.[23] Moreover, a systematic review and meta-analysis of 13 studies and more than 300,000 patients demonstrated that those with preexisting AF are at 64% higher risk of early mortality after CABG.[24] Even when including only propensity score-matched studies, preoperative AF was independently associated with a 56% higher risk of perioperative mortality.[24] Given these data, the Society of Thoracic Surgeons (STS) issued a class I recommendation for concomitant SA during isolated CABG in 2017.[13] Despite this recommendation, we found that national utilization of SA during CABG remained low during our study period, with less than one-quarter of patients receiving SA for nonparoxysmal AF. Using the STS Adult Cardiac Surgery Database, Badhwar and colleagues[2] found that from 2011 to 2014, patients undergoing CABG underwent concomitant SA 33% of the time, the lowest rate of any operation assessed. Our more recent cohort, which includes procedures performed outside of the STS Adult Cardiac Surgery Database, appears significantly lower. This discrepancy may represent nationwide practice variations in SA utilization. Emerging technologies that simplify and potentially reduce the time required to perform SA, such as the EnCompass device from AtriCure, may increase adoption of SA in patients undergoing CABG.[25]

The concern for a potentially increased risk of morbidity during CABG, where a left atriotomy is not otherwise indicated, has been cited as a potential explanation for the low use of concomitant SA.[14] In our propensity score-matched analysis of more than 8000 patients, SA during CABG did not influence perioperative or short-term outcomes, including in-hospital mortality, index hospitalization LOS, discharge disposition, or readmission up to 1 year. Rates of in-hospital mortality after CABG with SA have been mixed in previously published

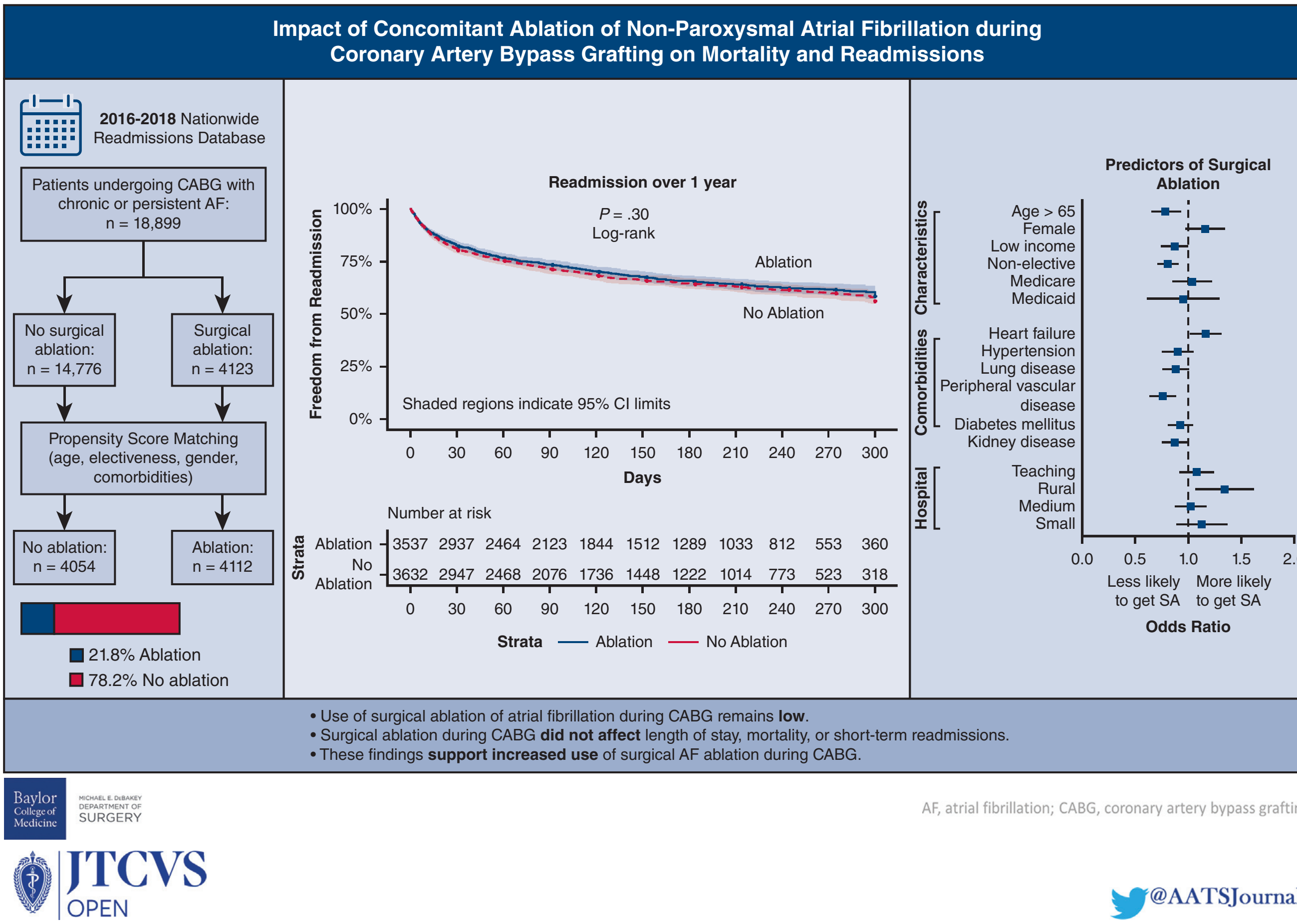

FIGURE 5. Influence of surgical ablation of nonparoxysmal atrial fibrillation (*AF*) during coronary artery bypass grafting (*CABG*) on mortality and readmissions. From 2016 to 2018, 18,899 patients with nonparoxysmal AF underwent CABG. A total of 4123 (21.8%) underwent concomitant surgical ablation and 14,776 (78.2%) underwent isolated CABG. After propensity score matching, surgical ablation was not associated with increased length of stay, in-hospital mortality, or readmissions up to 1 year. *SA*, Surgical ablation.

literature. In a large analysis of Medicare beneficiaries, Malaisrie and colleagues[5] demonstrated 27% greater odds of in-hospital mortality in CABG with SA than CABG alone. However, this finding contrasts with an analysis from Badhwar and colleagues[2] that found a lower in-hospital mortality rate in patients undergoing CABG with SA compared with those undergoing CABG with no SA. In our more contemporary, all-payer analysis that includes procedures not accounted for by the STS Adult Cardiac Surgery Database, in-hospital mortality was not different between propensity score-matched groups. Although an assessment of long-term mortality was not the purpose of this analysis, a significant mortality benefit for patients undergoing SA with CABG has been previously demonstrated.[5,26]

Index hospitalization LOS was similar between groups in our study, with both groups admitted for a median of 10 days. This conflicts with findings from a single-center study by Ad and colleagues,[14] which demonstrated an increased LOS in patients undergoing a Cox maze III procedure during CABG or aortic valve replacement (median, 6 days in SA vs 5 days in no SA); however, our results closely align with a national study of patients undergoing CABG with or without concomitant SA (median LOS, 9 days).[26] This difference may be due to the slightly less recent cohort in the single-center study, which assessed patients from 2005 to 2012, or to the fact that patients receiving aortic valve replacement and CABG plus aortic valve replacement were included. Finally, because of the intrinsic nature of the NRD, our hospital LOS includes both the preoperative and postoperative period; therefore, the actual postoperative LOS may have shown a similar difference to that of the findings of other investigators.

We found that concomitant SA during CABG was associated with increased index-hospitalization costs compared with CABG alone. This is somewhat unsurprising because the added initial costs of SA have been demonstrated to be more than $4000 Canadian dollars,[27] and the initial costs of catheter ablation have been shown to be as high as $26,656.[28] Our study, which found a $5123 US-dollar cost increase, aligns closely with the cost of SA revealed previously. Rankin and colleagues[26] demonstrated increased in-hospital costs in patients receiving SA during CABG but found that total inpatient costs were not different between groups after 2 years. Thus, an increased upfront cost appears to be balanced by lower resource utilization after surgery.

In our study, rates of readmission at 30 days, 90 days, and 1 year postoperatively were similar for patients undergoing CABG with SA and CABG alone. These findings support previously published results. Rankin and colleagues[26] found similar 1 and 2-year readmission rates in patients undergoing CABG with or without SA. Additionally, Ad and colleagues[14] found similar 30-day readmission rates in SA versus no SA groups. We also found that the most common reasons for readmission up to 1 year, which included heart failure, infection, and arrhythmia, were similar between the study groups. Notably, operative complications such as bleeding or pericardial or pleural effusions were not more common in patients undergoing CABG with SA. It is possible that if NRD readmission outcomes were available for up to 2 years, differences in readmission may have been seen.

Because the use of SA in patients with nonparoxysmal AF undergoing CABG was low, we assessed predictors of receiving concomitant SA in our cohort. We found that patients with preoperative congestive heart failure and those treated in a rural hospital were more likely to undergo SA. Patients older than age 65 years, those undergoing nonelective surgery, and those with preoperative peripheral vascular disease or renal disease were less likely to undergo SA. Low-income patients appeared to be less likely to receive SA, but this trend did not reach statistical significance. Studies assessing predictors of SA are limited, but Brancato and colleagues[29] found that patients were less likely to receive SA if they had previous cardiac surgery or if the primary surgeon was further out from training. Our finding that patients treated in rural hospitals were more likely to undergo SA at the time of CABG is somewhat surprising. We hypothesize that a large proportion of rural hospitals performing cardiac surgery are large academic centers that may be more likely to perform SA in general. Furthermore, rural hospitals may have fewer administrative restrictions and greater surgeon autonomy. However, both explanations are difficult to support with the NRD and require further study for confirmation. Our results point to opportunities to increase the adoption of SA during CABG, such as performing SA in patients older than age 65 years and in those with renal or peripheral vascular disease because these groups are likely to benefit from this procedure. Because CABG accounts for more than half of all cardiac surgeries performed in the United States,[30] concomitant SA represents a potential avenue for reducing AF-related morbidity and mortality.

Study Limitations

This study has a few important limitations, primarily due to the retrospective analysis of an administrative database such as the NRD. First, using ICD-10 coding, we were not able to determine the extent (eg, Cox maze procedure vs pulmonary vein isolation), location (eg, left atrial vs biatrial), or technique (eg, cryoablation vs radiofrequency ablation vs cut-and-sew technique) of the SA; we could ascertain only that it was performed using an open approach during CABG. It was also not possible to discern the anatomical or echocardiographic features of each patient, including the size of the atria, which may have influenced the decision to perform SA. In addition, we were unable to assess other surgical details pertinent to the discussion of SA, including operative time or duration of cardiopulmonary bypass. Second, we could not reliably discern if the SA procedure was successful because we could not assess the rate of postoperative patients who remained in normal sinus rhythm. However, the purpose of our study was not to assess the efficacy of SA, which has been demonstrated previously, but to assess the short-term safety, which has been cited as a potential concern affecting the use of SA during CABG.[2,13,14] Third, it is possible that rates of SA and outcomes are different for paroxysmal AF compared with nonparoxysmal AF. Thus, conclusions drawn for 1 form of AF may be different for another type of AF. In addition, we did not have information on anticoagulation (frequency of use, vitamin K antagonist vs direct oral anticoagulant), which may have influenced results. Fourth, although we used the primary diagnosis for the cause of readmission, some patients are readmitted for multiple diagnoses. Specifically, we were not able to assess whether the cause of readmission was related to a patient's procedure or to ascertain if a patient had multiple readmissions. Additionally, because stays in observation units are not technically coded as admissions, these were not captured by the NRD. Finally, because the NRD does not track out-of-hospital deaths, we were unable to perform a competing risks analysis for death versus readmission. Together, these limitations hindered our ability to assess many of the clinical details involved in a nuanced decision to perform SA during CABG. Despite these inherent limitations, the larger sample size and all-payer nature that databases such as the NRD can provide may produce more generalizable results, and the survey-adjusted statistics implemented in this study take into account the estimated variance from the assumptions used in the NRD's design.

CONCLUSIONS

In patients with nonparoxysmal AF, utilization of SA during CABG remains low. Surgical ablation during CABG did not influence mortality, short-term readmissions, or causes of readmission but was associated with increased index-hospitalization costs (Figure 5), although specific details on the type of SA are necessary to draw more firm conclusions. Older patients and those with renal or peripheral vascular disease were less likely to receive SA. These findings further support the safety of concomitant surgical AF ablation at the time of CABG and identify opportunities to increase the use of SA during CABG.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/impact-of-concomitant-ablation-of-non-paroxysmal-atrial-fibrillation-during-coronary-artery-bypass-grafting-on-mortality-and-readmissions.

Conflict of Interest Statement

Dr Coselli participates in clinical studies with and/or consults for Terumo Aortic, Medtronic, W. L. Gore & Associates, CytoSorbents, Edwards Lifesciences, and Abbott Laboratories and receives royalties and grant support from Terumo Aortic. Dr Moon serves on the advisory board for Medtronic. Dr Chatterjee has served on advisory boards for Edwards Lifesciences, La Jolla Pharmaceutical Company, Eagle Pharmaceuticals, and Baxter Pharmaceuticals. All other authors reported no conflicts of interest.

The *Journal* style requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: coronary artery bypass grafting, atrial fibrillation, surgical ablation, readmissions, Nationwide Readmissions Database

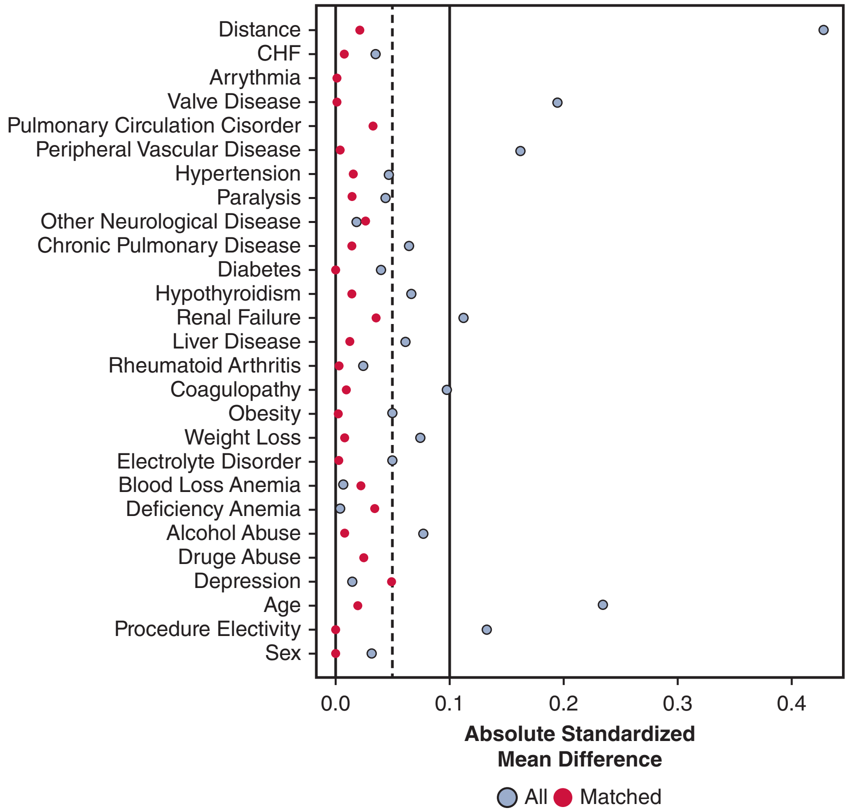

FIGURE E1. Love plot showing the absolute standardized mean differences between characteristics of ablation and no ablation cohorts before and after propensity score matching. *CHF*, Congestive heart failure.

TABLE E1. ***International Classification of Diseases-10th Revision*** **(ICD-10) codes used for patient inclusion and exclusion criteria**

Code*	Description
Codes used for inclusion	
ICD-10-PCS 0210	Bypass, coronary artery, 1 artery
ICD-10-PCS 0211	Bypass, coronary artery, 2 arteries
ICD-10-PCS 0212	Bypass, coronary artery, 3 arteries
ICD-10-PCS 0213	Bypass, coronary artery, 4 or more arteries
ICD-10-CM I48.1	Persistent atrial fibrillation
ICD-10-CM I48.2	Chronic atrial fibrillation
Codes used for exclusion	
ICD-10-CM I25.42	Coronary artery dissection
ICD-10-PCS 02QF	Repair, aortic valve
ICD-10-PCS 02QG	Repair, mitral valve
ICD-10-PCS 02QH	Repair, pulmonary valve
ICD-10-PCS 02QJ	Repair, tricuspid valve
ICD-10-PCS 02RF	Replacement, aortic valve
ICD-10-PCS 02RG	Replacement, mitral valve
ICD-10-PCS 02RH	Replacement, pulmonary valve
ICD-10-PCS 02RJ	Replacement, tricuspid valve
ICD-10-PCS 02H0	Insertion of device, coronary artery, 1 artery
ICD-10-PCS 02H1	Insertion of device, coronary artery, 2 arteries
ICD-10-PCS 02H2	Insertion of device, coronary artery, 3 arteries
ICD-10-PCS 02H3	Insertion of device, coronary artery, 4 or more arteries
ICD-10-PCS 02RX	Replacement of thoracic aorta, ascending/arch
ICD-10-PCS 02RW	Replacement of thoracic aorta, descending
ICD-10-PCS 02QX	Repair of thoracic aorta, ascending/arch
ICD-10-PCS 02QW	Repair of thoracic aorta, descending
ICD-10-PCS 02VX	Resection of thoracic aorta, ascending/arch
ICD-10-PCS 02VW	Resection of thoracic aorta, descending
ICD-10-PCS 02HX	Insertion of device, thoracic aorta, ascending/arch
ICD-10-PCS 02HW	Insertion of device, thoracic aorta, descending
ICD-10-PCS 04R0	Replacement of abdominal aorta
ICD-10-PCS 04Q0	Repair of abdominal aorta
ICD-10-PCS 04V0	Resection of abdominal aorta
ICD-10-PCS 04H0	Insertion of device, abdominal aorta

*All combinations of characters following the listed prefix were included.

TABLE E2. Characteristics of patients with chronic or persistent atrial fibrillation on preoperative oral anticoagulation undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

	Before propensity score matched			Propensity score matched		
Characteristic	CABG only (n = 9410)	CABG-SA (n = 2736)	*P* value*	CABG only (n = 2670)	CABG-SA (n = 2724)	*P* value*
Age (y)	73 (67-78)	71 (66-76)	<.001	71 (65-76)	71 (66-76)	.737
Age breakdown (y)			<.001			.001
<50	46 (0.5)	24 (0.9)		36 (1.3)	18 (0.7%)	
50-64	1460 (15.5)	524 (19.2)		601 (22.5)	521 (19.1)	
65-80	5964 (63.4)	1889 (69.0)		1656 (62.0)	1889 (69.3)	
>80	1940 (20.6)	299 (10.9)		378 (14.2)	296 (10.9)	
Female	1717 (18.2)	528 (19.3)	.467	485 (18.2)	528 (19.4)	.481
Elective	4899 (52.1)	1549 (56.6)	.004	1510 (56.5)	1539 (56.5)	.994
Income quartile			.133			.307
1	2338 (24.8)	618 (22.6)		641 (24.0)	612 (22.5)	
2	2834 (30.1)	900 (32.9)		784 (29.4)	896 (32.9)	
3	2508 (26.6)	676 (24.7)		729 (27.3)	673 (24.7)	
4	1731 (18.4)	543 (19.8)		516 (19.3)	543 (19.9)	
Primary payer			.018			.589
Medicaid	246 (2.6)	83 (3.0)		103 (3.8)	83 (3.0)	
Medicare	7435 (79.0)	2048 (74.8)		1940 (72.7)	2045 (75.1)	
Private insurance	1394 (14.8)	511 (18.7)		545 (20.4)	501 (18.4)	
Self-pay	82 (0.9)	23 (0.8)		26 (1.0)	23 (0.8)	

Values are presented as median (interquartile range) or n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation. *Kruskal-Wallis rank-sum test for complex survey samples; chi-squared test with Rao & Scott's second-order correction.

TABLE E3. Comorbidities of patients with chronic or persistent atrial fibrillation on preoperative oral anticoagulation undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

	Before propensity score matching			Propensity score matched		
Characteristic	CABG only (n = 9410)	CABG-SA (n = 2736)	*P* value*	CABG only (n = 2670)	CABG-SA (n = 2724)	*P* value*
Elixhauser score	17 (8-26)	16 (7-25)	.258	16 (7-25)	16 (7-25)	.749
Congestive heart failure	5323 (56.6)	1565 (57.2)	.694	1546 (57.9)	1557 (57.1)	.727
Arrhythmia	9410 (100.0)	2736 (100.0)		2670 (100.0)	2724 (100.0)	
Valve disease	3011 (32.0)	1123 (41.1)	<.001	1071 (40.1)	1114 (40.9)	.712
Pulmonary circulation disorder	1260 (13.4)	380 (13.9)	.646	370 (13.9)	377 (13.9)	>.999
Peripheral artery disease	2065 (21.9)	427 (15.6)	<.001	405 (15.2)	424 (15.6)	.796
Hypertension	8741 (92.9)	2514 (91.9)	.254	2498 (93.6)	2502 (91.8)	.113
Chronic obstructive pulmonary disease	2464 (26.2)	626 (22.9)	.024	599 (22.4)	620 (22.8)	.861
Diabetes mellitus	4977 (52.9)	1394 (51.0)	.243	1411 (52.8)	1390 (51.0)	.383
Renal disease	3034 (32.2)	764 (27.9)	.006	773 (29.0)	761 (27.9)	.598
Liver disease	371 (3.9)	97 (3.6)	.564	117 (4.4)	97 (3.6)	.380
Coagulopathy	2286 (24.3)	772 (28.2)	.009	735 (27.5)	770 (28.3)	.688
Alcohol abuse	347 (3.7)	151 (5.5)	.006	127 (4.8)	147 (5.4)	.452
Drug abuse	114 (1.2)	44 (1.6)	.293	38 (1.4)	44 (1.6)	.713
Depression	814 (8.7)	242 (8.8)	.845	215 (8.0)	239 (8.8)	.550

Values are presented as median (interquartile range) or n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation. *Kruskal-Wallis rank-sum test for complex survey samples; chi-squared test with Rao & Scott's second order correction.

TABLE E4. Outcomes of patients with chronic or persistent atrial fibrillation on preoperative oral anticoagulation therapy undergoing coronary artery bypass grafting (CABG) with and without concomitant surgical ablation (SA)

Characteristic	Before propensity score matching			Propensity score matched		
	CABG only (n = 8234)	CABG-SA (n = 2449)	*P* value*	CABG only (n = 2353)	CABG-SA (n = 2440)	*P* value*
In-hospital mortality	292/9410 (3.1)	74/2736 (2.7)	.466	64/2670 (2.4)	74/2724 (2.7)	.653
Length of stay (d)	10 (7-15)	10 (7-15)	.343	9 (7-14)	10 (7-15)	.453
Cost ($)	46,598 (35,186-64,683)	51,672 (39,961-69,620)	<.001	45,649 (33,581-65,285)	51,570 (39,924-69,220)	<.001
Disposition			.049			.112
Home health care	3394 (41.2)	961 (39.2)		1027 (43.6)	959 (39.3)	
Routine	2150 (26.1)	743 (30.3)		646 (27.4)	739 (30.3)	
Short-term hospital	71 (0.9)	26 (1.1)		18 (0.7)	26 (1.1)	
SNF or ICF	2607 (31.7)	719 (29.4)		657 (27.9)	716 (29.3)	
30-d readmissions	1447 (17.6)	447 (18.3)	.612	375 (15.9)	442 (18.1)	.184
90-d readmissions	1767/6665 (26.5)	531/1948 (27.3)	.667	484/1925 (25.1)	530/1943 (27.3)	.305
Readmission LOS (d)	4 (2-7)	4 (2-7)	.273	4 (2-7)	4 (2-7)	.182
Readmission cost ($)	9339 (5179-17,606)	9445 (5809-16,827)	.418	9239 (4751-20,123)	9430 (5809-16,697)	.471
Elective readmission	334/9410 (3.5)	105/2736 (3.8)	.616	122/2670 (4.6)	105/2724 (3.9)	.413

Values are presented as n/N (%), median (interquartile range) or n (%). *CABG*, Coronary artery bypass grafting; *SA*, surgical ablation; *LOS*, length of stay; *SNF*, skilled nursing facility; *ICF*, intermediate care facility. *Kruskal-Wallis rank-sum test for complex surey samples; chi-squared test with Rao & Scott's second-order correction.