A posterior pericardial chest tube is associated with reduced incidence of postoperative atrial fibrillation after cardiac surgery: A propensity score–matched study

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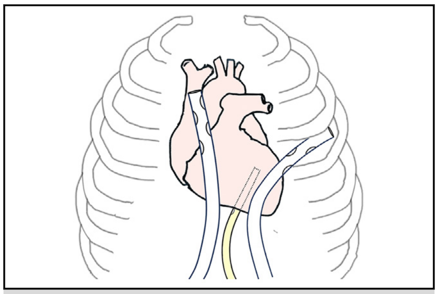
ABSTRACT

Objective: Postoperative atrial fibrillation (POAF) is a common complication after cardiac surgery that is associated with other adverse outcomes. Recent studies have shown that drainage of pericardial effusion by a posterior pericardial incision reduces the incidence of POAF. An alternative approach is a chest tube placed posteriorly in the pericardium. We evaluated whether the use of a posterior pericardial drain was associated with reduced risk of POAF in patients undergoing coronary artery bypass graft (CABG) and/or aortic valve replacement (AVR).

Methods: This observational study included 2535 patients who underwent CABG (n = 1997), AVR (n = 293), or combined CABG and AVR (n = 245) in Iceland from 2002 to 2020. From our study population, 553 (22%) received a 20-Fr posterior pericardial chest tube in addition to standard mediastinal and left pleural drains. The incidence of POAF in patients with and without a posterior pericardial drain was compared before and after 1:1 propensity score matching.

Results: Of 2535 patients, 1100 were included in the matched cohort. The incidence of POAF was lower in patients receiving posterior pericardial chest tube drainage compared with the control group, both before (34% vs 43%, $P < .001$) and after (33% vs 43%, $P = .002$) matching. In a multivariable analysis, posterior pericardial chest tube drainage was independently associated with a reduced risk for POAF (adjusted odds ratio 0.67; 95% confidence interval, 0.52-0.88; $P = .003$).

Conclusions: This observational study suggested that posterior pericardial chest tube drainage is associated with a significant reduction of POAF after routine CABG and/or AVR procedures. The results are hypothesis-generating and must be confirmed in prospective randomized trials. (JTCVS Open 2024;22:244-54)



A posterior pericardial drain after CABG and AVR is associated with reduced risk of POAF.

CENTRAL MESSAGE

The use of an additional 20-Fr posterior pericardial chest tube is associated with a reduced incidence of POAF in patients undergoing CABG and/or AVR procedures.

PERSPECTIVE

Placing a posterior pericardial chest tube after cardiac surgery is associated with a reduced risk of POAF. This approach may serve as a viable alternative to other POAF preventive strategies aimed at draining posterior pericardial effusion, such as posterior pericardiotomy. Future prospective randomized studies are necessary to confirm our findings.

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Abbreviations and Acronyms

AF = atrial fibrillation
AVR = aortic valve replacement
CABG = coronary artery bypass graft
CPB = cardiopulmonary bypass
POAF = postoperative atrial fibrillation
RCT = randomized controlled trial
SMD = standardized mean difference

Postoperative atrial fibrillation (POAF) is the most common complication after cardiac surgery, with a reported incidence ranging from 20% to 65%, depending on the type of procedure.[1] POAF is associated with unfavorable outcomes, including increased risk of stroke, mortality, prolonged hospital stay, readmission, and increased health care expenditures.[2-4] Current preventive measures involve pharmacologic treatment with β-blockers and/or amiodarone, but improved pericardial drainage has also been suggested to reduce the risk of POAF.[5-7]

In most cardiac procedures, the pericardium is opened anteriorly, providing access to the heart and great vessels, and is then left open.[5] Traditionally, a chest tube is inserted in the anterior mediastinum and one in each opened pleural cavity, usually only on the left side when the left internal mammary artery is harvested. However, several studies have shown a significant reduction of POAF when evacuating pericardial effusion from the posterior pericardium after cardiac surgery.[7,8] This can be achieved by posterior pericardiotomy, which is a 4- to 5-cm longitudinal incision of the posterior pericardium,[9] or by employing an additional pericardial chest tube placed posteriorly.[7,8] In a meta-analysis by Gozdek and colleagues[7] in which they examined posterior pericardiotomy and/or an additional posterior chest tube for posterior pericardial drainage, 2 of 19 studies evaluated solely a posterior pericardial chest tube. One of those 2 studies, conducted by Eryilmaz and colleagues,[10] found a significant reduction in the incidence of POAF when using an additional posterior pericardial chest tube in patients after ascending aortic surgery. In addition, the intervention did not increase the risk of bleeding, cardiac tamponade, or drain-associated infections.[10] However, the relatively small number of included patients was a limitation in both studies that investigated a prophylactic posterior pericardial drain.[10,11]

The present study aimed to evaluate the association between a posterior pericardial chest tube and POAF in a well-defined nationwide cohort. We hypothesized that employing an additional thin 20-Fr chest tube in the posterior pericardium might be associated with a lower incidence of POAF after coronary artery bypass grafting (CABG) and/or aortic valve replacement (AVR) procedures.

METHODS

This whole-nation, single-center, retrospective cohort study used the research database of the Department of Cardiothoracic Surgery at Landspitali – The National University Hospital of Iceland. The database contains all CABG and AVR procedures from 2002 to 2020 with approximately 200 variables, including medical history, preoperative use of medications, surgical details, clinical observations during the perioperative period, and long-term follow-up. The Icelandic Bioethics Committee and the Icelandic Data Protection Commission approved this study (VSN 10-009-V16) on December 13, 2023. Because individual patient identities were not disclosed, the requirement for obtaining individual informed consent for the study was waived.

Study Population

All patients who underwent CABG and/or AVR at Landspitali between 2002 and 2020 were eligible for inclusion. Patients were excluded if they had a preoperative history of atrial fibrillation (AF) or flutter, or if they were reoperated because of bleeding during their initial hospital stay. Inclusions and exclusions of patients are reported in Figure 1.

After exclusions, the study cohort was divided into 2 groups, an intervention group (n = 553) and a control group (n = 1982). In both groups, a 32-Fr drain was routinely placed in the anterior mediastinum overlying the heart and another 32-Fr in the left pleura. In addition, in the intervention group, a 20-Fr drain was consistently placed toward the posterior pericardium along the left ventricle in the retrocardiac cavity. The chest tubes were inserted through small separate incisions inferior to the median sternotomy, with the posterior pericardial drain incision in the intervention group positioned subxiphoid between the anterior mediastinal and left pleural drain incisions. The standard of practice for drain removal was removing all chest tubes (including the posterior drain) approximately 24 hours after surgery contingent upon drainage volume. In the unmatched cohort, 99% of patients underwent full sternotomy, 0.4% underwent hemisternotomy, and 0.6% underwent left minithoracotomy.

Data Variables and Definitions

The primary end point of this study was POAF, defined as a new-onset AF or flutter within 30 days after surgery in patients without any previous history of AF. The occurrence of POAF was determined by telemetry and/or electrocardiogram, defined as an AF period with a duration of $\geq$5 minutes or the initiation of treatment for AF such as amiodarone or electrical cardioversion. Secondary outcomes included 30-day mortality, stroke, deep sternal wound infection, noninfectious sternum insufficiency, length of primary hospital stay, pneumonia, chest tube output volume 24 hours after surgery, and perioperative myocardial infarction. For a diagnosis of perioperative stroke, the symptoms must have lasted longer than 24 hours or resulted in death. The diagnosis of stroke was confirmed by computed tomography or magnetic resonance imaging of the brain showing necrosis or signs of hemorrhage. Any mention of a pneumonia diagnosis in physician notes was used to identify this outcome. The follow-up period was 30 days for all complications except for total chest tube drainage volume (24 hours). The length of stay was defined from the first postoperative date to hospital discharge from Landspitali. Valve replacement included both isolated AVR and when combined with CABG.

Statistical Analysis

Statistical analyses were performed using R, version 4.3.1, and RStudio, version 2023.06.2 build 561. Comparisons between groups were performed using χ^2 analyses for categorical variables and the Mann-Whitney U test for continuous variables caused by non-normally distributed data. Categorical variables are presented as counts and percentages, and numerical variables are presented as median and interquartile range. A 1:1 propensity score match was executed and the distribution of variables between the 2 groups was compared on the basis of standardized mean difference

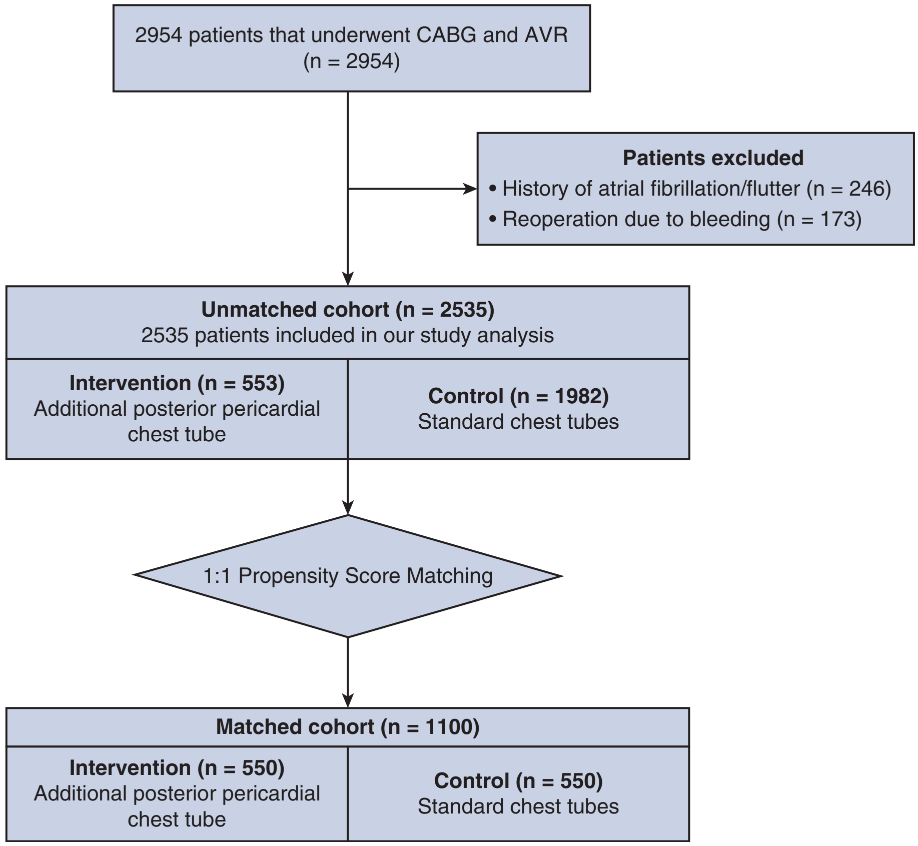

FIGURE 1. A flowchart of the study population showing inclusion and exclusion criteria. *CABG*, Coronary artery bypass graft; *AVR*, aortic valve replacement.

(SMD) from univariate analysis before matching. The model was matched for age, recent myocardial infarction, preoperative left ventricular ejection fraction <40%, European System for Cardiac Operative Risk Evaluation II, year of surgery, nonelective surgery, off-pump coronary artery bypass, cardiopulmonary bypass (CPB) time >100 minutes and crossclamp time >60 minutes. The matching method, nearest neighbor, was selected on the basis of the criteria of achieving the best balance after the matching process while maintaining an adequate sample size. A love plot where the covariate balance was plotted is shown in Figure E1 (Appendix E1).

Multivariable logistic regression of the matched cohort was used to analyze the association between posterior pericardial chest tube drainage and POAF, presented as adjusted odds ratio and 95% confidence interval. All variables with a SMD >0.100 in the univariable analysis of the matched cohort and variables with clinical significance indicated by available literature were included as covariates in the multivariable model. In addition, variance inflation factors were calculated to assess for multicollinearity. Covariates included posterior pericardial chest tube, sex, age, body mass index, history of hypertension, history of chronic obstructive pulmonary disease, preoperative use of β-blockers, year of surgery, CPB time, and valve replacement. Statistical tests were 2-tailed. C-statistic and the Hosmer-Lemeshow test for goodness of fit were calculated to evaluate the model's performance. We additionally performed sensitivity analyses to provide information on the impact of confounders and to ensure the reliability and robustness of the findings, shown in Table E1 (Appendix E1).

RESULTS

Figure 1 shows a flow chart of the patients included in the study and the 2 groups compared. A total of 2954 patients underwent CABG and/or AVR in Iceland from 2002 to 2020. After exclusion, 2535 patients remained in the final cohort before matching; 1997 (78.7%) underwent CABG, 293 (11.6%) underwent AVR, and 245 (9.7%) underwent combined CABG and AVR.

Patient Characteristics

Table 1 shows the baseline characteristics of the study population before and after matching and stratified into the intervention and control groups. The median age in the overall study population was 68 [61, 74] years, ranging from 18 to 92 years, and the majority were male (79%). Two surgeons predominantly employed a posterior pericardial chest tube, with one of them placing the posterior chest tube routinely in all cases, which accounted for 96% of patients in the intervention group.

At baseline before matching, patients who were treated with a posterior pericardial chest tube were younger (67 [60, 74] years vs 68 [61, 74] years) and underwent surgery later during the study period (interquartile range, 2008-2015 vs 2005-2014). The intervention group also demonstrated a lower operative risk, reflected by a median European System for Cardiac Operative Risk Evaluation II of 1.4 [0.9, 2.1] compared with 1.6 [1.0, 2.8] in the control

TABLE 1. Baseline and surgical characteristics stratified by intervention of the unmatched and matched cohorts

Variable	Unmatched			Matched		
	Intervention (n = 553)	Control (n = 1982)	SMD	Intervention (n = 550)	Control (n = 550)	SMD
Baseline characteristics						
Sex (male)	428 (77)	1571 (79)	0.045	425 (77)	444 (81)	0.085
Age, y	67 [60, 74]	68 [61, 74]	0.107	67 [60, 73]	66 [60, 74]	0.029
BMI, kg/m^2	28 [26, 31]	28 [25, 31]	0.082	28 [26, 31]	28 [25, 31]	0.037
History of arterial hypertension	355 (64)	1315 (66)	0.045	353 (64)	363 (66)	0.038
History of COPD	53 (10)	138 (7)	0.095	52 (10)	34 (6)	0.122
Preoperative GFR <60 mL/min	99 (18)	350 (18)	0.006	99 (18)	97 (18)	0.010
Recent myocardial infarction	116 (21)	545 (28)	0.153	116 (21)	109 (20)	0.032
LVEF <40%	41 (7)	221 (11)	0.129	41 (8)	47 (9)	0.040
EuroSCORE II	1.4 [0.9, 2.1]	1.6 [1.0, 2.8]	0.134	1.4 [0.9, 2.1]	1.4 [1.0, 2.5]	0.054
Preoperative CCB	116 (21)	457 (23)	0.050	115 (21)	114 (21)	0.004
Preoperative β-blocker	378 (69)	1327 (67)	0.030	375 (68)	357 (66)	0.069
Year of surgery (enrollment year)	2012 [2008, 2015]	2009 [2005, 2014]	0.514	2012 [2008, 2015]	2013 [2008, 2016]	0.062
Surgical characteristics						
Nonelective surgery	279 (51)	893 (45)	0.108	277 (50)	296 (54)	0.069
OPCAB	18 (3)	311 (16)	0.435	18 (3)	16 (3)	0.021
CPB time, min	105 [87, 129]	91 [73, 120]	0.285	105 [87, 129]	102 [79, 129]	0.097
CPB >100 min	299 (54)	655 (33)	0.434	296 (54)	282 (51)	0.065
Crossclamp time, min	57 [45, 74]	51 [38, 75]	0.064	57 [45, 74]	55 [42, 80]	0.070
Crossclamp >60 min	229 (41)	653 (33)	0.176	229 (42)	232 (42)	0.011
Valve replacement	111 (20)	427 (22)	0.036	111 (20)	151 (27)	0.171

The table shows patient demographics, history of diseases, preoperative risk assessment, preoperatively prescribed medication, and intraoperative risk factors of POAF for each group. Variables are presented as counts (%) or median [interquartile range]. *SMD*, Standardized mean difference; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *GFR*, glomerular filtration rate; *LVEF*, left ventricular ejection fraction; *EuroSCORE II*, European System for Cardiac Operative Risk Evaluation II; *CCB*, calcium channel blocker; *OPCAB*, off-pump coronary artery bypass; *CPB*, cardiopulmonary bypass. *POAF*, postoperative atrial fibrillation.

group. In addition, fewer patients in the intervention group had a preoperative left ventricular ejection fraction <40% (7% vs 11%), a recent myocardial infarction (21% vs 28%), or an off-pump coronary artery bypass procedure (3% vs 16%). A greater proportion of nonelective procedures were observed in the intervention group (51% vs 45%). In addition, patients in the intervention group had longer CPB and crossclamp times of 105 [87, 129] minutes and 57 [45, 74] minutes, respectively, compared with 91 [73, 120] minutes and 51 [38, 75] minutes in the control group.

The matched cohort consisted of 1100 patients, with 550 in each group. The covariates used for propensity score matching were successfully balanced, as depicted in Figure E1. However, the proportion of valve replacement (20% vs 27%, SMD = 0.163) and history of chronic obstructive pulmonary disease (10% vs 6%, SMD = 0.122) differed between groups after matching; therefore, they were included in the multivariable analysis.

Postoperative Outcomes

The overall POAF incidence among our study cohort was 41%. Postoperative outcomes of the unmatched and matched cohort stratified by intervention are shown in Table 2. Before and after matching, the incidence of POAF was significantly lower in the intervention group (34% vs 43%, $P \leq .001$, and 33% vs 43%, $P = .002$, respectively). After matching, there was no significant difference between the groups after surgery regarding mortality, stroke, deep sternal wound infection, sternal insufficiency, pneumonia, or length of hospital stay. The total median chest tube output was slightly greater in the intervention group after matching (700 [531, 948] mL vs 640 [450, 857] mL, $P < .001$).

Multivariable Analysis

The covariates included in the multivariable analysis of the matched cohort are shown in Table 3. A posterior pericardial chest tube was associated with a statistically significant 34% lower odds of POAF compared with the control group (adjusted odds ratio, 0.66; 95% confidence interval, 0.51-0.86; $P = .002$) (Figure 2). In addition, POAF was positively correlated with advancing age ($P \leq .001$), aortic valve replacement ($P = .046$), and CPB time ($P = .024$) and negatively correlated with year of surgery ($P = .038$).

As shown in Figure 3, the odds ratio for POAF between the groups remained significant both after propensity score matching (0.67 [0.52-0.87], $P \leq .002$) and multivariable logistic regression (0.67 [0.52-0.88], $P = .003$). The results also remained consistent after sensitivity analyses shown in Table E1.

TABLE 2. Postoperative outcomes before and after propensity score matching

	Unmatched data			Matched data		
	Intervention (n = 553)	Control (n = 1982)	*P*	Intervention (n = 550)	Control (n = 550)	*P*
Postoperative atrial fibrillation	186 (34)	856 (43)	<.001	184 (33)	235 (43)	.002
30-d mortality	7 (1)	48 (2)	.135	7 (1)	14 (3)	.123
Perioperative stroke	7 (1)	26 (1)	1	7 (1)	8 (1)	.795
Deep sternal wound infection	7 (1)	13 (1)	.172	7 (1)	5 (1)	.562
Noninfectious sternal insufficiency	4 (1)	25 (1)	.370	4 (1)	10 (2)	.107
Postoperative pneumonia	50 (9)	139 (7)	.119	50 (9)	40 (7)	.271
24-h tube drainage, mL	700 [530, 940]	690 [493, 950]	.362	700 [531, 948]	640 [450, 857]	<.001
Hospital stay, d	8 [7, 10]	9 [7, 12]	<.001	8 [7, 10]	8 [7, 11]	.944

The table shows adverse outcomes within 30 days and the total chest tube drainage volume after 24 hours postoperatively. Variables are presented as counts (%) or median [interquartile range].

DISCUSSION

In this propensity score–matched study, posterior pericardial drainage with an additional chest tube was independently associated with a reduced risk of POAF after CABG and/or AVR. Notably, placement of the posterior chest tube was not associated with a greater risk of postoperative complications.

In the current study, the overall incidence of POAF was 41%, which falls within the commonly reported range of 20% and 55% in studies including both CABG and AVR procedures.[12] Usually, the incidence of POAF is greater in those undergoing AVR compared with CABG and tends to increase further when the procedures are performed in combination, which was also confirmed in the present study. Because CABG and/or AVR are the most common cardiac procedures performed at our institution, we managed to include more than 80% of cardiac surgical procedures in a whole-nation cohort during 2002-2020.

Pericardial effusion, primarily induced by intra- and postoperative bleeding, is a frequent occurrence after cardiac surgery and has been recognized as a significant trigger for POAF, supposedly by inducing oxidative stress and inflammation within the atrial myocardium.[7,9,13] To the best of our knowledge, only 3 studies have previously evaluated the independent effect of a posterior pericardial chest tube drainage compared to standard intervention on rates of POAF.[10,11] Two of the studies were prospective randomized controlled trials (RCTs) and one had a retrospective design. In the RCT conducted by Eryilmaz and colleagues,[10] including a total of 140 patients undergoing complex ascending aortic procedures, a significantly decreased incidence of POAF was reported in patients receiving a posterior pericardial chest tube (10% vs 33%, $P = .03$). In the latter RCT, Kaya and colleagues[11] assessed the incidence of POAF between 3 different intervention groups, including posterior pericardiotomy, posterior pericardial chest tube drainage, and standard chest tubes. No significant difference between groups was detected (20%, 21%, and 33%, respectively; $P = .392$). However, only 96 patients were included in the study, limiting its statistical

TABLE 3. Multivariable model of the propensity-matched cohort for variables associated with POAF

Variable	β coefficient	aOR [95% CI]	*P* value
Posterior pericardial chest tube	−0.394	0.67 [0.52-0.88]	.003
Sex (male)	0.125	1.13 [0.82-1.58]	.449
Age (per one year)	0.053	1.05 [1.04-1.07]	<.001
BMI (per one kg/m^2)	0.011	1.01 [0.98-1.04]	.461
Arterial hypertension	0.091	1.10 [0.83-1.46]	.529
History of COPD	−0.168	0.85 [0.51-1.4]	.499
Preoperative β-blocker	−0.090	0.91 [0.69-1.21]	.538
Year of surgery (per one year)	−0.030	0.97 [0.94-1.0]	.038
CPB time	0.005	1.005 [1.001-1.008]	.009
Valve replacement	0.358	1.43 [1.01-2.03]	.046
Intercept	−5.24		

The table presents the associations between variables included in the multivariable analysis and POAF. *aOR*, Adjusted odds ratio; *CI*, confidence interval; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *CPB*, cardiopulmonary bypass; *POAF*, postoperative atrial fibrillation.

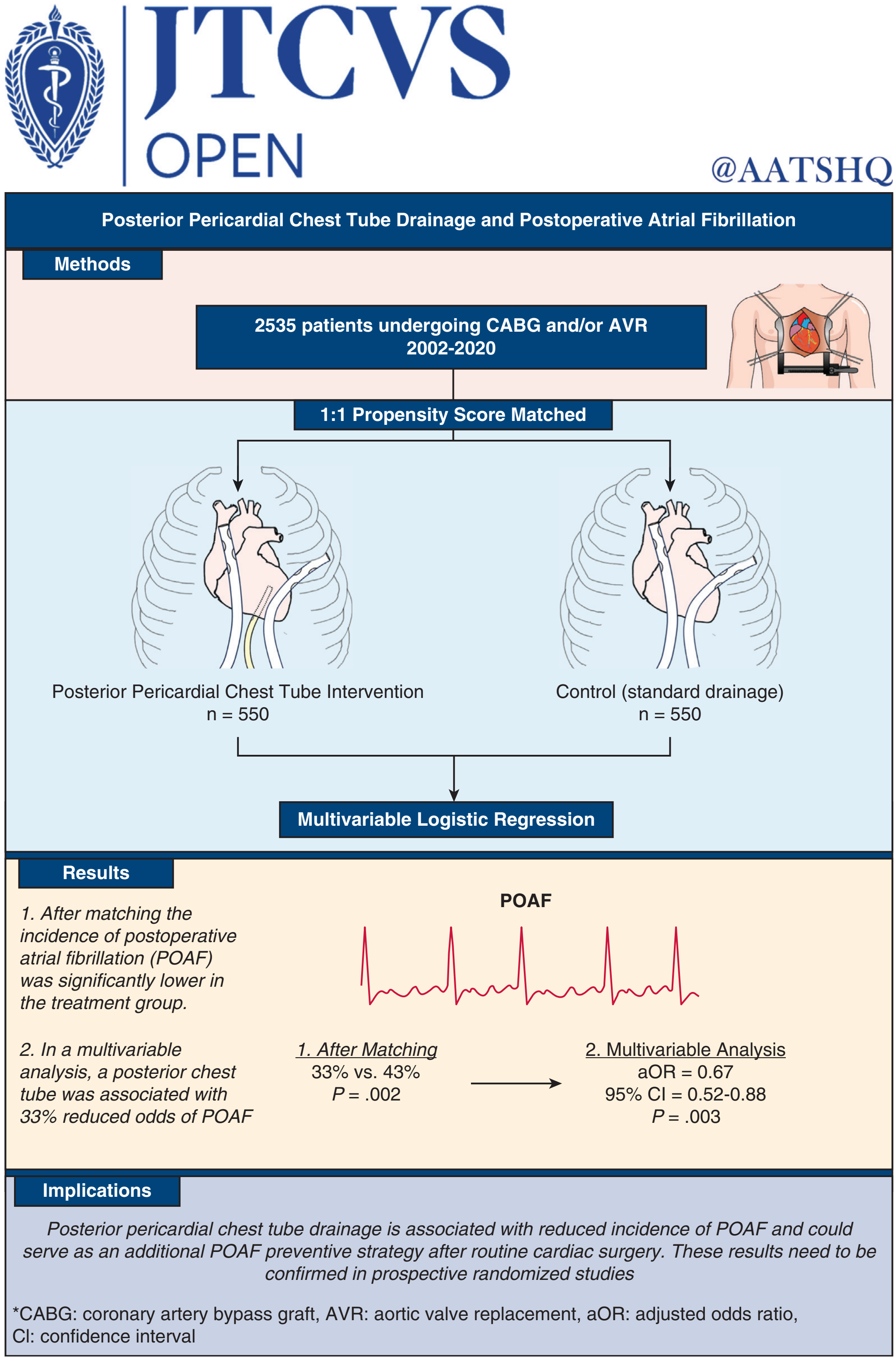

FIGURE 2. A posterior pericardial chest tube, in addition to standard chest tubes, is associated with a reduced incidence of postoperative atrial fibrillation (*POAF*) after cardiac surgery. After propensity score matching, patients with an additional posterior chest tube had lower POAF rates and significantly reduced odds of POAF in a multivariable analysis. *CABG*, Coronary artery bypass graft; *AVR*, aortic valve replacement; *aOR*, adjusted odds ratio; *CI*, confidence interval.

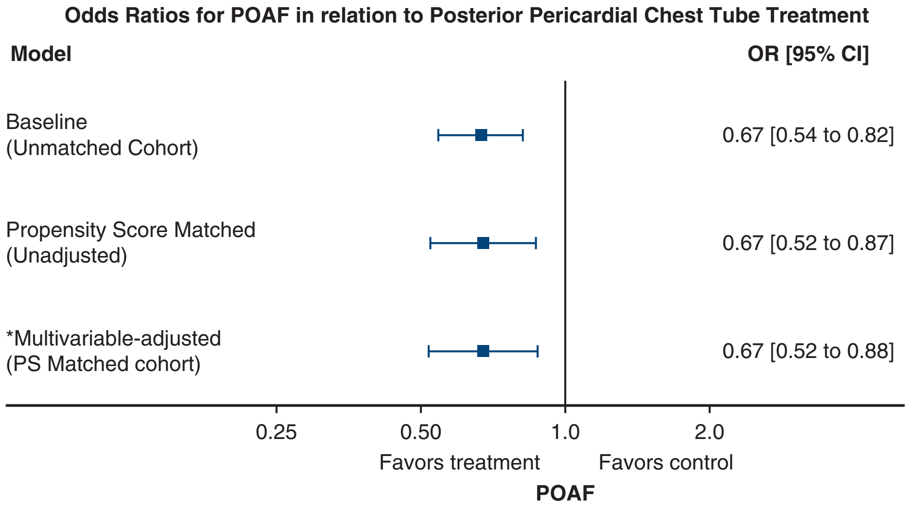

FIGURE 3. Association between a posterior pericardial chest tube and POAF, before and after matching. A forest plot shows crude and adjusted OR (before and after matching) with corresponding 95% CIs of POAF in relation to posterior pericardial chest tube drainage. *Adjusted for sex, age, body mass index, arterial hypertension, chronic obstructive pulmonary disease, preoperative use of β-blockers, year of surgery, cardiopulmonary bypass time and valve replacement in a multivariable logistic regression model of the matched cohort. *POAF*, Postoperative atrial fibrillation; *OR*, odds ratio; *CI*, confidence interval; *PS*, propensity score.

power.[11] More recently, Comentale and colleagues[14] conducted a retrospective single-center study including 250 patients who underwent CABG and found an association between the use of a posterior pericardial chest tube and a reduction in POAF, mirroring our findings. In their univariate analysis, the incidence of POAF was significantly lower in patients who received a posterior chest tube intervention compared to those who received standard drainage (6% vs 25%, $P \leq .001$).[14]

Drainage of posterior pericardial effusion after cardiac surgery via posterior pericardiotomy has been subject to more extensive study and is potentially more effective than chest tube placement for posterior pericardial drainage and reducing rates of POAF.[7-9,15] This is intuitively attributed to its prolonged functioning compared with chest tube drainage. In a meta-analysis by Gozdek and colleagues[7] of 19 studies, 15 evaluated intervention solely with posterior pericardiotomy, and 4 studies investigated either an additional posterior chest tube with or without pericardiotomy. Whether posterior pericardial drainage was implemented by posterior pericardiotomy and/or an additional chest tube, the meta-analysis indicated significantly reduced odds of POAF, late cardiac tamponade, and a shorter hospital stay.[7] Importantly, the studies in the analysis did not report any significantly increased risk of complications in the intervention groups, except in two studies that evaluated posterior pericardiotomy, where Zhao and colleagues[16] reported a statistically significant increase in mechanical ventilation time in patients >70 years in the intervention group, and the study by Kongmalai and colleagues[17] reporting an increased length of intensive care unit stay in the intervention group. However, the latter study only included 20 patients, and the adverse outcomes in both studies are not likely directly related to the intervention. Although very rare, there have also been individual reports of protrusion of the left atrial appendix through the pericardial incision causing compression on the vein grafts, and bleeding from the pericardial incisional edges after posterior pericardiotomy.[7,16-18] Displacement of a pericardial drain can also cause compression of vein grafts.[19] While posterior pericardiotomy and chest tubes are not entirely free of risk, they are generally considered to be simple and safe interventions. Implementing active tube clearance, a technique that uses technology to break down clots within the chest tube lumen to improve drainage after cardiac surgery may also be a possible avenue for reducing the incidence of POAF.[5] In a retrospective study by St-Onge and colleagues[5] involving 300 patients undergoing cardiac surgery, active tube clearance drainage was reported as an independent protective factor for POAF.

Although CABG and AVR procedures demonstrate excellent short-term survival in low-risk patients, an association between POAF and long-term mortality, as well as increased hospital readmission following cardiac surgery has been observed.[20] However, a definitive causal relationship indicating that POAF directly introduces lower survival rates has not been established, necessitating further research to determine if reducing the incidence of POAF correlates with reducing long-term adverse outcomes. Patients who develop POAF may potentially be considered at greater risk for adverse outcomes. In addition to complications associated with POAF, treatment with oral anticoagulation may also introduce additional risks, including bleeding complications.[21] Therefore, it is important to explore strategies aimed at preventing POAF, as it is the most common complication after cardiac surgery.

Our study has limitations because of its retrospective and single-center design. Furthermore, not all surgeons placed an additional posterior pericardial chest tube; one surgeon consistently adhered to this practice, whereas another did so selectively, with significant risk for expertise bias. Therefore, we could not adjust for different surgeons in our multivariable model. However, cases were evenly distributed among surgeons, all of whom actively participated in postoperative care within the ward, including the decision on when to remove chest tubes and initiate treatment for POAF if required. During the study period, POAF prophylaxis was administered by surgeon's preference and mainly consisted of continuing β-blockers pre- and perioperatively. There was no strict protocol followed when POAF was detected. Nevertheless, the standard approach involved increased use of β-blockers and/or amiodarone to restore sinus rhythm, followed by cardioversion if intravenous amiodarone was unsuccessful in restoring sinus rhythm within 24 hours.

Despite the intervention group showing a significant increase of 60 mL in chest-tube output after 24 hours, the clinical significance of this finding is unclear. It is standard practice at our institution to remove the chest tubes either after 24 hours or when output has significantly decreased. The acceptable output volume for chest tube removal may vary between surgeons. Because our database did not contain information on postoperative chest tube output after 24 hours, we could not assess the total chest tube output. In addition, postoperative echocardiograms were not routinely performed after CABG procedures, limiting retrospective assessment of pericardial fluid accumulation after drain removal. Importantly, the total chest tube output may not reflect the effect of the posterior chest tube on preventing POAF, as it could improve drainage of the posterior pericardium without affecting total output volume. In the previously mentioned RCT by Eryilmaz and colleagues,[10] a decreased risk of POAF in the posterior drain group was reported whereas chest-tube output did not differ between the posterior drain group and the control group. Future prospective studies should ideally measure the volumes of different chest tubes separately as well as assess pericardial effusion using echocardiograms after drain removal.

As of today, our study featured the largest cohort that evaluates a posterior pericardial chest tube drainage on POAF. The cohort was propensity score–matched and assessed using a robust multivariable model. Future research should include a prospective study to better account for potential confounders. Moreover, investigations into the possible complications associated with using an additional posterior pericardial chest tube are advised to assess the safety and efficacy of this approach.

CONCLUSIONS

This propensity score–matched observational study showed that employing an additional posterior pericardial chest tube is associated with a reduced incidence of POAF in patients undergoing CABG and/or AVR. Although placing a 20-Fr posterior chest tube in the posterior pericardium seems valuable in improving POAF preventive strategies after cardiac surgery, further research, including prospective randomized multicenter studies, is warranted to confirm these findings and explore potential complications of this approach.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing 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: atrial fibrillation, POAF, posterior pericardial chest tube, cardiac surgery, posterior pericardial drainage, CABG and AVR

APPENDIX E1.

Table E1, we provide a sensitivity analysis to assess the robustness of our findings. The C-statistic of the primary multivariable model (Model 1) was 0.67 and the *P* value of the Hosmer-Lemeshow goodness of fit was .603, indicating an acceptable model. Initially, we calculated the unadjusted OR for both the unmatched and matched cohorts. Second, we included only valve replacement as it was the only covariate with an SMD >0.100 after matching, suggesting an imbalance that could affect the primary outcome. Next, we employed the best subset method using all variables in Table 1, selecting the model with the lowest AIC value as the best fit. We also executed a multivariable logistic regression analysis on our unmatched cohort and included covariates used in our primary multivariable model and the propensity score. In this study, we applied a random forest method for imputing missing data. The primary analyses were done on the imputed data, and a complete case analysis was performed as a sensitivity analysis (Model 5 in Table E1). The research database had missing data for BMI (2.2%), preoperative ejection fraction (3.0%), a prescription for β-blockers (3.3%) and calcium channel blockers (7.0%) at admission, CPB time (2.3%) and cross-clamp time (2.6%), and 24-hour chest tube output (1.8%). Other variables used had missing data for <1.0% of patients. Lastly, we calculated the E-value for the point estimate and upper confidence interval for the primary adjusted results on the matched cohort was 1.74 and 1.33, respectively.

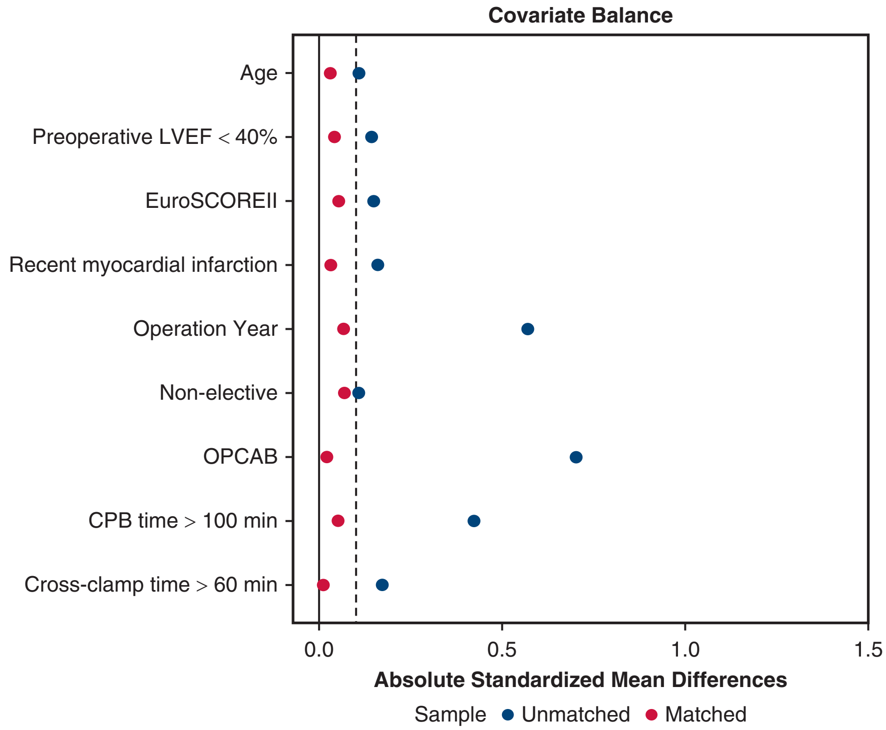

FIGURE E1. A love plot representing the covariate balance of the matched model. The graph displays the standardized mean differences, before and after matching, of all covariates matched for in the propensity score matched model. *LVEF*, Left ventricular ejection fraction; *EuroSCORE II*, European System for Cardiac Operative Risk Evaluation II; *OPCAB*, off-pump coronary artery bypass; *CPB*, cardiopulmonary bypass.

TABLE E1. Results of the primary and sensitivity analyses of the association between a posterior pericardial chest tube and POAF after cardiac surgery

Model	Cohort	OR [95% CI]	*P*	E-value for OR (E-value for CI)
Unadjusted				
Crude analysis before matching	Unmatched	0.67 [0.54-0.82]	<.001	1.74 (1.44)
Crude analysis after propensity score matching	Matched	0.67 [0.52-0.87]	.002	1.74 (1.35)
Adjusted				
Model 1 – Primary multivariable analysis (Adjusted-for variables included sex, age, BMI, arterial hypertension, history of COPD preoperative β-blocker, year of surgery, CPB time and valve replacement)	Matched	0.67 [0.52-0.88]	.003	1.74 (1.33)
Model 2 (Adjusted only for valve replacement and COPD)	Matched	0.70 [0.55-0.90]	.005	1.68 (1.29)
Model 3 (Adjusted for age, preoperative LVEF, EuroSCORE II, inclusion year (operation year), CPB time and valve replacement)	Matched	0.68 [0.53-0.89]	.004	1.72 (1.31)
Model 4 (Adjusted for Model 1 variables in addition to propensity score on the unmatched cohort)	Unmatched	0.74 [0.60-0.93]	.008	1.6 (1.23)
Model 5 – Excluding cases with missing data (Adjusted for Model 1 variables)	Matched	0.74 [0.57-0.96]	.022	1.6 (1.17)

The table displays the odds ratio of postoperative atrial fibrillation (POAF) with respect to posterior pericardial chest tube intervention for each analysis, with adjusted-for variables depicted in parenthesis. *OR*, Odds ratio; *CI*, confidence interval; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *CPB*, cardiopulmonary bypass; *LVEF*, left ventricular ejection fraction; *EuroSCORE II*, European System for Cardiac Operative Risk Evaluation II; *POAF*, postoperative atrial fibrillation.