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## Systematic Review/Meta-analysis

# Concomitant Atrial Fibrillation Ablation in Surgical Aortic Valve Replacement: A Systematic Review and Meta-Analysis

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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 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 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 plans, potentially enhancing the clinical outcomes for patients scheduled for aortic valve intervention.

### RÉSUMÉ

**Contexte :** La fibrillation auriculaire (FA) est fréquente chez les patients qui subissent une chirurgie de remplacement valvulaire aortique, mais l'ablation chirurgicale reste sous-utilisée en raison du manque de données sur son efficacité.

**Méthodologie :** Nous avons procédé à une analyse systématique de la littérature en recherchant dans PubMed, Embase, Web of Science, Emcare et la Cochrane Library des études rapportant les résultats de l'ablation chirurgicale concomitante de la FA chez des patients subissant une chirurgie de remplacement valvulaire aortique. Les critères de jugement principaux comprenaient l'absence de récurrence de la FA, la survie globale et les complications. Nous avons analysé les résultats à l'aide d'une méta-analyse traditionnelle à des points temporels spécifiques, ainsi qu'à l'aide de courbes de Kaplan-Meier regroupées.

**Résultats :** Neuf études ont été incluses, totalisant 12 683 patients. L'ablation concomitante a réduit le risque de FA postopératoire, mais a augmenté le risque d'implantation d'un stimulateur cardiaque permanent (rapport de risque [RR] 1,36, intervalle de confiance [IC] à 95 % 1,16-1,60,  $p < 0,01$ ) et d'insuffisance rénale postopératoire (RR 1,38, IC à 95 % 1,11-1,71,  $p < 0,01$ ). Au cours du suivi, l'ablation concomitante a permis de rétablir et de maintenir efficacement le rythme sinusal, avec jusqu'à 80 % des patients exempts de récurrence de FA 2 à 4 ans après l'intervention. En outre, une amélioration de la survie à long terme a été observée avec l'ablation concomitante (rapport de risque non ajusté 0,84, IC à 95 % 0,73-0,96,  $p = 0,013$ ).

**Conclusions :** L'ablation chirurgicale réalisée lors de la chirurgie de remplacement valvulaire aortique s'est révélée efficace pour restaurer

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See page 895 for disclosure information.

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 postoperative outcomes, including stroke, prolonged hospital stays, and mortality.<sup>1</sup> Even in the absence of preoperative AF, more than 40% of patients undergoing SAVR experience new-onset postoperative AF, which also has been associated with

et maintenir le rythme sinusal après l'intervention. Le statut rythmique préopératoire peut jouer un rôle important dans l'orientation du plan de traitement, améliorant potentiellement les résultats cliniques pour les patients candidats à une intervention sur la valve aortique.

poorer outcomes on follow-up.<sup>2,3</sup> Long-term, AF is associated with an increased risk of stroke, heart failure, and mortality.<sup>4</sup>

Although substantial evidence supports use of concomitant surgical AF ablation in patients with mitral valve disease, data on the outcomes of ablation in patients undergoing SAVR remain limited. This lack of data may be due to procedural factors, as the left atrium is typically not opened during SAVR, or the belief that ablation is 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 suggest that this does not often occur. According to the Society of Thoracic Surgeons database, only 28% of SAVR patients with known preoperative AF undergo concomitant ablation, compared to 52% of patients undergoing mitral valve surgery.<sup>5</sup>

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.<sup>6</sup>

Original studies examining 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 23, 2024 (Supplemental Appendix S1). Only English-language articles were included, with no restrictions on time period. After removal of duplicates, 2 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 process was inconclusive. Discrepancies were discussed and resolved by consulting other review authors (R.K.K. and A.T.). No approval was needed from the ethics committee, given 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.K. and A.T.). Using the RoB 2 (Cochrane risk of bias tool for randomized trials, version 2) and ROBINS-I (risk of bias in nonrandomized studies of interventions) tools, 2 independent reviewers (E.P. and M.G.) assessed the risk of bias in the included studies.<sup>7,8</sup>

### Study endpoints

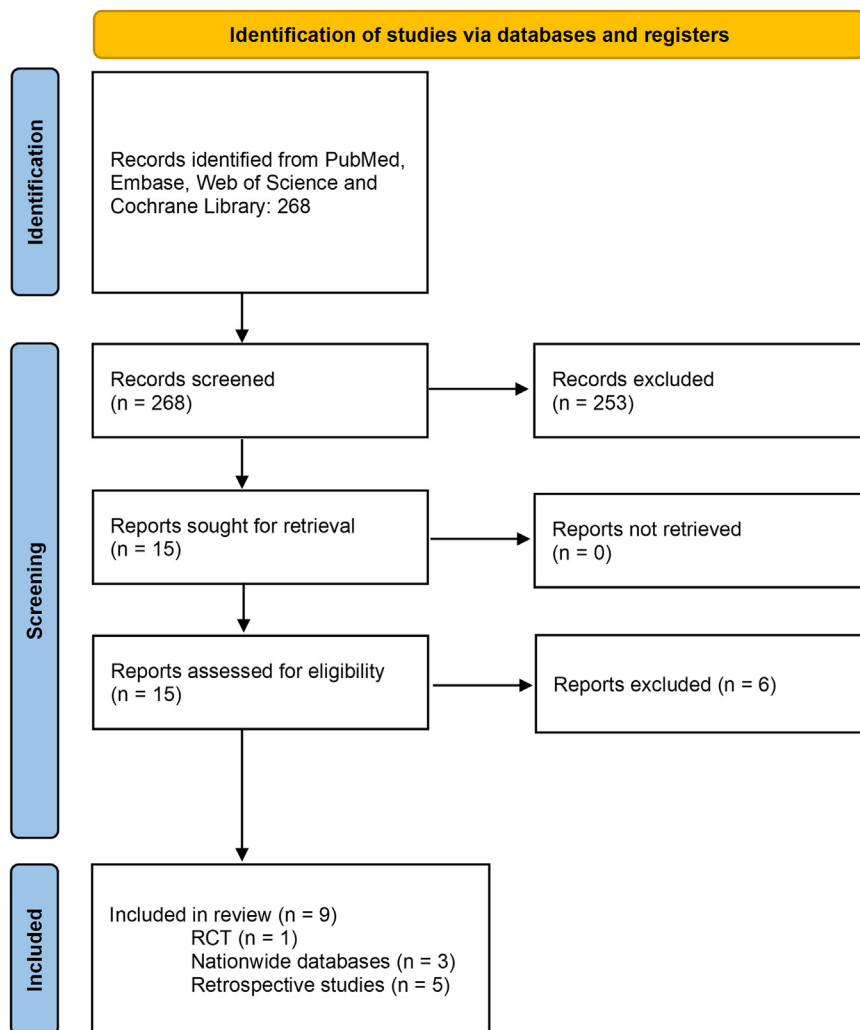
The primary endpoint was freedom from all-cause mortality. Secondary endpoints included freedom from recurrent AF and early postoperative complications (during index hospitalization or within 30 days after surgery), including postoperative AF, permanent pacemaker implantation, renal failure, postoperative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

### Statistical analysis

Patient and procedural characteristics were presented as reported by the included studies. Nonreported or missing data were indicated by N/A (not available). A complete case analysis was performed. Data presented as median and interquartile range were converted to mean and standard deviation, using McGrath's method.<sup>9</sup> 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  $I^2$  metric, with  $I^2 > 75\%$  implying high between-study heterogeneity, for which a  $P$ -value of  $< 0.05$  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. A univariable, unadjusted Cox proportional hazards regression model was used to calculate hazard ratios and corresponding confidence intervals (CIs) for intergroup comparisons. No time-to-event 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.<sup>10</sup>

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 statistically significant.



**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flowchart for study inclusion. RCT, randomized controlled trial.

## Results

### Study selection

The search yielded 268 articles. After the titles and abstracts were screened, 15 articles underwent full-text screening for eligibility. Of these, 6 additional studies were excluded following full-text review. No additional relevant full-text articles were found through screening of the reference lists of the included studies. Ultimately, 9 individual studies published between 2012 and 2023 met the inclusion criteria. Among these, one was a randomized controlled trial,<sup>11</sup> and 3 utilized data from large, (nationwide) multicentric prospective databases.<sup>12-14</sup> The remaining 5 studies were retrospective—1 was a multicentre study,<sup>15</sup> and the other 4 were single-centre studies.<sup>16-19</sup>

The study by Kim et al. reported survival outcomes separately for cohorts of patients undergoing either biological or mechanical aortic valve replacement.<sup>13</sup> Survival data were extracted for each cohort and reported separately. Henn et al. and Goebel et al. conducted single-arm studies.<sup>18,19</sup> As these 2 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 RoB 2 tools. The randomized controlled trial by Guo et al. was at low risk of bias.<sup>11</sup> Of the remaining studies, 2 had a serious risk of bias, 2 had a moderate risk of bias, and 4 had a low risk of bias. The risk-of-bias assessment is presented in [Supplemental Figures S1 and 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 5229 underwent concomitant AF ablation. Patient characteristics are summarized in [Table 1](#). Within comparative studies, no difference was present in either patient age at the time of surgery or proportion of male patients between the groups of patients who did vs did not undergo ablation ([Supplemental Figs.S3 and S4](#)). The proportion of patients

**Table 1. Characteristics of included studies**

Study	Study design	Sample size		Sex, male		Age at surgery y		Paroxysmal AF		Isolated AVR +/- ablation		Ablation lesion set	Left atrial appendage exclusion		Mechanical aortic valve prosthesis implanted	
		SA	No SA	SA	No SA	SA	No SA	SA	No SA	SA	No SA		SA	No SA	SA	No SA
Comparative studies																
Churyla et al. <sup>12</sup> (2021)	STS DB, 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 (7)	518 (9)
Guo et al. <sup>11</sup> (2023)	RCT	58	50	22 (38)	22 (44)	61 ± 10	60 ± 9	20 (35)	21 (42)	58 (100)	50 (100)	C-M IV	58 (100)	21 (42)	34 (58)	30 (60)
Kim et al. <sup>13</sup> (2024)	Nationwide DB, 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)	142 (33)
Malaisrie et al. <sup>16</sup> (2012)	Retro, single- centre	80	44	61 (76)	29 (66)	73 ± 11	75 ± 14	51 (64)	29 (66)	41 (51)	32 (73)	C-M IV (10), left-sided C-M IV (15) or PVI (55)	70 (88)	N/A	0 (0)	3 (7)
Sasaki et al. <sup>15</sup> (2023)	Retro, multi centre	135	36	89 (66)	22 (61)	73.5 ± 7.5	76.4 ± 6.6	59 (44)	7 (19)	98 (73)	28 (78)	C-M IV (79), or PVI (56)	108 (80)	13 (36)	22 (16)	9 (25)
Yoo et al. <sup>17</sup> (2014)	Retro, single- centre	50	74	31 (62)	54 (73)	66.8 ± 9.5	65.6 ± 11.9	22 (44)	13 (18)	N/A	N/A	C-M III (38), left-sided C-M IV (10) or PVI (2)	16 (32)	7 (10)	22 (44)	50 (68)
Cheng et al. <sup>14</sup> (2023)*	Nationwide DB	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)	0 (0)
Cheng et al. <sup>14</sup> (2023)*	Nationwide DB	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)	486 (100)
Single-arm studies																
Goebel et al. <sup>19</sup> (2021)	Retro, single- centre	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	N/A
Henn et al. <sup>18</sup> (2015)	Retro, single- centre	75	0	50 (67)	N/A	70.5 ± 8.2	N/A	45 (60)	N/A	75 (100)	N/A	C-M IV (58), left-sided C-M IV (3) or PVI (14)	N/A	N/A	N/A	N/A

Values are n (%), or mean ± standard deviation.

AF, atrial fibrillation; AVR, aortic valve replacement; C-M, Cox-Maze; DB, database; N/A, not available; PS, propensity score; PVI, pulmonary vein isolation; RCT, randomized controlled trial; Retro, retrospective; SA, surgical ablation; STS, Society of Thoracic Surgeons.

\*Separate outcomes are provided for the mechanical and biological aortic valve replacement groups.

**Table 2. Early outcomes**

Study	Early mortality		PPI		Early POAF		Postoperative TIA or CVA		Postoperative renal failure or dialysis		Follow-up duration,	
	SA	No SA	SA	No SA	SA	No SA	SA	No SA	SA	No SA	SA	No SA
<b>Comparative studies</b>												
Churyla et al. <sup>12</sup> (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. <sup>11</sup> (2023)	0 (0)	0 (0)	0 (0)	1 (2)	N/A	N/A	0 (0)	1 (2)	1 (2)	0 (0)	198 (175–311) d	N/A
Kim et al. <sup>13</sup> (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. <sup>16</sup> (2012)	2 (3)	3 (7)	1 (1)	0 (0)	23 (27)	29 (62)	0 (0)	1 (2)	N/A	N/A	17 ± 12 mo	18 ± 13 mo
Sasaki et al. <sup>15</sup> (2023)	2 (1)	0 (0)	8 (6)	1 (3)	39 (29)	27 (75)	2 (1)	0 (0)	N/A	N/A	2 y	2 y
Yoo et al. <sup>17</sup> (2014)	1 (2)	3 (4)	N/A	N/A	6 (12)	69 (93)	1 (2)	2 (3)	4 (8)	2 (3)	18.1 (6.9–47.8) mo	N/A
Cheng et al. <sup>14</sup> (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. <sup>14</sup> (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
<b>Single-arm studies</b>												
Goebel et al. <sup>19</sup> (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 mo	N/A
Henn et al. <sup>18</sup> (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 y	N/A

Values are n (%), mean ± standard deviation, or median (interquartile range).

CVA, cerebrovascular accident; N/A, not available; POAF, postoperative atrial fibrillation; PPI, permanent pacemaker implantation; SA, surgical ablation; TIA, transient ischemic attack.

\* Separate outcomes are provided for the mechanical and biological aortic valve replacement groups.

presenting with paroxysmal AF varied considerably among studies but did not differ between patients who did vs did not undergo surgical ablation (risk ratio [RR] 1.39, 95% CI 0.80-2.41,  $P = 0.25$ ; Supplemental Fig. S5).

### Intraoperative characteristics

The majority of the studies, with the exception of those by Sasaki et al.<sup>15</sup> and Malaisrie et al.<sup>16</sup>, reported on cohorts of patients undergoing isolated aortic valve intervention. The ablation strategy varied considerably, from isolated pulmonary vein isolation to left-sided lesion set or a full Cox-Maze III or IV procedure. Left atrial appendage amputation or closure was not always performed in the surgical ablation arm, and it 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 Fig. S6). Moreover, patients from the ablation group underwent mechanical valve implantation less often than did those patients who did not undergo ablation (RR 0.81, 95% CI 0.67-0.97,  $P = 0.02$ ; Supplemental Fig. S7). Both aortic cross-clamp time and cardiopulmonary bypass time were longer in the surgical ablation group, with an absolute difference of 20.6 minutes (95% CI 12.5-28.7 minutes,  $P < 0.01$ ) and 27.4 minutes (95% CI 16.4-38.1 minutes,  $P < 0.01$ ), respectively (Supplemental Figs. S8 and S9).

### Early outcomes

Early postoperative outcomes are summarized in Table 2. The rate of early postoperative mortality did not differ between the 2 groups (RR 0.95, 95% CI 0.76-1.19,  $P = 0.67$ ), whereas the rate of postoperative AF was significantly lower in the ablation group (RR 0.38, 95% CI 0.20-0.73,  $P < 0.01$ ; Fig. 2). On the other hand, a significant increase in the 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 (Fig. 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,  $P = 0.54$ ).

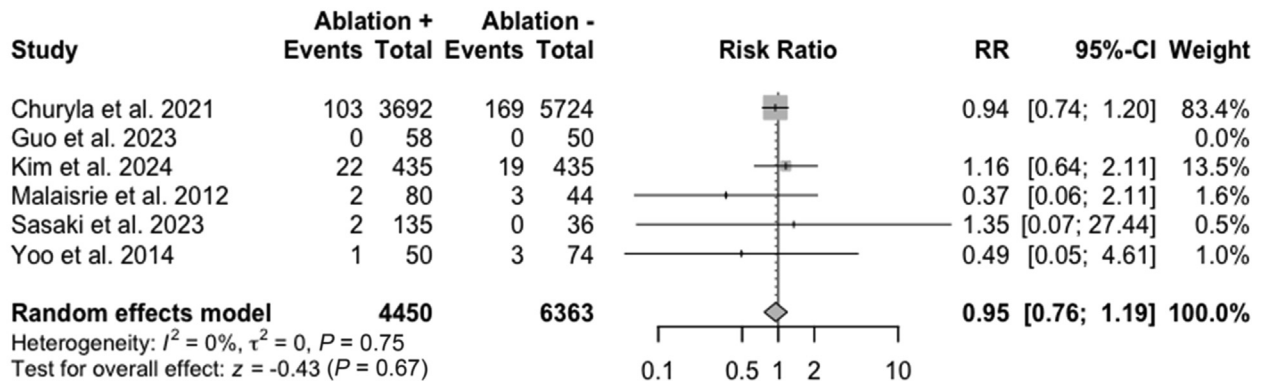
### Late outcomes

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

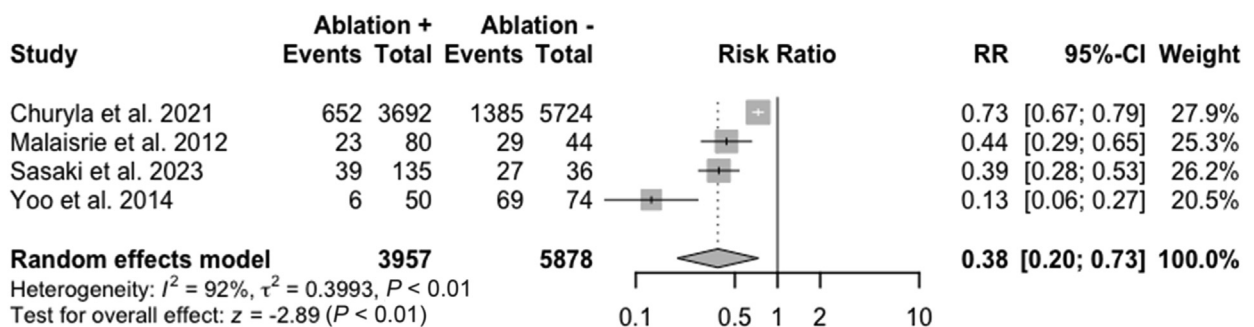
Table 3 provides an overview of the reported freedom from AF following surgical ablation. Due to the use of various methods for data analysis and presentation, including different subgroup analyses (which compared groups based on either the characteristics of AF or the type of procedure performed), formal analyses could not be conducted. Additionally, the follow-up period was limited to 2 years post-surgery.

In patients with paroxysmal AF, surgical ablation appeared to be effective in reducing recurrence. Both Goebel et al. and Sasaki et al. reported freedom from AF of > 80% at 2 years,

## A Early mortality



## B Postoperative atrial fibrillation



**Figure 2.** Concomitant ablation (A) did not affect postoperative mortality but (B) was effective at reducing the incidence of postoperative atrial fibrillation. CI, confidence interval; RR, risk ratio.

regardless of the type of surgical procedure performed.<sup>15,19</sup> In contrast, recurrence was more frequent in patients with non-paroxysmal AF.

According to Sasaki et al., better outcomes were observed when a Cox-Maze procedure was performed, as compared to pulmonary vein isolation.<sup>15</sup>

Lastly, no beneficial effect of surgical ablation on the incidence of late stroke could be observed (RR 0.98, 95% CI 0.45-2.13,  $P = 0.49$ ; [Supplemental Fig. S10](#)).

## Discussion

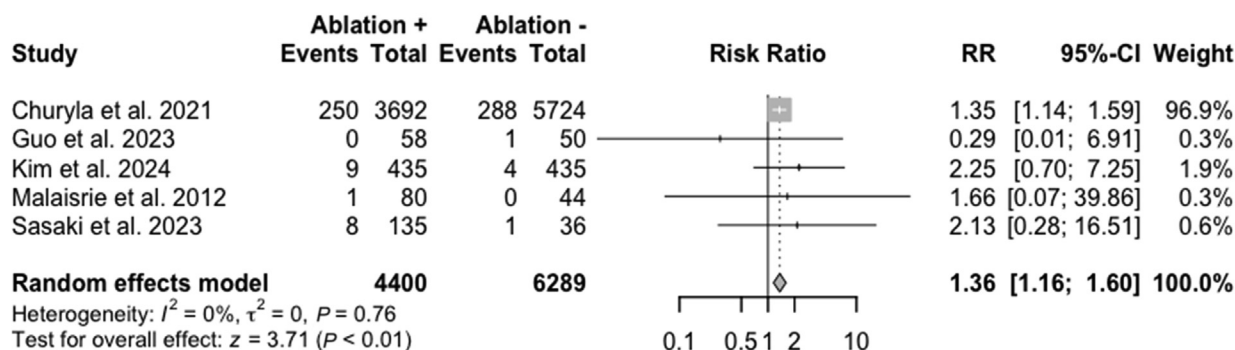
This review is the first meta-analysis to assess the safety, efficacy, and long-term outcomes of concomitant AF ablation in patients undergoing SAVR. Although concomitant surgical AF ablation appears to be effective in reducing the incidence of postoperative AF, our results suggest that it also may be 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.

Increasing evidence shows the clinical benefits of concomitant AF ablation. Although its adoption is accepted widely for certain patient populations, such as those undergoing mitral valve surgery, a growing body of evidence suggests that concomitant ablation may offer superior outcomes

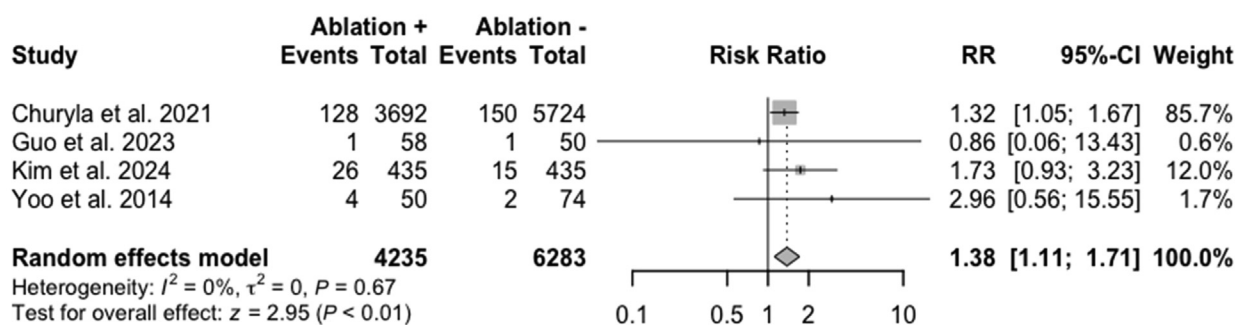
in other cohorts as well.<sup>20,21</sup> Our study focused on patients undergoing SAVR, in whom ablation of AF seems meaningful. The majority of SAVR patients have (severe) left ventricular hypertrophy associated with diastolic dysfunction and a decrease in passive left ventricular filling. Restoring and maintaining sinus rhythm in these patients is expected to improve intracardiac hemodynamics, and in turn, result in improved clinical outcomes. A recent meta-analysis of patients with hypertrophic obstructive cardiomyopathy 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.<sup>22</sup> 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, in which concomitant AF ablation and left atrial appendage ligation were performed in only 26% and 51% of patients with known preoperative AF, respectively.<sup>23</sup>

The early results of our study align with expectations. Concomitant ablation resulted in significant prolongation of aortic cross-clamp time and cardiopulmonary bypass time, which in turn were 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

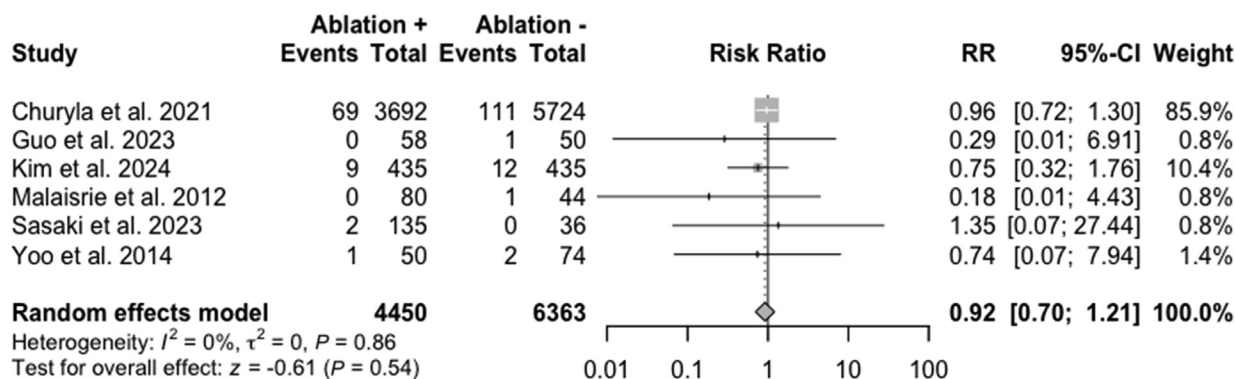
### A Permanent pacemaker implantation



### B Postoperative renal failure



### C Postoperative stroke



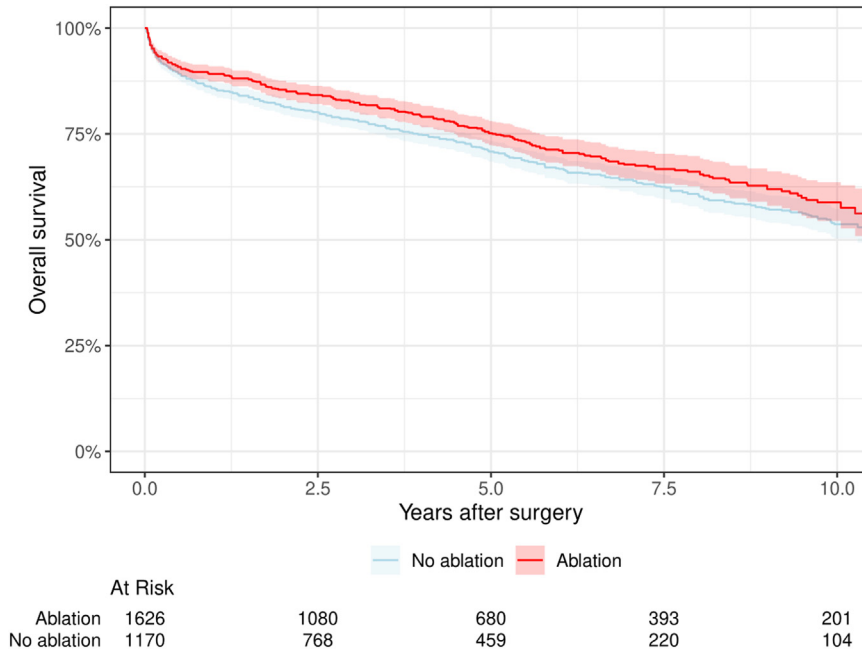
**Figure 3.** Concomitant ablation resulted in a higher incidence of (A) postoperative pacemaker implantation and (B) renal failure; (C) no effect on the incidence of postoperative stroke was observed. CI, confidence interval; RR, risk ratio.

mitral valve surgery, in which increased operative times and pacemaker implantation rates have likewise been observed.<sup>24</sup> An important point to note is that such complications have not translated into increased early mortality or worse long-term outcomes in mitral cohorts. This finding suggests that, although 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 does persistent or long-standing forms. However, the AF subtype was not consistently reported or stratified in the included studies; thus, our ability to explore its potential impact on clinical outcomes was limited.

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.<sup>25</sup> In addition, novel surgical ablation clamps that allow for the creation of a Box-lesion with a single application could be particularly



**Figure 4.** Overall survival rates for the ablation and no ablation group.

beneficial for SAVR patients, in whom the left atrium typically is not opened.<sup>26</sup> 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. A point worth mentioning is that mechanical valves, which generally are 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 on 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.<sup>27</sup> Nevertheless, for

**Table 3. Reported freedom from atrial fibrillation**

Study	3 mo	6 mo	9 mo	12 mo	24 mo	48 mo
<b>Guo et al.<sup>11</sup> (2023)</b>	—	—	—	-KME: 100%	—	—
<b>Goebel et al.<sup>19</sup> (2021)</b>	—	—	—	-KME: 100%	-KME: 83.7% (95% CI 70.1%–92.1%)	—
Paroxysmal AF	—	—	—	KME: 93.4% (95% CI 81.4%–98.2%)	-KME: 72.5% (95% CI 41.2%–90.9%)	—
Non-paroxysmal AF	—	—	—	—	—	—
<b>Henn et al.<sup>18</sup> (2015)</b>						
Cox-Maze group	98%	92%	—	97%	88%	—
PVI group	56%	43%	—	60%	63%	—
<b>Malaisrie et al.<sup>16</sup> (2012)</b>	—	—	85% (60 of 71)	—	—	—
<b>Sasaki et al.<sup>15</sup> (2023)</b>						
Paroxysmal AF						
Cox-Maze group	95% (18 of 19)	93% (14 of 15)	—	—	87% (13 of 15)	—
PVI group	88% (30 of 34)	90% (27 of 30)	—	—	97% (30 of 31)	—
Non-paroxysmal AF						
Cox-Maze group	63% (32 of 51)	64% (27 of 42)	—	—	53% (24 of 45)	—
PVI group	47% (7 of 15)	55% (6 of 11)	—	—	42% (5 of 12)	—
<b>Yoo et al.<sup>17</sup> (2014)</b>						KME: 80.6% (95% CI 69.0%–92.2%)

AF, atrial fibrillation; CI, confidence interval; KME, Kaplan-Meier estimate; PVI, pulmonary vein isolation.

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 prolonged hospital stay, increased risk of stroke, infection, renal or respiratory failure, and cardiac arrest, among other negative effects.<sup>28</sup> This beneficial effect of concomitant ablation is 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. Although rhythm follow-up data were missing in a significant portion of the included studies, those that reported rhythm outcomes demonstrated excellent results. A point worth noting is that 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.<sup>29</sup> An encouraging finding from our study is the improvement in overall survival that occurred in association 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 what constitutes optimal treatment of patients with severe aortic valve stenosis. Currently, a history of AF does not factor into the decision to perform either SAVR or transcatheter aortic valve implantation. In the only available (to the best of our knowledge) study on this topic, SAVR combined with ablation demonstrated markedly superior outcomes in these patients, compared to transcatheter treatment.<sup>30</sup> The clinical benefits observed in our study may support the use of SAVR with concomitant ablation for patients with a history of AF who are scheduled to undergo aortic valve intervention.

### Limitations

Limitations and biases of our study relate largely 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 they warrant confirmation through well-designed future studies. Additionally, several studies did not report important outcomes of interest, primarily heart rhythm status, which is of specific interest in our research. This omission is related partly to the logistical and economic challenges in obtaining structured follow-up data for heart rhythm assessment. Similarly, the definition of renal failure varied across studies, with some reporting only dialysis-dependent cases, and others using 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 evidence 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, concomitant ablation did lead to increased aortic cross-clamp time and cardiopulmonary bypass time, resulting in an increased risk of postoperative renal failure. Despite these challenges, concomitant ablation resulted in a high rate of sinus rhythm restoration and even improved overall survival, thereby providing an argument to increase the utilization of concomitant ablation in SAVR patients with a known history of AF.

### 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.

### Ethics Statement

The research has adhered to the relevant ethical guidelines.

### Patient Consent

The authors confirm that patient consent is not applicable to this article. This is a systematic review and meta-analysis using de-identified data; therefore, the institutional review board did not require consent from the patients.

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The authors have no conflicts of interest to disclose.

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### Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjopen.ca/> and at <https://doi.org/10.1016/j.cjco.2025.05.001>.