SGLT2 inhibitors and risk of atrial fibrillation recurrence after catheter ablation: A systematic review and meta-analysis of observational studies

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BACKGROUND Sodium–glucose cotransporter 2 inhibitors (SGLT2i) exhibit potential antiarrhythmic effects, but their influence on atrial fibrillation (AF) recurrence after catheter ablation (CA) remains unclear.

OBJECTIVE This study aimed to assess the association between SGLT2i therapy and the risk of recurrent AF after CA through an updated systematic review and meta-analysis of observational studies.

METHODS A systematic search of PubMed and Scopus (inception to July 2025) identified eligible observational studies. Pooled hazard ratios for AF recurrence after CA were estimated using Mantel–Haenszel random-effects models, with heterogeneity assessed by I^2. The protocol was registered in PROSPERO (CRD42024620765).

RESULTS 6 observational studies were included, comprising 2165 patients (mean age 65.2 years; 34.9% female), of whom 663 received SGLT2i therapy and 1502 did not. The average follow-up duration was 19.9 months. Pooled analysis showed a significantly reduced risk of AF recurrence in patients treated with SGLT2i compared with those not receiving SGLT2i (hazard ratio 0.49; 95% confidence interval 0.36–0.67; $P < .0001$; $I^2 = 68.3\%$). Subgroup analyses confirmed consistent benefits in both diabetic and nondiabetic patients and with the use of radiofrequency or cryoablation. A multivariable meta-regression model including age, female sex, diabetes mellitus, and follow-up duration accounted for a significant portion of the observed heterogeneity ($R^2 = 58.1\%$; $P = .01$).

CONCLUSION SGLT2i therapy is associated with a significantly lower risk of AF recurrence after CA, independent of diabetic status. Further randomized controlled trials are warranted to validate these findings and explore the mechanisms underlying this association.

KEYWORDS Atrial fibrillation; Catheter ablation; Sodium–glucose cotransporter 2 inhibitors; Arrhythmias; Meta-analysis

Introduction

Catheter ablation (CA) has become a cornerstone therapy for rhythm control in patients with symptomatic or recurrent atrial fibrillation (AF), demonstrating clear superiority over antiarrhythmic drugs in maintaining sinus rhythm and improving cardiovascular outcomes.[1–4] However, AF recurrence remains a significant clinical challenge, occurring in approximately 20% to 50% of patients after CA, after 5 years.[5–7] These recurrences often require further interventions, including repeat ablation procedures, reinitiation of antiarrhythmic drug therapy, or cardioversion, all of which entail additional risks, health care costs, and a negative impact on patients' quality of life.[8]

Over the last decade, growing evidence has suggested a potential antiarrhythmic effect of sodium–glucose cotransporter 2 inhibitors (SGLT2i),[9,10] beyond their established role in glycemic control and cardiovascular protection.[11] Emerging data suggest that SGLT2i may also lower the incidence of AF or atrial flutter by approximately 20% in patients with type 2 diabetes mellitus (DM).[12,13] Furthermore, preliminary observational studies have reported a reduced risk of AF recurrence after CA in patients

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KEY FINDINGS

- Treatment with sodium–glucose cotransporter 2 inhibitors (SGLT2i) was associated with a substantially lower risk of atrial fibrillation recurrence after catheter ablation, corresponding to an approximate 51% relative risk reduction compared with patients not receiving SGLT2i therapy.
- The observed benefit remained consistent across multiple sensitivity analyses and was evident in both diabetic and nondiabetic populations, as well as across different ablation modalities (radiofrequency and cryoballoon), suggesting that the antiarrhythmic effect of SGLT2i may be independent of glycemic control or procedural technique.
- Meta-regression analyses identified age, female sex, and diabetes as significant predictors of atrial fibrillation recurrence, whereas longer follow-up durations were inversely associated with recurrence risk, collectively accounting for more than half of the observed heterogeneity across studies.

treated with SGLT2i compared with those not treated, particularly among those with diabetes.[12,14] However, these findings are largely based on single-center, retrospective studies with inherent limitations, including small sample sizes, lack of randomization, and limited statistical power.

To strengthen and expand upon these preliminary observations, we conducted an updated systematic review and meta-analysis based on observational studies, aimed at synthesizing the available evidence on the effect of SGLT2i therapy, compared with no SGLT2i use, on the risk of AF recurrence after CA. By incorporating data from both diabetic and nondiabetic populations, this analysis seeks to clarify the potential role of SGLT2i in secondary AF prevention and to inform future clinical decision making.

Methods

This meta-analysis was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Supplemental Table 1).[15] The prespecified study protocol was registered in PROSPERO (CRD42024620765).

Search strategy

We conducted a systematic search of PubMed/MEDLINE and Scopus from inception to July 1, 2025, without language restrictions, using predefined Medical Subject Headings terms and keywords. The following search terms were used: "Sodium-Glucose Cotransporter-2 Inhibitor" OR "SGLT2i" AND "Atrial Fibrillation" OR "AF" AND "Catheter Ablation." The full electronic search strategy is presented in Supplemental Table 2. In addition, we manually screened the reference lists of all included studies and relevant reviews to identify any additional eligible publications. Studies were included if they were (1) prospective or retrospective investigations; (2) enrolling patients who underwent CA for AF, comparing those treated with SGLT2i with those not receiving SGLT2i therapy; and (3) reporting adjusted hazard ratios (HRs) with corresponding 95% confidence intervals (CIs) for the risk of AF recurrence. In particular, AF recurrence was defined as any episode of AF lasting more than 30 seconds, occurring after a 3-month postablation blanking period and in the absence of ADD therapy. In contrast, exclusion criteria were (1) studies comparing SGLT2i with other antidiabetic medications rather than with no SGLT2i use, (2) studies not reporting HRs with corresponding 95% CIs for AF recurrence risk, and (3) case reports, review articles, editorials, letters, conference abstracts, or case series with fewer than 15 participants.

Data extraction and quality assessment

Study selection was independently performed by 2 authors (L.C. and F.V.) in a blinded manner. Any discrepancies regarding study inclusion were resolved through discussion with a third reviewer (M.B.). Data extraction was likewise conducted independently by 2 authors (M.Z. and M.B.), and disagreements were resolved by consensus. The following information was extracted from each eligible study, when available: publication year, study design, number of participants, mean or median age, sex distribution, cardiovascular comorbidities (including hypertension, DM, stroke, and coronary artery disease), left ventricular ejection fraction, type of AF (ie, paroxysmal or persistent), type of CA performed, and duration of follow-up. The quality of observational studies was assessed using the Newcastle–Ottawa scale (NOS), which evaluates studies based on 3 domains: selection of study groups (0–4 points), comparability of cohorts (0–2 points), and outcome assessment (0–3 points), for a maximum total score of 9 points. Studies with an NOS score of $\geq$6 were considered to be of moderate to high quality.[16]

Study outcomes

The primary outcome of this study was the risk of AF recurrence after CA in patients treated with SGLT2i compared with those not receiving SGLT2i therapy. Secondary outcomes included subgroup analyses evaluating the risk of AF recurrence in diabetic and nondiabetic patients separately and according to the CA modality (radiofrequency vs cryoablation) consistently comparing those treated with SGLT2i with those not receiving such therapy.

Data synthesis and analysis

Continuous variables were reported as means, whereas categorical variables were expressed as absolute numbers and corresponding percentages. Risk estimates for recurrent AF after CA were pooled using the Mantel–Haenszel random-effects model, with HRs and 95% CIs as the effect

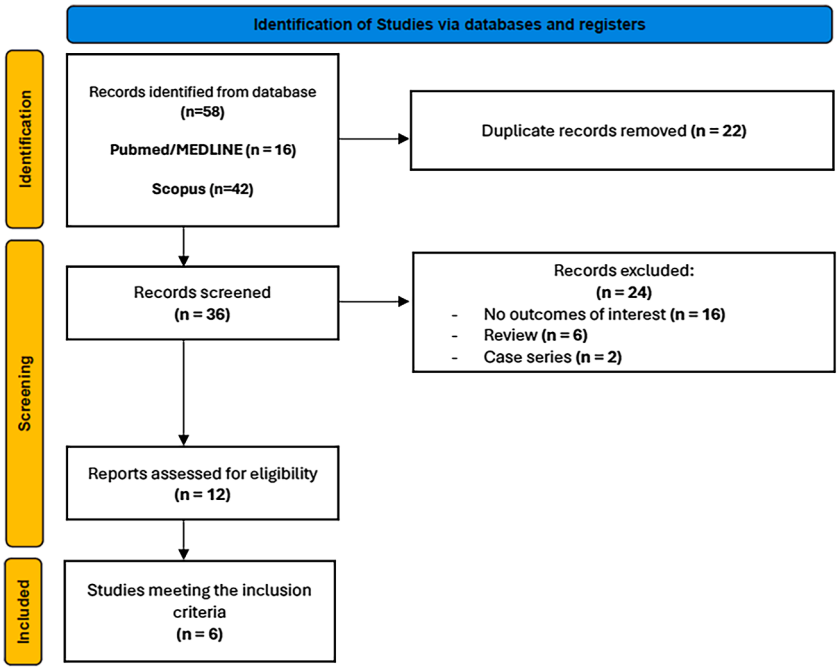

Figure 1 PRISMA flowchart. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

measures. When available, HRs derived from propensity score–matched cohorts were preferentially used over those from unmatched analyses to reduce confounding. Between-study heterogeneity was assessed using the Higgins and Thompson I^2 statistic, with values interpreted as follows: low (<25%), moderate (25%–75%), and high heterogeneity (>75%). The DerSimonian and Laird method was used to estimate the between-study variance (tau^2). Potential publication bias was evaluated through visual inspection of funnel plots. However, given the small number of included studies (<10), formal tests for small-study effects were not performed, given that the analysis was underpowered to reliably detect such bias. To confirm the robustness of our findings, we conducted several dedicated subgroup and sensitivity analyses. A leave-one-out sensitivity analysis was performed by sequentially removing each study to assess its influence on the overall effect estimate. To further explore the impact of potential baseline confounders, univariate and multivariable meta-regression analyses were also conducted. All statistical analyses were performed using Comprehensive Meta-Analysis software, version 3 (Biostat).

Results

Search results and included studies

A total of 58 articles were obtained using our search strategy. After excluding duplicates and preliminary screening, 36 full-text articles were screened. Among them, 16 studies were excluded because they did not report the outcome of interest and 8 for not meeting the inclusion criteria, leaving 6 investigations fulfilling the inclusion criteria (Figure 1).[12,17–21]

Characteristics of the population and quality assessment

Among the 6 studies included in this meta-analysis, only 1 had a prospective design.[12] The baseline characteristics of the included studies are presented in Table 1. A total of 2165 patients (mean age 65.2 years; 34.9% female) were included in the pooled analysis. Of these, 663 received SGLT2i therapy, whereas 1502 did not. Although comorbidities were not systematically reported across all studies, the populations largely consisted of middle-aged patients, with hypertension and type 2 DM being the most observed associated conditions. The average left ventricular ejection fraction was 55.3%. 4 studies used radiofrequency CA as the ablation strategy,[12,18,19,21] whereas the remaining 2 used cryoballoon ablation.[17,20] The mean follow-up duration after the index ablation procedure was 19.9 months. According to the NOS, all included studies were assessed as having moderate to high methodological quality (Supplemental Table 3).

Risk of recurrent AF

During the follow-up period, 710 patients (23.5%) experienced recurrent AF, including 138 (20.8%) in the SGLT2i group and 572 (38.0%) in the non-SGLT2i group. Pooled analysis of adjusted HRs for recurrent AF after CA (Supplemental Tables 4 and 5) showed that patients treated with SGLT2i had a significantly lower risk of recurrence than those not receiving SGLT2i therapy (HR 0.49; 95% CI 0.36–0.67; $P < .0001$; $I^2 = 68.3\%$) (Figure 2). Visual inspection of the funnel plot suggested possible asymmetry, likely owing to the limited number of included studies and the absence of smaller studies at the base of the plot triangle

Table 1 General characteristics of the studies considered for the analysis

Author	Year	Population	SGLT2i	No SGLT2i	Type of study	Mean age	Females, n (%)	HTN, n (%)	DM, n (%)	Stroke, n (%)	CAD, n (%)	LVEF, (%)	Parox AF	Persist AF	Type of ablation	Follow-up (mo)
Cetin et al[17]	2025	246	71	175	Retro	64.1	94 (38.2)	98 (39.8)	83 (33.7)	12 (4.8)	NR	31.9	134 (54.4)	112 (45.2)	Cryo	11.4
Luo et al[18]	2024	326	79	247	Retro	63.6	134 (41.1)	210 (64.4)	326 (100)	NR	133 (40.7)	60.2	NR	154 (47.2)	RFCA	36
Zhao et al[13]	2023	525	138	387	Prosp	63.9	151 (28.7)	417 (89.7)	525 (100)	63 (12.0)	179 (34.0)	62.8	NR	267 (50.8))	RFCA	18
Noh et al[19]	2024	272	73	199	Retro	72.5	36 (13.2)	191 (70.2)	89 (36.0)	NR	36 (13.2)	56.1	150 (55.1)	122 (44.8)	RFCA	18
Hakgor et al[20]	2025	614	211	403	Retro	58.1	259 (24.2)	429 (69.9)	148 (24.1)	46 (7.5)	212 (34.5)	57.7	415 (67.6)	199 (32.6)	Cryo	24
Qi et al[21]	2024	182	91	91	Retro	69.1	82 (45.0)	148 (81.3)	182 (100)	NR	NR	63.2	NR	NR	RFCA	12

AF = atrial fibrillation; CAD = coronary artery disease; Cryo = cryoablation; DM = diabetes mellitus type II; HTN = hypertension; LVEF = left ventricular ejection fraction; NR = not reported; Parox = paroxysmal; Persist = persistent; Prosp = prospective; RFCA = radiofrequency catheter ablation; Retro = retrospective; SGLT2i = sodium–glucose cotransporter 2 inhibitors.

(Supplemental Figure 1), which precludes definitive assessment of publication bias. Sensitivity analysis using the leave-one-out method demonstrated consistent results, with HRs ranging from 0.46 (95% CI 0.31–0.68; $P < .0001$; $I^2 = 73.8\%$) to 0.53 (95% CI 0.40–0.70; $P < .001$; $I^2 = 62.9\%$), confirming that the overall findings were not driven by any single study.

Subgroup analyses

Subgroup analyses based on diabetic status confirmed the robustness of the findings, with SGLT2i treatment significantly reducing the risk of recurrent AF after CA in both diabetic (HR 0.54; 95% CI 0.34–0.84; $P = .007$; $I^2 = 67.5\%$)[12,18,21] and nondiabetic patients (HR 0.40; 95% CI 0.19–0.60; $P < .001$; $I^2 = 66.2\%$)[17,19,20] (Figure 3). In another subgroup analysis, stratifying the population according to the type of CA revealed no differences in the risk of recurrent AF after CA in patients treated with radiofrequency CA (HR 0.57; 95% CI 0.42–0.78; $P < .001$; $I^2 = 51.3\%$) or cryoablation (HR 0.40; 95% CI 0.23–0.69; $P = .001$; $I^2 = 67.7\%$) (Figure 4).

Sensitivity analyses

In the sensitivity analysis, excluding the study by Cetin et al[17] that specifically focused on patients with heart failure with reduced ejection fraction, the association between SGLT2i use and reduced AF recurrence after CA remained significant (HR 0.48; 95% CI 0.33–0.70; $P < .001$; $I^2 = 74.2\%$). Similarly, exclusion of the study by Zhao et al,[13] the only prospective investigation included in the analysis, did not alter the overall findings (HR 0.44; 95% CI 0.33–0.62; $P < .001$; $I^2 = 65.1\%$).

Meta-regression for the risk of recurrent AF

Univariate meta-regression analysis revealed a significant direct association between the risk of recurrent AF after CA and the moderators age ($P = .003$), female sex ($P = .01$), and DM ($P = .008$). In contrast, an inverse relationship was observed when follow-up duration was used as the moderating variable ($P = .01$) (Table 2). A multivariable meta-regression model incorporating all these variables explained a significant proportion of the observed heterogeneity ($R^2 = 58.1\%$; $P = .01$).

Discussion

This meta-analysis demonstrates that treatment with SGLT2i is associated with a significantly reduced risk of AF recurrence after CA compared with no SGLT2i therapy. These findings suggest a potential role for SGLT2i not only in cardiometabolic risk reduction but also in the secondary prevention of AF after CA. Furthermore, the observed association remained robust across multiple sensitivity and subgroup analyses, regardless of the diabetic status, the type of CA, and the study design.

The magnitude of risk reduction observed aligns with previous evidence supporting the broader cardiovascular

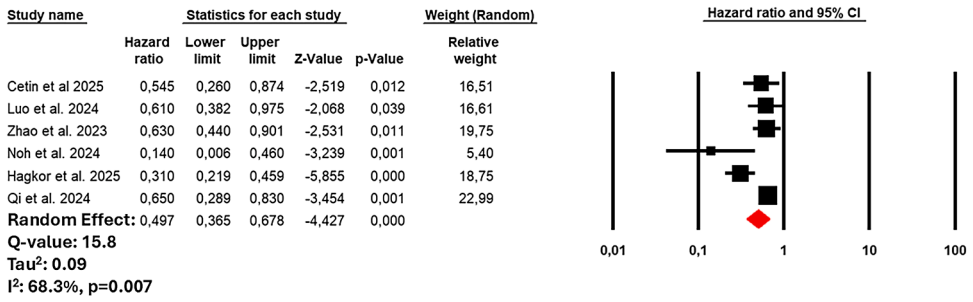

Figure 2 Forrest plot investigating the risk of recurrent atrial fibrillation who underwent catheter ablation and were treated with or without sodium–glucose cotransporter 2 inhibitors. CI = confidence interval.

benefits of SGLT2i, including reductions in heart failure hospitalization and cardiovascular mortality.[22–24] Our subgroup analysis showed consistent benefits in both diabetic and nondiabetic populations, suggesting that the antiarrhythmic effect of SGLT2i may be independent of glycemic control. This hypothesis is biologically plausible, given that SGLT2i have been shown to modulate several mechanisms implicated in AF pathophysiology, including improvement in ventricular loading conditions,[25] attenuation of atrial fibrosis,[26–28] reduction in systemic inflammation,[29,30] and favorable effects on autonomic tone and myocardial energetics.[31]

Our findings were also consistent when accounting for study-level characteristics. Meta-regression analyses identified age, female sex, and DM as significant positive moderators of AF recurrence risk, as previously described.[32–36] Age is a well-established risk factor for both the development and recurrence of AF. In fact, aging promotes structural and electrical remodeling of the atria, including increased interstitial fibrosis, cellular apoptosis, and impaired gap junction function, all of which contribute to a substrate that promotes AF persistence and reduces the success of CA.[37] Similarly, female sex has been independently associated with a higher risk of AF recurrence after CA.[38] Potential explanations include sex-related differences in atrial size, hormonal influences on ion channel expression, and autonomic regulation.[39] Moreover, a greater distribution of periatrial fat in women may contribute to a more arrhythmogenic substrate.[40] In addition, women are often referred for ablation later in the disease course, which may result in more advanced atrial remodeling at the time of the procedure.[41] Finally, DM promotes a proarrhythmic atrial substrate through mechanisms such as chronic systemic inflammation, oxidative stress, insulin resistance, and myocardial fibrosis.[42] These changes not only increase the susceptibility to AF but also reduce the likelihood of long-term maintenance of sinus rhythm after ablation.

Conversely, in the multivariate meta-regression analysis, follow-up duration was inversely associated with the risk of recurrent AF, suggesting that longer follow-up periods may dilute the observed effect of SGLT2i on AF recurrence. This could reflect a progressive attenuation of treatment benefit

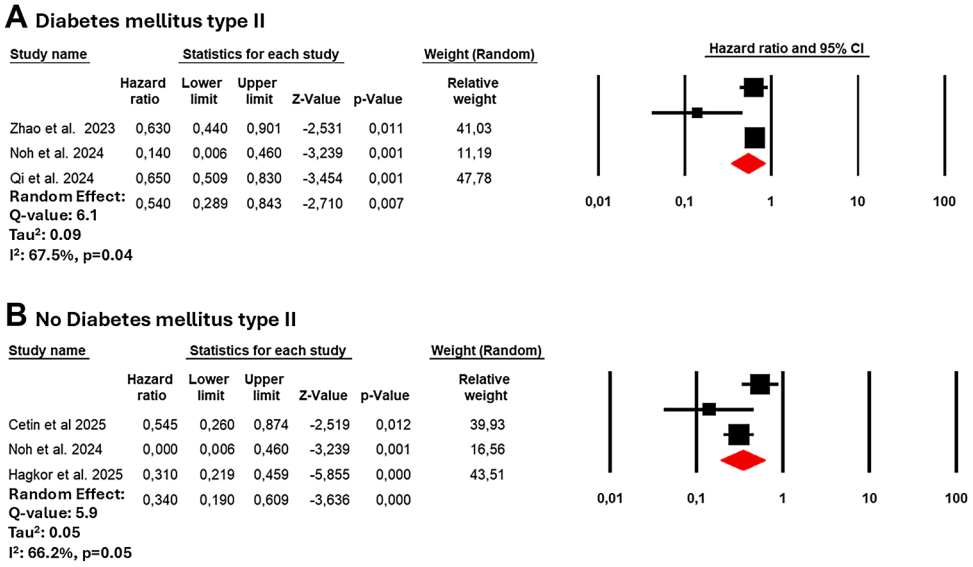

Figure 3 Forest plot illustrating the risk of recurrent atrial fibrillation in patients who underwent catheter ablation, comparing those treated with vs without sodium–glucose cotransporter 2 inhibitors, stratified by diabetic status. CI = confidence interval.

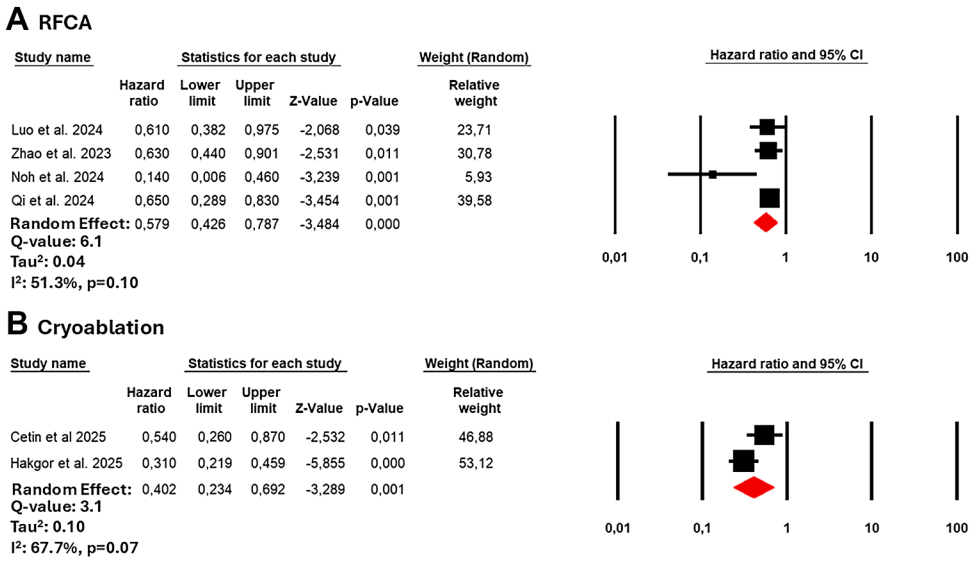

Figure 4 Forest plot illustrating the risk of recurrent atrial fibrillation in patients who underwent catheter ablation, comparing those treated with vs without sodium–glucose cotransporter 2 inhibitors, stratified by type of cardiac ablation. CI = confidence interval; RFCA = radiofrequency cardiac ablation.

over time; the influence of competing risk factors, such as aging and/or structural remodeling of the heart; and increased AF recurrence in both groups owing to the natural history of the disease.[43] Alternatively, shorter follow-up studies may overestimate treatment effects owing to early suppression of arrhythmia recurrence, often influenced by procedural success and early antiarrhythmic effects. The multivariable model incorporating these covariates explained more than half of the observed heterogeneity, suggesting that baseline population characteristics may have substantially influenced treatment effect estimates in the revised observational studies.

This meta-analysis offers several important advancements over previous investigations. First, it represents the most up-to-date synthesis of available evidence and is the first to include both diabetic and nondiabetic patients undergoing CA for AF. In contrast, earlier meta-analyses were limited to diabetic populations or included comparator groups who received a mix of treatments, including other antidiabetic agents, potentially introducing confounding and biasing the results.[44,45] In contrast, by focusing exclusively on studies comparing SGLT2i users with untreated controls (ie, no SGLT2i use), we ensured a cleaner and more clinically relevant comparison. Moreover, we only included studies reporting adjusted HRs, thereby accounting for baseline imbalances in key confounding variables.[44,45] This approach is methodologically superior to pooling unadjusted event rates or crude risk estimates, which fail to account for differences in patient characteristics and may lead to misleading conclusions, particularly in observational research. In addition, compared with previous meta-analyses,[44–46] we also performed a multivariable meta-regression, which allowed us to explore the contribution of study-level covariates to the observed heterogeneity. Together, these methodological refinements enhance the robustness and clinical relevance of our findings, providing more reliable evidence on the potential role of SGLT2i in reducing AF recurrence after CA.

Nonetheless, this meta-analysis provides updates and clinically relevant insights, extending and supporting previous preliminary evidence on their antiarrhythmic potential. Given the clinical burden of AF recurrence, the favorable safety profile of SGLT2i, and their growing use in both diabetic and nondiabetic cardiovascular patients, our findings support further investigation of SGLT2i in randomized controlled trials specifically designed to assess AF-related outcomes.

Table 2 Univariate and multivariate meta-regression analyses for the risk of recurrent atrial fibrillation after catheter ablation in patients treated or not with sodium–glucose cotransporter 2 inhibitors

Moderator	Coefficient	95% CI	*P* value	R^2
Univariable analysis				
Age (y)	0.015	0.005–0.026	.003	0.12
Women (%)	0.031	0.019–0.041	.01	0.218
HTN (%)	0.003	−0.0174 to 0.024	.73	0
DM (%)	0.007	0.002–0.013	.008	0.142
LVEF (%)	0.002	−0.027 to 0.033	.19	0
FW length (mo)	−0.042	−0.062 to −0.028	.01	0.148
Multivariate analysis				
Age (y)	0.011	0.009–0.019	.01	0.581
Females (%)	0.026	0.018–0.0.42	.03	
DM (%)	0.006	0.002–0.013	.02	
FW length (mo)	−0.038	−0.489 to −0.284	.03	

CI = confidence interval; DM = diabetes mellitus type II; FW = follow-up; HTN = hypertension; LVEF = left ventricular ejection fraction.

Limitations

This study has several limitations, primarily stemming from the observational nature of the included studies, with their

inherent risk of bias and confounding. Moreover, owing to limited data, we were unable to evaluate the potential differential effects of specific SGLT2i. The overall number of eligible studies was small, which precluded a formal assessment of small-study effects and publication bias. Heterogeneity also represents a significant limitation. Although moderate to high heterogeneity is common in meta-analyses based on observational data, particularly in conditions like AF, which is influenced by multiple clinical and procedural factors, our meta-regression analysis accounted for approximately 50% of the observed heterogeneity. Importantly, various sensitivity analyses consistently confirmed the robustness of our findings. Nonetheless, we cannot exclude the possibility that unmeasured confounders may have influenced the results. In addition, another key limitation of our study is that it is based solely on observational data, and therefore, the results should be interpreted as hypothesis-generating rather than definitive evidence. Finally, baseline comorbidities and procedural characteristics were not uniformly reported across studies, which may have introduced residual confounding.

Conclusion

SGLT2i therapy was associated with a significantly reduced risk of AF recurrence after CA, regardless of diabetic status. Adequately powered randomized controlled trials with more diverse populations and longer follow-up durations are needed to confirm the potential role of SGLT2i as a preventive strategy for postablation AF recurrence.

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Patient Consent: Not applicable owing to the study design.

Ethics Statement: This meta-analysis was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hroo.2025.10.017.

References

1. Packer DL, Mark DB, Robb RA, et al. Effect of catheter ablation vs antiarrhythmic drug therapy on mortality, stroke, bleeding, and cardiac arrest among patients with atrial fibrillation: the CABANA randomized clinical trial. JAMA 2019;321:1261–1274.
2. Mark DB, Anstrom KJ, Sheng S, et al. Effect of catheter ablation vs medical therapy on quality of life among patients with atrial fibrillation: the CABANA randomized clinical trial. JAMA 2019;321:1275–1285.
3. Bunch TJ, Poole JE, Silverstein AP, et al. The prognostic impact of sinus rhythm in atrial fibrillation patients: separating rhythm outcomes from randomized strategy findings from the CABANA trial. Circ Arrhythm Electrophysiol 2024;17:e012697.
4. Tzeis S, Gerstenfeld EP, Kalman J, et al. 2024 European Heart Rhythm Association/Heart Rhythm Society/Asia Pacific Heart Rhythm Society/Latin American Heart Rhythm Society expert consensus statement on catheter and surgical ablation of atrial fibrillation. Europace 2024;26:euae043.
5. Kobza R, Hindricks G, Tanner H, et al. Late recurrent arrhythmias after ablation of atrial fibrillation: incidence, mechanisms, and treatment. Heart Rhythm 2004;1:676–683.
6. Cappato R, Calkins H, Chen SA, et al. Updated worldwide survey on the methods, efficacy, and safety of catheter ablation for human atrial fibrillation. Circ Arrhythm Electrophysiol 2010;3:32–38.
7. Calkins H, Hindricks G, Cappato R, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation. Europace 2018;20:e1–e160.
8. Natale A, Calkins H, Osorio J, et al. Positive clinical benefit on Patient Care, quality of life, and symptoms after contact force-guided radiofrequency ablation in persistent atrial fibrillation: analyses from the PRECEPT prospective multicenter study. Circ Arrhythm Electrophysiol 2021;14:e008867.
9. Duan HY, Barajas-Martinez H, Antzelevitch C, Hu D. The potential antiarrhythmic effect of SGLT2 inhibitors. Cardiovasc Diabetol 2024;23:252.
10. Jaiswal V, Ang SP, Kumar D, et al. Sodium-glucose Cotransporter-2 inhibitors and arrhythmias: A meta-analysis of 38 randomized controlled trials. JACC Adv 2025;4:101615.
11. Cowie MR, Fisher M. SGLT2 inhibitors: mechanisms of cardiovascular benefit beyond glycaemic control. Nat Rev Cardiol 2020;17:761–772.
12. Wang M, Zhang Y, Wang Z, Liu D, Mao S, Liang B. The effectiveness of SGLT2 inhibitor in the incidence of atrial fibrillation/atrial flutter in patients with type 2 diabetes mellitus/heart failure: a systematic review and meta-analysis. J Thorac Dis 2022;14:1620–1637.
13. Zhao Z, Jiang C, He L, et al. Impact of sodium-glucose cotransporter 2 inhibitor on recurrence after catheter ablation for atrial fibrillation in patients with diabetes: a propensity-score matching study and meta-analysis. J Am Heart Assoc 2023;12:e031269.
14. Abdelhadi NA, Ragab KM, Elkholy M, Koneru J, Ellenbogen KA, Pillai A. Impact of sodium-glucose co-transporter 2 inhibitors on atrial fibrillation recurrence post-catheter ablation among patients with type 2 diabetes mellitus: a systematic review and meta-analysis. J Cardiovasc Electrophysiol 2025;36:673–682.
15. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
16. The Ottawa Hospital. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses, https://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed July 14, 2025.
17. Cetin EHO, Cetin MS, Könte HC, et al. The impact of SGLT2 inhibitors on atrial fibrillation recurrence and long-term clinical outcomes in HFrEF patients undergoing cryoballoon ablation: a new frontier beyond diabetes and heart failure. J Cardiovasc Electrophysiol 2025;36:952–960.
18. Luo F, Sun L, Wang Z, et al. Effect of dapagliflozin on the outcome of radiofrequency catheter ablation in patients with type 2 diabetes mellitus and atrial fibrillation. Cardiovasc Drugs Ther 2024;38:91–98.
19. Noh HJ, Cha SJ, Kim CH, Choi SW, Lee CH, Hwang JK. Efficacy of dapagliflozin in improving arrhythmia-related outcomes after ablation for atrial fibrillation: a retrospective single-center study. Clin Res Cardiol 2024;113:924–932.
20. Hakgor A, Olgun FE, Dursun A, et al. Sodium glucose cotransporter 2 inhibitors improve long-term atrial fibrillation-free survival after catheter ablation. J Cardiovasc Pharmacol 2025;85:225–232.
21. Qi D, Guan X, Liu X, Liu L, Liu Z, Zhang J. Relationship between sodium-glucose cotransporter 2 inhibitors and atrial fibrillation recurrence after pulmonary vein isolation in patients with type 2 diabetes and persistent atrial fibrillation. J Cardiovasc Electrophysiol 2024;35:1799–1805.
22. McMurray JJV, Solomon SD, Inzucchi SE, et al. Dapagliflozin in patients with heart failure and reduced ejection fraction. N Engl J Med 2019;381:1995–2008.
23. Zinman B, Wanner C, Lachin JM, et al. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. N Engl J Med 2015;373:2117–2128.
24. Packer M, Anker SD, Butler J, et al. Cardiovascular and renal outcomes with empagliflozin in heart failure. N Engl J Med 2020;383:1413–1424.
25. Lopaschuk GD, Verma S. Mechanisms of cardiovascular benefits of sodium glucose co-transporter 2 (SGLT2) inhibitors: a state-of-the-art review. JACC Basic Transl Sci 2020;5:632–644.
26. Zhan X, Cheng L, Huo N, et al. Sodium-glucose cotransporter-2 inhibitor alleviated atrial remodeling in STZ-induced diabetic rats by targeting TLR4 pathway. Front Cardiovasc Med 2022;9:908037.
27. Luedde M, Sedighi J, Hippe HJ, Sossalla S, Kostev K. SGLT2 inhibitors are associated with a reduced incidence of atrial fibrillation in type 2 diabetes mellitus. Diabetes Obes Metab 2025;27:4603–4606.

28. Eroglu TE, Coronel R, Souverein PC. Sodium-glucose cotransporter-2 inhibitors and the risk of atrial fibrillation in patients with type 2 diabetes: a population-based cohort study. Eur Heart J Cardiovasc Pharmacother 2024;10:289–295.
29. Sourij H, Aziz F, Mangge H, von Lewinski D. SGLT2 inhibition could potentially impact inflammation in acute myocardial infarction. Eur Heart J 2023; 44:3931.
30. Brata R, Pascalau AV, Fratila O, et al. Hemodynamic effects of SGLT2 inhibitors in patients with and without diabetes mellitus-a narrative. Healthcare (Basel) 2024;12:2464.
31. Sardu C, Massimo Massetti M, Rambaldi P, et al. SGLT2-inhibitors reduce the cardiac autonomic neuropathy dysfunction and vaso-vagal syncope recurrence in patients with type 2 diabetes mellitus: the SCAN study. Metabolism 2022; 137:155243.
32. Darby AE. Recurrent atrial fibrillation after catheter ablation: considerations for repeat ablation and strategies to optimize success. J Atr Fibrillation 2016;9:1427.
33. Dagres N, Clague JR, Lottkamp H, Hindricks G, Breithardt G, Borggrefe M. Impact of radiofrequency catheter ablation of accessory pathways on the frequency of atrial fibrillation during long-term follow-up; high recurrence rate of atrial fibrillation in patients older than 50 years of age. Eur Heart J 2001; 22:423–427.
34. Wesselink R, Mossink B, Meulendijks ER, et al. Women have more recurrences of atrial fibrillation than men after thoracoscopic ablation and suffer more from established risk factors. J Clin Med 2023;12:2650.
35. Al-Sadawi M, Aslam F, Gier C, et al. Effect of gender on atrial fibrillation ablation outcomes using a propensity score-matched analysis. Heart Rhythm O2 2023;4:309–316.
36. Wang A, Truong T, Black-Maier E, et al. Catheter ablation of atrial fibrillation in patients with diabetes mellitus. Heart Rhythm O2 2020;1:180–188.
37. Nattel S. Molecular and cellular mechanisms of atrial fibrosis in atrial fibrillation. JACC Clin Electrophysiol 2017;3:425–435.
38. Beck H, Curtis AB. Sex differences in outcomes of ablation of atrial fibrillation. J Atr Fibrillation 2014;6:1024.
39. Wong GR, Nalliah CJ, Lee G, et al. Sex-related differences in atrial remodeling in patients with atrial fibrillation: relationship to ablation outcomes. Circ Arrhythm Electrophysiol 2022;15:e009925.
40. Patel D, Mohanty P, Di Biase L, et al. Outcomes and complications of catheter ablation for atrial fibrillation in females. Heart Rhythm 2010;7:167–172.
41. Kuck KH, Brugada J, Fürnkranz A, et al. Impact of female sex on clinical outcomes in the FIRE AND ICE trial of catheter ablation for atrial fibrillation. Circ Arrhythm Electrophysiol 2018;11:e006204.
42. Lin CH, Chang SL, Lin YJ, et al. Distribution of triggers foci and outcomes of catheter ablation in atrial fibrillation patients in different age groups. Pacing Clin Electrophysiol 2021;44:1724–1732.
43. Evans JM, Withers KL, Lencioni M, et al. Quality of life benefits from arrhythmia ablation: a longitudinal study using the C-CAP questionnaire and EQ5D. Pacing Clin Electrophysiol 2019;42:705–711.
44. Soliman Y, Abuelazm M, Amer BE, et al. Impact of SGLT2 inhibitors on atrial fibrillation recurrence after catheter ablation in type 2 diabetes mellitus: a meta-analysis of reconstructed Kaplan-Meier curves with trial sequential analysis. Am J Cardiovasc Drugs 2024;24:629–640.
45. Abu-Qaoud MR, Kumar A, Tarun T, et al. Impact of SGLT2 inhibitors on AF recurrence after catheter ablation in patients with type 2 diabetes. JACC Clin Electrophysiol 2023;9:2109–2118.
46. Zhang X, Zhang Y, Sun G, et al. Effectiveness of sodium-glucose co-transporter 2 inhibitors on atrial fibrillation recurrence after catheter ablation: a systemic review and meta-analysis. Int J Cardiol 2024;413:132359.