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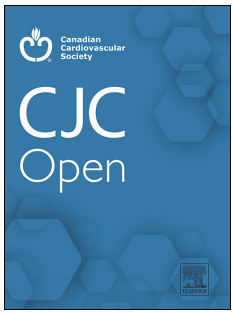

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Concomitant atrial fibrillation ablation in surgical aortic valve replacement: a systematic review and meta-analysis

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Data availability statement

All data used in the current meta-analysis have been extracted from previously published studies. The data repository and analyses are available upon reasonable request to the corresponding author.

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ABSTRACT

Background

Atrial fibrillation (AF) is common in patients undergoing surgical aortic valve replacement, however surgical ablation remains underused due to limited data on its efficacy.

Methods

We conducted a systematic review of the literature by searching PubMed, Embase, Web of Science, Emcare, and the Cochrane Library for studies reporting outcomes of concomitant surgical AF ablation in patients undergoing surgical aortic valve replacement. The primary outcomes included freedom from AF recurrence, overall survival and complications. We analyzed outcomes using traditional meta-analysis at specific time points, alongside pooled Kaplan-Meier curves.

Results

Nine studies were included, encompassing a total of 12,683 patients. Concomitant ablation reduced the risk of postoperative AF but increased the risk of permanent pacemaker implantation (risk ratio [RR] 1.36, 95% confidence interval [CI] 1.16-1.60, P<0.01) and postoperative renal failure (RR 1.38, 95% CI 1.11-1.71, P<0.01). During follow-up, concomitant ablation effectively restored and maintained sinus rhythm, with up to 80% of patients remaining free from recurrent AF 2-4 years post-surgery. Moreover, improved late survival was observed with concomitant ablation (unadjusted hazard ratio [HR] 0.84, 95% CI 0.73-0.96, P=0.013).

Conclusions

Surgical ablation during surgical aortic valve replacement was effective in restoring and maintaining sinus rhythm after surgery. Preoperative rhythm status may play an important role in guiding treatment plan, potentially enhancing the clinical outcomes for patients scheduled for aortic valve intervention.

Key words: Cardiac surgery; Aortic valve; Surgical aortic valve replacement; Atrial fibrillation.

INTRODUCTION

Atrial fibrillation (AF) is present in up to 25% of patients undergoing surgical aortic valve replacement (SAVR), making it a prevalent comorbidity linked to worse post-operative outcomes, including stroke, prolonged hospital stay and mortality (1). Even in the absence of pre-operative AF, over 40% of patients undergoing SAVR experience new-onset postoperative AF, which has also been associated with poorer outcomes on follow-up (2, 3). On the long-term, AF is associated with an increased risk of stroke, heart failure and mortality (4).

While there is substantial evidence supporting concomitant surgical AF ablation in patients with mitral valve disease, data on the outcomes of ablation in patients undergoing SAVR remains limited. This may be due to procedural factors, as the left atrium is typically not opened during SAVR, or the belief that ablation may be less effective in these patients. Consequently, cardiac surgeons may hesitate to perform an ablation procedure alongside SAVR. Despite strong guideline recommendations endorsing concomitant AF ablation, real-world data suggests otherwise. According to the Society of Thoracic Surgeons (STS) database, only 28% of SAVR patients with known pre-operative AF undergo concomitant ablation, compared to 52% in patients undergoing mitral valve surgery (5).

To address the gap of evidence in the current literature, the present systematic review and meta-analysis aimed to evaluate the safety, efficacy and long-term outcomes of concomitant AF ablation in patients undergoing SAVR.

METHODS

Design and eligibility criteria

A systematic review and meta-analysis were conducted to evaluate the clinical outcomes and efficacy of concomitant ablation for AF in patients undergoing SAVR. The study adhered to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (6).

Original studies examining both early and/or late postoperative outcomes of concomitant ablation for AF in this patient population were included. Relevant studies comprised both comparative and single-arm designs, providing data on the effectiveness of surgical ablation. No restrictions were placed on the publication date or the number of patients enrolled in the studies.

Search strategy, data extraction and risk of bias assessment

A literature search of PubMed, Embase (Ovid version), Web of Science, Emcare (Ovid version), and the Cochrane Library was performed by a biomedical information specialist (J.W.S.). The final search was conducted on March 23rd 2024 (**Supplemental Appendix S1**). Only English-language articles were included, with no restrictions on time-period. After removal of duplicates, two reviewers (E.P. and M.G.) independently assessed the titles and abstracts of the remaining articles for eligibility. Full-text articles were assessed when this was inconclusive. Discrepancies were discussed and resolved by consulting other review authors (R.K. and A.T.). No approval of the ethical committee was needed due to the nature of this study.

Data extraction was independently performed by two reviewers (E.P. and M.G.) using a pre-defined worksheet relying on the variable definitions used in the included studies. Any disagreements were discussed and resolved by consulting other review authors (R.K. and A.T.). Using the RoB 2 and ROBINS-I tools for RCTs and non-randomized studies, two independent reviewers (E.P. and M.G.) assessed the risk of bias of the included studies (7, 8).

Study endpoints

The primary endpoint was freedom from all-cause mortality. Secondary endpoints included freedom from recurrent AF and early postoperative complications (during index hospitalization or within 30 days after surgery), including postoperative AF, permanent pacemaker implantation, renal failure, postoperative stroke and early mortality.

Statistical analysis

Patient- and procedural characteristics were presented as reported by the included studies. Non-reported/missing data were indicated with N/A (not available). A complete case analysis was performed. Data from studies presenting medians and inter-quartile ranges were converted to mean and standard deviation using McGrath's method (9). Comparisons between patient characteristics and early outcomes for studies reporting on concomitant ablation vs. no concomitant ablation were assessed with a meta-analysis of continuous or categorical variables using inverse variance weighting in a random effects model. Early outcomes were presented in forest plots and the degree of statistical heterogeneity was assessed using the I2 metric, with I2 > 75% implying high between-study heterogeneity, for which a P-value <0.05 indicated the presence of statistically significant between-study heterogeneity.

For assessment of overall survival, a meta-analysis of reconstructed Kaplan-Meier-derived individual patient data (IPD) was performed. Published Kaplan-Meier graphs were digitized and the reconstructed IPD were combined by group to create the study dataset, which was then visualized using a cumulative Kaplan-Meier curve. An univariable, unadjusted Cox proportional hazards regression model was used to calculate hazard ratios (HRs) and corresponding confidence intervals (CIs) for inter-group comparisons. No time-to-event individual patient data IPD could be extracted from the articles included for late stroke. As a result, late stroke was treated as a binary variable in the pooled analysis. Given the low event probability, this approach is considered adequate for the analysis (10).

All statistical analyses were performed with R version 4.3.1 (R foundation, Vienna, Austria) using 'meta', 'survival', 'survminer', 'estmeansd', and 'IPDfromKM' packages. A P-value of < 0.05 was deemed as statistically significant.

RESULTS

Study selection

The search yielded 268 articles. After screening the titles and abstracts, 15 articles underwent full-text screening for eligibility. Of these, six additional studies were excluded following full-text review. No additional relevant full-text articles were found through screening the reference lists of the included studies. Ultimately, nine individual studies published between 2012 and 2023 met the inclusion criteria. Among these, one was a randomized controlled trial (11) and three utilized data from large, (nationwide) multi-centric prospective databases (12-14). The remaining five studies were retrospective, with one being multi-center (15) and the other four single-center studies (16-19).

The study of Kim et al. reported survival outcomes separately for cohorts of patients undergoing either biological or mechanical aortic valve replacement (13). Survival data were extracted for each cohort and reported separately. The studies of Goebel et al. and Henn et al. were single arm studies (18, 19). As the studies provided data on freedom from recurrent AF, both were included in the analysis and data synthesis. The detailed study flow diagram is shown in **Figure 1**.

Risk of Bias Assessment

A qualitative assessment was performed using the ROBINS-I and the RoB2 tools. The randomized controlled trial by Guo et al. was at low risk of bias (11). Of the remaining studies, two were at serious, two at moderate and four at low risk of bias. The risk of bias assessment is presented in **Supplemental Figure S1** and **Figure S2**, with a description of domain-specific grading per study.

Patient characteristics

A total of 12.683 patients were included in the review, of whom 5.229 underwent concomitant AF ablation. Patient characteristics are summarized in **Table I**. Within comparative studies, there was no difference in patient age at the time of surgery or proportion of male patients between the groups of patients undergoing ablation or not (**Supplemental Figure S3-4**). The proportion of patients presenting with paroxysmal AF varied considerably between studies but did not differ between patients who

underwent surgical ablation or not [risk ratio (RR) 1.39, 95% CI 0.80-2.41, P=0.25; **Supplemental Figure S5**].

Intra-operative characteristics

The majority of studies, with the exception of studies by Malaisrie et al. and Sasaki et al., reported on cohorts of patients undergoing isolated aortic valve intervention. The ablation strategy varied considerably, from either isolated pulmonary vein isolation to left sided lesion set or full Cox-Maze III or IV procedure. Left atrial appendage amputation or closure was not always performed in the surgical ablation arm and was performed inconsistently in the no ablation group. Left atrial appendage exclusion was performed significantly more often in the ablation group (RR 2.03, 95% CI 1.47-2.80, P<0.01; **Supplemental Figure S6**). Moreover, patients from the ablation group underwent mechanical valve implantation less often than patients who did not undergo ablation (RR 0.81, 95% CI 0.67-0.97, p=0.02; **Supplemental Figure S7**). Both aortic cross-clamp and cardiopulmonary bypass times were longer in the surgical ablation group with an absolute difference of 20.6 min (95% CI 12.5-28.7 min, P<0.01) and 27.4 min (95% CI 16.4-38.1 min, P<0.01), respectively (**Supplemental Figure S8-9**).

Early outcomes

Early postoperative outcomes are summarized in **Table II**. The rate of early postoperative mortality did not differ between both groups (RR 0.95, 95% CI 0.76-1.19, P=0.67) while the rate of postoperative AF was significantly lower in the ablation group (RR 0.38, 95% CI 0.20-0.73, P<0.01; **Figure 2**). On the other hand, a significant increase in postoperative permanent pacemaker implantation rate (RR 1.36, 95% CI 1.16-1.60, P<0.01) as well as an increase in the incidence of postoperative renal failure (RR 1.38, 95% CI 1.11-1.71, P<0.01) were seen with concomitant ablation (**Figure 3**). Lastly, no significant effect of concomitant ablation on the risk of postoperative stroke was seen (RR 0.92, 95% CI 0.70-1.21, P=0.54).

184

185 **Late outcomes**

186 The 1-, 5- and 10-years estimated overall survival rates were 89.2% (95% CI 87.4-91.0%), 75.2% (95%
187 CI 72.5-77.9%) and 58.8% (95% CI 54.3-63.3%), and 85.8% (95% CI 87.6-84.0%), 70.8% (95% CI
188 68.4-73.2%) and 53.7% (95% CI 50.2-57.2%) for the ablation and no ablation group, respectively
189 (**Figure 4**). Overall survival was superior in the ablation group (unadjusted HR 0.84, 95% CI 0.73-0.96,
190 P=0.013).

191 **Table III** provides an overview of the reported freedom from AF following surgical ablation.
192 Due to the use of various methods for data analysis and presentation, including different subgroup
193 analyses (which compared groups based on either the characteristics of AF or the type of procedure
194 performed), formal analyses could not be conducted. Additionally, the follow-up period was limited to
195 two years post-surgery.

196 In patients with paroxysmal AF, surgical ablation appeared effective in reducing recurrence.
197 Both Goebel et al. and Sasaki et al. reported freedom from AF of more than 80% at 2 years, regardless
198 of the type of surgical procedure performed (15, 19). In contrast, recurrence was more frequent in
199 patients with non-paroxysmal AF.

200 According to Sasaki et al., better outcomes were observed when a Cox-Maze procedure was
201 performed, as compared to pulmonary vein isolation (15).

202 Lastly, no beneficial effect of surgical ablation on the incidence of late stroke could be observed
203 (RR 0.98, 95% CI 0.45-2.13, P=0.49; **Supplemental Figure S10**).

204

205 **DISCUSSION**

206 This is the first meta-analysis to assess the safety, efficacy and long-term outcomes of concomitant AF
207 ablation in patients undergoing SAVR. While concomitant surgical AF ablation appears effective in
208 reducing the incidence of post-operative AF, our results suggests it may also be associated with an

increased risk of permanent pacemaker implantation and postoperative renal failure. Notably, studies reported good freedom from recurrent AF following surgical AF ablation and we even observed improved 10-year survival rates with concomitant ablation.

There is increasing evidence supporting the clinical benefits of concomitant AF ablation. While its adoption is widely accepted in certain patient populations, such as those undergoing mitral valve surgery, a growing body of evidence suggests that concomitant ablation may offer superior outcomes in other cohorts as well (20, 21). Our study focused on patients undergoing SAVR, in whom ablation of AF seems meaningful. The majority of SAVR patients have (severe) left ventricular hypertrophy associated with diastolic dysfunction and a decrease in passive left ventricular filling. Restoring and maintaining SR in these patients is expected to improve intra-cardiac hemodynamics and, in turn, result in improved clinical outcomes. A recent meta-analysis in patients with hypertrophic obstructive cardiomyopathy (HOCM) undergoing surgical septal myectomy and concomitant AF ablation, in whom similar pathophysiology is present, demonstrated promising results, further supporting the benefits of concomitant ablation in this context (22). Despite the theoretical benefits, surgeons remain hesitant to perform AF ablation in SAVR patients, as evidenced by the recent Placement of Aortic Transcatheter Valves (PARTNER) 3 trial, where concomitant AF ablation and left atrial appendage ligation were performed in only 26% and 51% of patients with known pre-operative AF, respectively (23).

The early results of our study align with expectations. Concomitant ablation resulted in significant prolongation of aortic cross-clamp and cardiopulmonary bypass times, which in turn was anticipated to increase the risk of postoperative renal failure. Advancements in surgical techniques and technological development of surgical ablation probes are expected to improve these outcomes. These findings are consistent with previous reports on concomitant ablation in mitral valve surgery, where increased operative times and pacemaker implantation rates have likewise been observed (24). Importantly, such complications have not translated into increased early mortality or worse long-term outcomes in mitral cohorts. This suggests that, while procedural complexity and complication rates may increase, the overall clinical benefit of restoring sinus rhythm often outweighs these risks−particularly in well-selected patients.

The underlying AF subtype may also influence treatment response, as paroxysmal AF typically shows better outcomes with less extensive ablation sets than persistent or longstanding forms. However, AF subtype was not consistently reported or stratified in the included studies, which limited our ability to explore its potential impact on clinical outcomes.

In the context of mitral valve surgery, McCarthy et al. demonstrated that concomitant ablation could be performed with only an 11-minute increase in aortic cross-clamp time, without an associated rise in renal failure risk (25). Furthermore, novel surgical ablation clamps, which allow for the creation of a Box-lesion with a single application, could be particularly beneficial for SAVR patients, in whom the left atrium is not typically opened (26). As the number of patients undergoing minimally invasive SAVR continues to rise, these devices could provide a valuable option for addressing AF during the procedure, further expanding the possibilities of minimally invasive surgery. It is worth mentioning that mechanical valves, which are generally associated with better long-term durability but necessitate lifelong oral anticoagulation therapy, were used less frequently in the ablation group. Due to the lack of patient-level data, we could not explore the effects of valve choice of outcomes of interest.

The increased risk of permanent pacemaker implantation is, paradoxically, a known marker of successful ablation. In patients with AF, the conduction system is diseased and may require time to recover after surgery. It is well-established that in more than half of patients, the conduction system recovers following ablation, although temporary bradycardic arrhythmias can occur during this recovery period (27). Nevertheless, for logistical reasons, permanent pacemaker implantation is often performed early to facilitate prompt hospital discharge.

An important observation from our study is the reduction of postoperative AF. Postoperative AF remains a significant issue, leading to, among others, prolonged hospital stays, increased risk of stroke, infection, renal or respiratory failure, and cardiac arrest (28). This beneficial effect of concomitant ablation likely to improve the overall risk profile of cardiac surgery for SAVR. Notably, the positive results were sustained over time, with recurrent AF rarely observed during follow-up after ablation. While rhythm follow-up data were missing in a significant portion of the included studies, those that reported rhythm outcomes demonstrated excellent results. It is worth noting that an ablation

therapy, compared to standard medical therapy, has been linked to significant cardiovascular morbidity and mortality benefits in patients with heart failure and preserved ejection fraction population (29). An encouraging finding from our study is the improvement in overall survival associated with concomitant ablation. Although this observation must be interpreted with caution due to the limitations of our study, it aligns with the clinical significance of AF in SAVR patients and underscores the need for further investigation in this area.

The results of our study could significantly influence the optimal treatment of patients with severe aortic valve stenosis. Currently, history of AF does not factor into the decision to perform either SAVR of trans-catheter aortic valve implantation. In, to the best of our knowledge, the only available study on this topic, SAVR combined with ablation has demonstrated markedly superior outcomes in these patients when compared to trans-catheter treatment (30). The clinical benefits observed in our study may support the use of SAVR with concomitant ablation for patients with history of AF who are scheduled to undergo aortic valve intervention.

LIMITATIONS

Limitations and biases of our study are largely related to the retrospective nature of most studies included in the review. The absence of randomization and double blinding raises concerns regarding detection bias. The limited number of studies available for analysis prevented us from conducting additional risk-adjusted analyses. Consequently, our findings should be considered exploratory and warrant confirmation through well-designed future studies. Additionally, several studies did not report important outcomes of interest, primarily hearth rhythm status, which is of specific interest to our research. This omission is partially related to the logistical challenges and economical restrains in obtaining structured follow-up for hearth rhythm assessment. Similarly, the definition of renal failure varied across studies, with some reporting only dialysis-dependent cases while others used broader clinical criteria. This inconsistency may have influenced the pooled effect size and should be considered when interpreting the results.

Another important limitation is the heterogeneity of ablation lesion sets among the included studies. Approaches ranged from isolated pulmonary vein isolation to more extensive left- or bi-atrial Cox-Maze procedures, using either cryothermal or radiofrequency energy sources. These procedural variations can substantially influence clinical outcomes such as aortic cross-clamp duration, pacemaker implantation, and postoperative renal failure. Unfortunately, due to inconsistent reporting across studies, a stratified analysis by lesion set or energy modality was not feasible. This variability may have introduced unmeasured confounding and should be considered when interpreting the pooled results. Nevertheless, our study demonstrates a clear benefit in terms of overall survival, which is of primary importance. We believe that, despite these limitations, the results provide valuable new evidence regarding the effectiveness of concomitant ablation in SAVR patients. We hope this will encourage further research on this topic.

CONCLUSIONS

In patients undergoing SAVR with a known history of AF, concomitant ablation was related to a decreased risk of postoperative AF. However, it did lead to increased aortic cross-clamp and cardiopulmonary times, resulting in an increased risk of postoperative renal failure. Despite these challenges, concomitant ablation resulted in a high rate of SR restoration and even improved overall survival, providing an argument to increase the utilization of concomitant ablation in SAVR patients with a known history of AF.

FIGURE LEGENDS

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 flowchart for study inclusion.

Figure 2. Concomitant ablation did not affect postoperative mortality (A) but was effective at reducing the incidence of postoperative atrial fibrillation (B).

Figure 3. Concomitant ablation resulted in a higher incidence of postoperative pacemaker implantation (A) and renal failure (B) while no effect on the incidence of postoperative stroke was observed (C).

330 Tables

331

332 Table 1. Characteristics of included studies.

Study	Study design	Sample size		Sex, Male		Age at surgery (years), Mean/Median (SD or IQR)		Paroxysmal atrial fibrillation		Isolated AVR +/- ablation (N (%))		Ablation lesion set performed	Left atrial appandage exclusion (N (%))		Me va
		Surgical ablation (N)	No surgical ablation (N)	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation	No surgical ablation	Surgical ablation	No surgical ablation	Surgical ablation (N (%))	No surgical ablation (N (%))		Surgical ablation (N)	No surgical ablation (N)	Surg abla (N)
Comparative studies															
Churyla et al., 2021	STS database, PS matched	3692	5724	2454 (67)	3754 (67)	71.5 ± 8.9	71.5 ± 10.1	N/A	N/A	3692 (100)	5724 (100)	N/A	1487 (40)	1540 (27)	243
Guo et al., 2023	Randomised controlled trial	58	50	22 (38)	22 (44)	61 ± 10	60 ± 9	20 (35)	21 (42)	58 (100)	50 (100)	Cox-Maze IV	58 (100)	21 (42)	34 (
Kim et al., 2024	Nationwide databse, PS matched	435	435	294 (68)	297 (68)	68.0 ± 10.9	68.2 ± 9.2	N/A	N/A	435 (100)	435 (100)	N/A	N/A	N/A	139 (32)
Malaisrie et al., 2012	Retrospective, single center	80	44	61 (76)	29 (66)	73 ± 11	75 ± 14	51 (64)	29 (66)	41 (51)	32 (73)	Cox-Maze IV (10), left-sided Cox-Maze IV (15) or PVI (55)	70 (88)	N/A	0 (0
Sasaki et al., 2023	Retrospective, multi center	135	36	89 (66)	22 (61)	73.5 ± 7.5	76.4 ± 6.6	59 (44)	7 (19)	98 (73)	28 (78)	Cox-Maze IV (79), or PVI (56)	108 (80)	13 (36)	22 (
Yoo et al., 2014	Retrospective, single center	50	74	31 (62)	54 (73)	66.8 ± 9.5	65.6 ± 11.9	22 (44)	13 (18)	N/A	N/A	Cox-Maze III (38), left-sided Cox-Maze IV (10) or PVI (2)	16 (32)	7 (10)	22 (
Cheng et al., 2023*	Nationwide database	365	605	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0 (0
Cheng et al., 2023*	Nationwide database	272	486	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	272 (100
Single-arm studies															
Goebel et al., 2021	Retrospective, single center	67	0	38 (57)	N/A	75.3 ± 6.3	N/A	11 (16)	N/A	67 (100)	N/A	PVI	N/A	N/A	N/A
Henn et al., 2015	Retrospective, single center	75	0	50 (67)	N/A	70.5 ± 8.2	N/A	45 (60)	N/A	75 (100)	N/A	Cox-Maze IV (58), left-sided Cox-Maze IV (3) or PVI (14)	N/A	N/A	N/A

Abbreviations: AVR: aortic valve replacement; IQR: interquartile range; N/A: not available; SD: standard deviation; PVI: pulmonary vein isolation; STS: Society of Thoracic Surgeons. *Separate provided for the mechanical and biological aortic valve replacement groups.

333

334 Table 2. Early Outcomes

Study	Early mortality		Permanent pacemaker implantation		Early POAF		Postoperative TIA or CVA		Postoperative renal failure or dialysis		Follow-up duration (years), Mean/Median (SD or IQR)	
	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation (N (%))	No surgical ablation (N (%))	Surgical ablation	No surgical ablation
Comparative studies												
Churyla et al., 2021	103 (3)	169 (3)	250 (7)	288 (5)	652 (18)	1385 (24)	69 (1.9)	111 (2.0)	128 (3.5)	150 (2.6)	N/A	N/A
Guo et al., 2023	0 (0)	0 (0)	0 (0)	1 (2)	N/A	N/A	0 (0)	1 (2)	1 (2)	0 (0)	198 (IQR 175–311) days	
Kim et al., 2024	22 (5)	19 (4)	9 (2)	4 (1)	N/A	N/A	9 (3)	12 (4)	26 (6)	15 (4)	N/A	N/A
Malaisrie et al., 2012	2 (3)	3 (7)	1 (1)	0 (0)	23 (27)	29 (62)	0 (0)	1 (2)	N/A	N/A	17 ± 12 months	18 ± 13 months
Sasaki et al., 2023	2 (1)	0 (0)	8 (6)	1 (3)	39 (29)	27 (75)	2 (1)	0 (0)	N/A	N/A	2 years	2 years
Yoo et al., 2014	1 (2)	3 (4)	N/A	N/A	6 (12)	69 (93)	1 (2)	2 (3)	4 (8)	2 (3)	18.1 (IQR 6.9–47.8) months	
Cheng et al., 2023*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cheng et al., 2023*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single-arm studies												
Goebel et al., 2021	2 (3)	N/A	6 (9)	N/A	47 (72)	N/A	4 (6)	N/A	N/A	N/A	38.0 ± 22.6 months	N/A
Henn et al., 2015	3 (4)	N/A	18 (24)	N/ A	N/A	N/A	2 (3)	N/A	6 (8)	N/A	3.0 ± 2.5 years	N/A

Abbreviations: CVA: cerebrovascular accident; IQR: interquartile range; POAF: postoperative atrial fibrillation; SD: standard deviation; TIA: transient ischemic attack. *Separate outcomes are provided for the mechanical and biological aortic valve repalacement groups.

335

336 Table 3. Reported freedom from atrial fibrillation

	3 months	6 months	9 months	12 months	24 months	48 months
Guo et al.						
				Kaplan-Meier estimate: 100%		
Goebel et al.						
Paroxysmal AF				Kaplan-Meier estimate: 100%	Kaplan-Meier estimate: 83.7% (95% CI 70.1-92.1%)	
Non-paroxysmal AF				Kaplan-Meier estimate:	Kaplan-Meier estimate:	

				93.4% (95% CI 81.4-98.2%)	72.5% (95% CI 41.2-90.9%)	
Henn et al.						
Cox-Maze group	98%	92%		97%	88%	
PVI group	56%	43%		60%	63%	
Malaisrie et al.						
			85% (60/71)			
Sasaki et al.						
Paroxysmal AF						
Cox-Maze group	95% (18/19)	93% (14/15)			87% (13/15)	
PVI group	88% (30/34)	90% (27/30)			97% (30/31)	
Non-paroxysmal AF						
Cox-Maze group	63% (32/51)	64% (27/42)			53% (24/45)	
PVI group	47% (7/15)	55% (6/11)			42% (5/12)	
Yoo et al.						
						Kaplan-Meier estimate: 80.6% (95% CI 69.0-92.2%)

Abbreviations: AF: atrial fibrillation; PVI: pulmonary vein isolation

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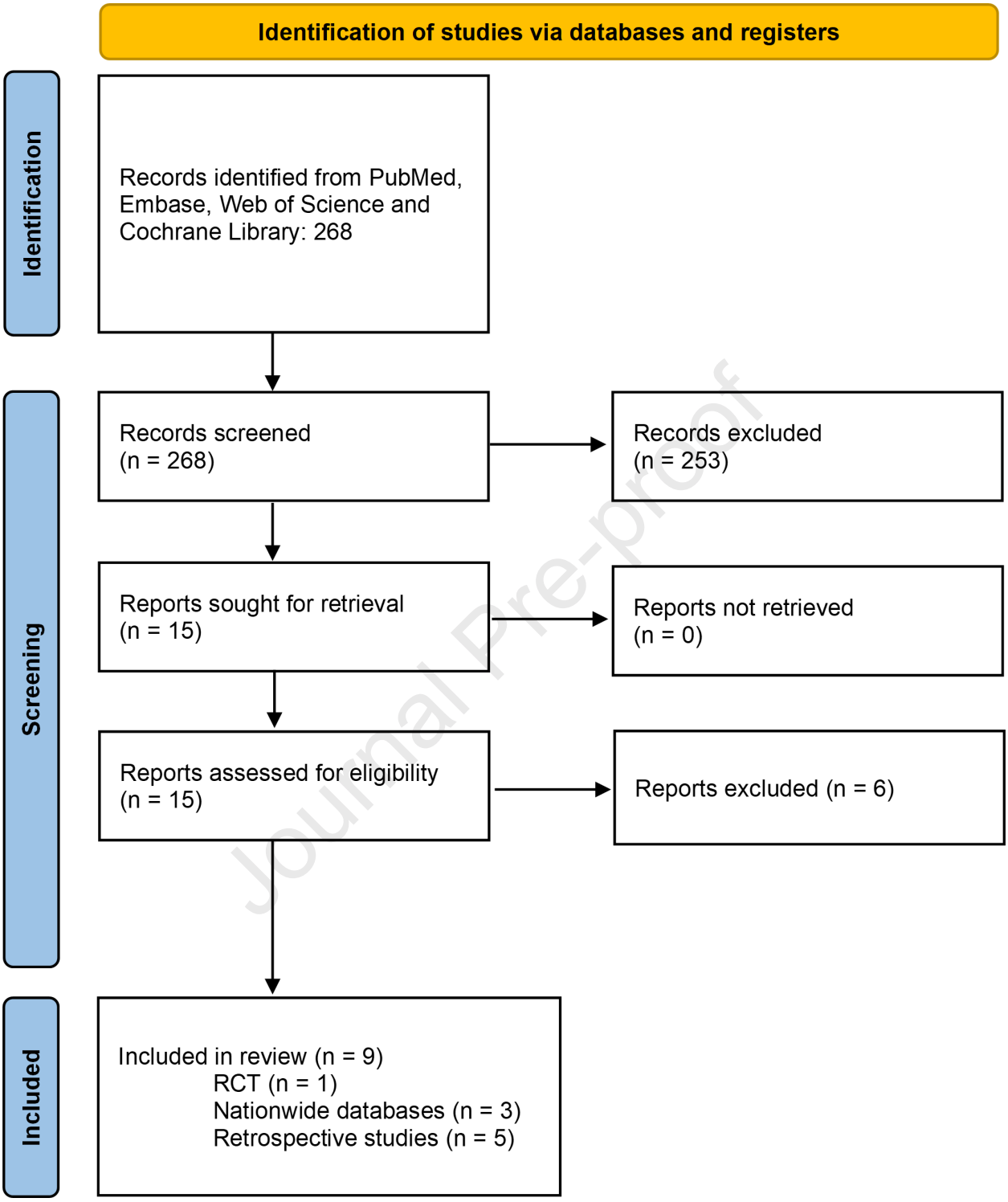
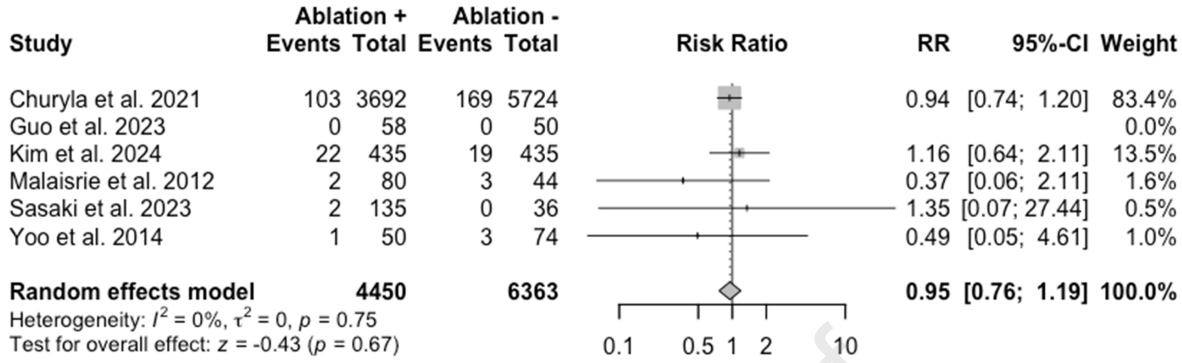
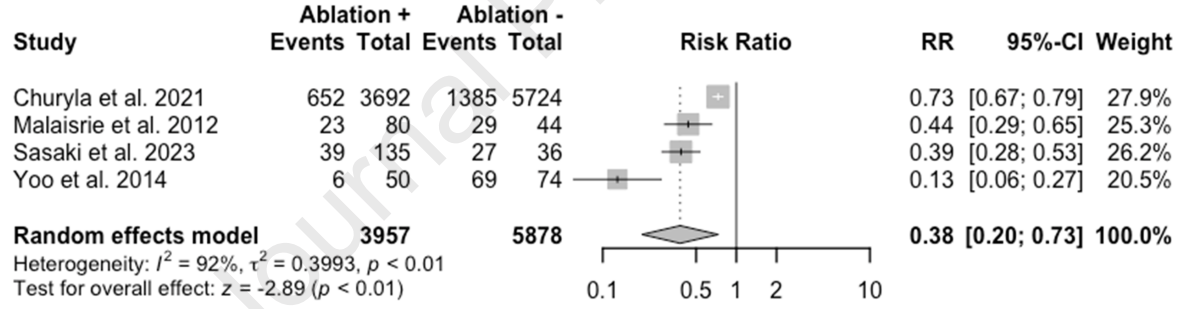


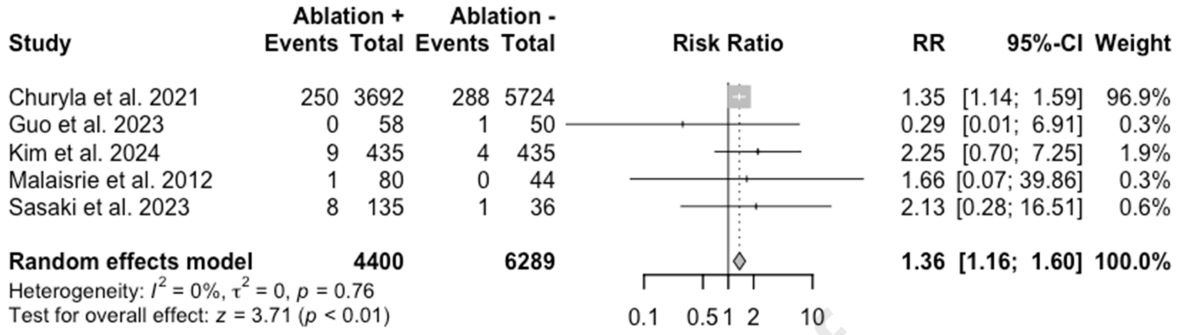
A. Early mortality



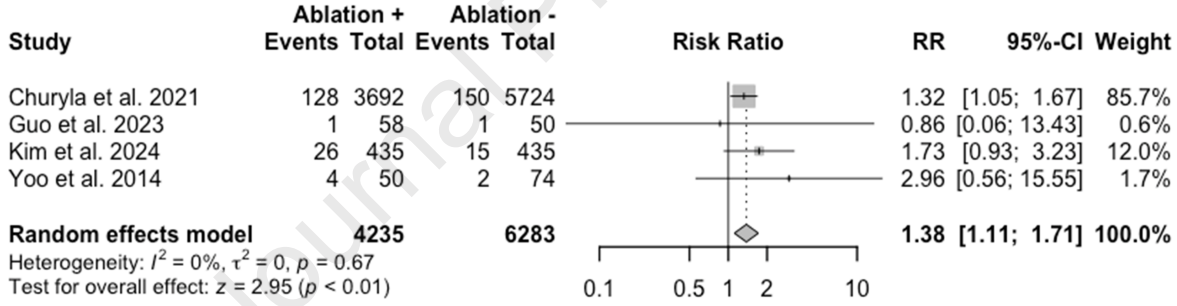
B. Postoperative atrial fibrillation



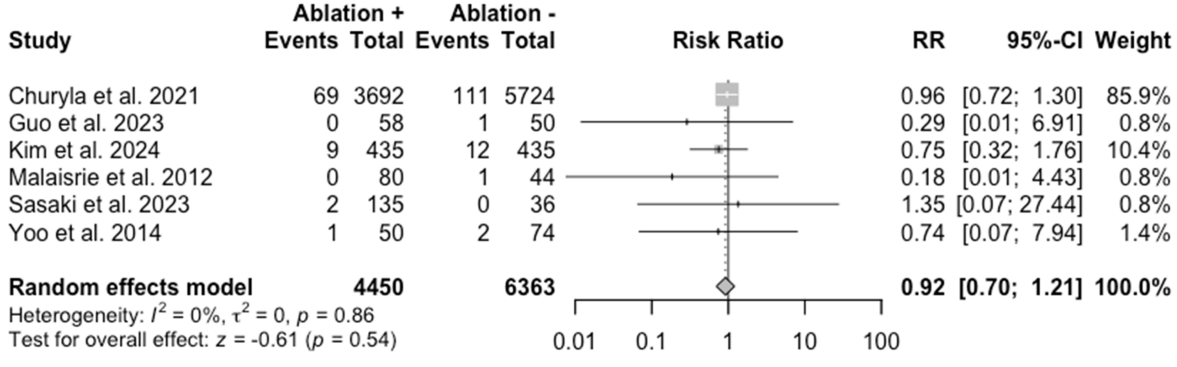
A. Permanent pacemaker implantation

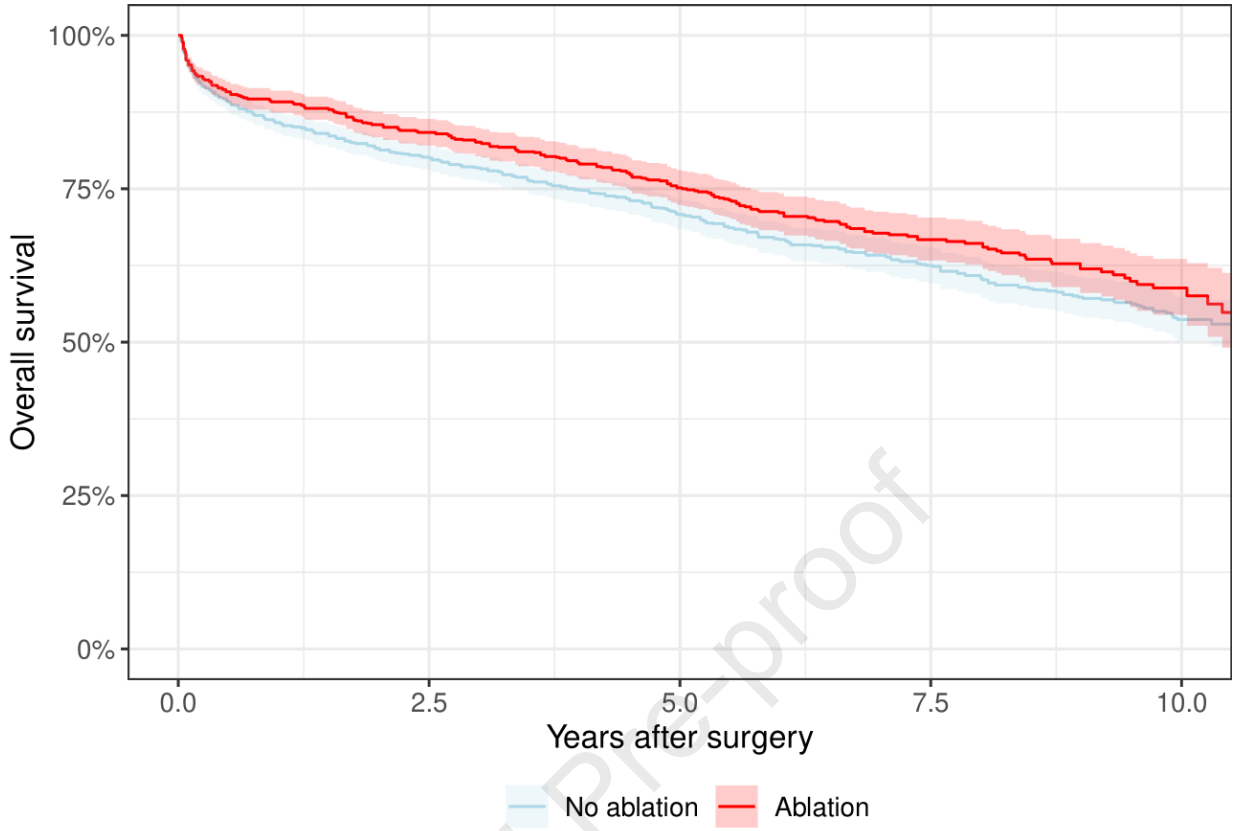


B. Postoperative renal failure



C. Postoperative stroke





At Risk					
Ablation	1626	1080	680	393	201
No ablation	1170	768	459	220	104