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Review

Comprehensive Review of Approaches to Postoperative Atrial Fibrillation: Current Strategies and Future Directions

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Abstract

Postoperative atrial fibrillation (POAF) is a prevalent complication in the inpatient setting, commonly occurring after surgery. While various risk factors contribute to the development of POAF, distinct postoperative mechanisms can trigger its onset, regardless of whether cardiac surgery is involved. Thus, early detection and appropriate management of POAF are critical in mitigating additional postoperative complications, improving patient outcomes, reducing the risk of prolonged hospital stays, and minimizing downstream consequences such as stroke. Most current literature emphasizes the prevention of POAF through a combination of pharmacological interventions, non-pharmacological strategies, and other experimental treatments, which are examined in this review. This paper also analyzes the management of acute POAF, including rate and rhythm control, as well as anticoagulation (AC) therapy. It further explores the complications associated with POAF, including thromboembolic risks, its impact on recovery, and its influence on hospital length of stay. Meanwhile, special considerations are given to specific populations, such as older adult populations, those with pre-existing heart disease, obese patients, and individuals from certain racial backgrounds. The guidelines from the European Society of Cardiology and the American College of Cardiology (ACC)/American Heart Association (AHA) for POAF are also discussed. Finally, this review highlights emerging trends, including novel therapies, technologies, and the potential role of artificial intelligence (AI) in predicting and managing POAF.

Keywords

postoperative atrial fibrillation (POAF); atrial fibrillation (AF); rate control; rhythm control; coronary artery bypass graft (CABG); beta-blocker; amiodarone; ablation; thromboembolism; anticoagulation (AC)

Introduction

Definition of Postoperative Atrial Fibrillation

Postoperative atrial fibrillation (POAF) is commonly defined as new-onset atrial fibrillation (AF) occurring after surgery, particularly following cardiac procedures. Moreover, no universal consensus exists regarding the precise definition of POAF, resulting in variability in reported incidence and management strategies. According to the Journal of Surgical Research, POAF is a common, expensive, and critical surgical complication, not solely a consequence of surgery, as it can lead to adverse health outcomes, increased mortality risk, prolonged hospital stay, and increased medical costs [1].

In clinical practice, POAF is often identified through continuous electrocardiographic monitoring during the postoperative period. Additionally, the criteria for clinically significant AF episodes can vary between studies and clinical guidelines. Some studies define POAF as any AF episode lasting more than 30 seconds, while others may require longer durations or symptomatic presentations for diagnosis [1]. This lack of standardization can impact the reported prevalence and outcomes associated with POAF, as standardization in definition and monitoring practices is essential for consistent diagnosis and management across clinical settings. This review focuses on the recent literature and highlights new insights about the manifestations, impact, treatment, and prevention of POAF. Furthermore, this manuscript aims to address this issue in a multidisciplinary manner, shedding light on the knowledge gaps regarding POAF and exploring potential areas for further improvement in POAF care.

Incidence and Prevalence

POAF occurs in approximately 20% to 50% of patients undergoing cardiac surgery, with rates varying based on the type of procedure and monitoring techniques used [2]. POAF is observed in 20% to 40% of coronary artery bypass grafting (CABG) cases, 30% to 50% in valvular surgeries, and in more than 50% of combined CABG and valvular surgeries [2–4]. However, POAF is less frequent among noncardiac surgeries, but remains clinically significant, occurring in 1% to 3% of cases, particularly after major thoracic, abdominal, or orthopedic procedures [2].

Overview of the Impact on Patient Outcomes

POAF is not merely a transient arrhythmia but has far-reaching consequences that extend beyond the immediate postoperative period, significantly impacting morbidity, mortality, and healthcare costs.

POAF is linked to higher mortality rates, with a 30% to 60% increase in all-cause mortality within the first year postoperatively compared to patients without POAF. Notably, cardiovascular mortality is particularly significant, driven by complications such as heart failure and recurrent arrhythmia. POAF is associated with a 2- to 4-fold increase in the risk of thromboembolic events, particularly ischemic stroke—the stroke incidence among POAF patients ranges from 3% to 8% within 30 days postoperatively [2,3]. These episodes contribute to long-term stroke risk that persists even after arrhythmia resolution, necessitating anticoagulation (AC) therapy, which carries its own morbidity and mortality risks. Cardiac dysfunction can occur as a result of hemodynamic instability due to POAF, causing rapid and irregular ventricular rates, which can precipitate heart failure. POAF patients experience worsening left ventricular dysfunction that might require prolonged treatment and/or inotropic support [2].

POAF also prolongs hospital stay by an average of 1.5 to 2.5 days, resulting in increased healthcare utilization [2]. Further, readmission rates were significantly higher in patients with POAF. With time, POAF can serve as a marker for developing chronic AF affecting 20% to 30% of patients within five years postoperatively [4]. Moreover, POAF leads to a decline in functional capacity and quality of life, particularly in older patients. Lastly, the economic burden of POAF is substantial. The extended length of hospital stay, need for AC therapy, and readmissions contribute between USD 10,000 and USD 15,000 in added costs per patient [4]. Fig. 1 below summarizes the key impacts of POAF on patients, which may be direct or indirect consequences of AF.

Cost–Benefit Considerations

As previously mentioned, complications from POAF can add up to USD 10,000 to USD 15,000 in added cost per patient. These represent significant costs when compared to the prevention of POAF. A study performed by Walter and Heringlake [5] in the German Health Care System compared Landiolol (an ultrashort-acting beta-blocker) with standard of care (SoC), and it showed that SoC was associated with POAF rates of 36% to 39.2% in a mix of cardiac surgical procedures (MIX-CS) and 24.4% to 30.1% in isolated CABG, while Landiolol reduced the POAF rates to 12.6% in the MIX-CS and 12.1% in the CABG groups. A cost reduction of EUR 2.209 (in MIX-CS) and EUR 1.470 (in CABG) was observed in the Landiolol group compared to SoC [5]. Additionally, a study by Wang *et al.* [6] examined bi-atrial pacing as a means to prevent POAF and divided 240 patients into three groups. Group I used overdrive bi-atrial pacing, group II used single atrial pacing, and group III had no pacing. The study found that not only was the incidence of recurrent POAF significantly less in group I compared to group II ($p < 0.01$) and group III ($p < 0.01$), but the length of hospital stay, and mean cost of hospital stay were also significantly lower in group I ($p < 0.05$) [6].

Purpose

The purpose of this conceptual review is to critically analyze and expand on the current understanding of POAF, with a specific focus on its management. By exploring theoretical frameworks, existing strategies, and emerging perspectives, this paper aims to provide a comprehensive overview of POAF management, integrating diagnosis, prevention, acute and long-term management, and complications. Additionally, this review will critique current management strategies, assess their evidence base concerning current guidelines, and propose fresh perspectives on novel approaches and future directions to guide future research.

Pathophysiology of Postoperative AF

Generally, AF is a type of supraventricular tachyarrhythmia caused by the firing and re-entry of irregular ectopic electrical signals originating from the atria. Patients with risk factors for AF, such as male sex, age >70 years, hypertension, history of heart failure or arrhythmias, hypertension, and peripheral vascular disease are all at increased risk of POAF [7,8]. Furthermore, age- or hypertension-related structural changes to the atria, such as fibrosis and dilation, also increase the risk [9]. Age-related and hypertension-related myocardial changes are associated with electrophysiological abnormalities causing abnormal depolarization, conduction velocities, and impulse propagation that predispose to re-entrant arrhythmias [9]. This remodeling of the atria promotes alterations within calcium ion channels, reducing calcium ion entry into myocardial cells and thereby decreasing depolarization duration, which keeps reentry pathways intact [10].

Post-surgical patients have increased sympathetic activity and decreased vagal tone [11,12]. These conditions are associated with higher levels of norepinephrine and inflammatory markers, such as C-reactive protein (CRP), interleukin-2, and interleukin-6 [13–15]. Subsequently,

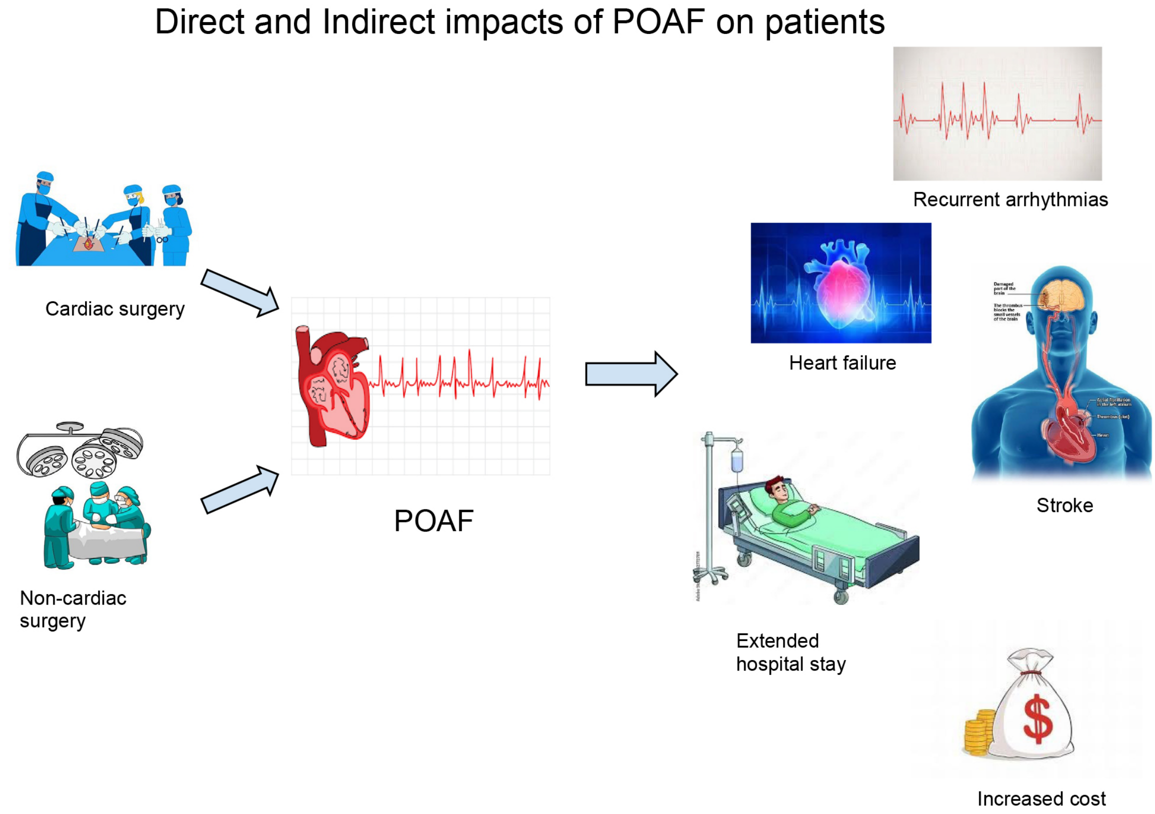

Fig. 1. Cardiac and noncardiac surgeries can cause POAF, other arrhythmias, congestive heart failure, and stroke, which contribute to extended hospital stays and increased costs. POAF, postoperative atrial fibrillation.

these elevated inflammatory markers and increased adrenergic activity contribute to the increased sympathetic response that drives POAF.

Manipulation of an injury to the myocardium is a unique feature of cardiac surgery and contributes to the genesis of POAF [2]. The more invasive the surgery, the higher the risk of POAF. For example, valvular surgeries have a higher risk of POAF compared to CABG due to the impact of suturing replacement valves in mitral valve or tricuspid valve surgery on the atria, as opposed to CABG [16]. Furthermore, on-pump CABG has a higher risk of POAF than off-pump CABG [17,18]. Nevertheless, atrial inflammation is the driving force of POAF. This inflammation leads to alterations in intra-atrial conduction, producing chaotic electric signals that contribute to the propagation of POAF [19]. Cytokines and interleukins are postulated to affect sodium channels, decreasing their current and thereby reducing the upstroke velocity [20]. Furthermore, tumor necrosis factor-α (TNF-α) downregulates connexin 43 (Cx43), which is a key component in cardiac gap junctions [21]. The loss of cell–cell coupling also contributes to chaotic, disorganized electrical activity within the atria [21].

Pericardial effusions contribute to the development of POAF, as the presence of blood inside the pericardium is both oxidative and proinflammatory. The byproducts activate the coagulation cascade, leading to an oxidative burst and neutrophil activation [22]. Surgical manipulation of the pericardium also induces cytokine production, which overall leads to a proinflammatory and pro-arrhythmogenic state [22].

Cardioplegia is another unique component of cardiac surgery that contributes to POAF. Indeed, following ventricular arrest, patients with persistent or recurrent atrial activity were at an increased risk of AF or atrial flutter [23]. The risk increased, in proportion, to the longer duration of atrial activity [23]. Branching from the notion of atrial inflammation, ischemic reperfusion injury also occurs in the context of cardioplegia. Oxidative stress from reperfusion can contribute to local atrial inflammation, which, in turn, leads to POAF [2].

Diagnosis

Clinical Presentation

POAF is a less-studied arrhythmia compared to chronic AF. The true incidence of POAF may be underreported, given that continuous cardiac monitoring is rarely used outside of intensive care settings. POAF is defined as new-onset AF that occurs immediately after surgery and is the most common type of secondary AF. Moreover, POAF arises within the first six days after surgery, and the patient returns to normal sinus rhythm.

The incidence of POAF varies depending on the type of surgery performed [2]. After cardiac surgery, the overall incidence is approximately 30%, with rates of 20% for CABG, 40%–50% for valve surgery, and around 30% for aortic surgery [2]. Heart transplant recipients have a notably lower incidence, at about 4% [2]. In the context of thoracic surgery, the overall incidence of POAF is approximately 15%, with pneumonectomy having a particularly high incidence of around 30% [2]. For other types of surgery, the incidence of POAF ranges from 0.4% to 15%, depending on the procedure [2].

One study by Abdelmoneim *et al*. [24] examined the incidence and natural progression of new-onset POAF in 42 patients over 1.7 $\pm$ 1.2 years and found that the AF recurrence rate in these patients was 71%. The authors also examined the rate of recurrence within the first 12 months and recurrence beyond 1-year follow-up in this 71% cohort of patients (N = 30). These two categories were further subdivided into the number of recurrences, which included one recurrence, two recurrences, and more than two recurrences, as depicted in Fig. 2. This study found that 30 patients experienced a recurrence of AF within the follow-up period. Out of those 30 patients, 24 patients (80%) experienced their first recurrence within the first month [24]. Additionally, 76% of patients experienced AF recurrences during a 1 to 12-month follow-up (10% had their first AF recurrence, 43% had their second AF recurrence, and 23% had more than 2 AF recurrences) [24]. Beyond the 12-month follow-up, 30% of patients had any AF recurrences (10% had their first AF recurrence, 7% had their second AF recurrence, and 13% had more than two AF recurrences) [24]. The Kaplan–Meier curve in Fig. 3 (Ref. [24]) illustrates the detection of the first occurrence of AF between months 1 and 24 [24].

Diagnostic Criteria

The detection of POAF is similar to that of non-postoperative AF. An irregular pulse, auscultated heart rhythm, AF on a 12-lead electrocardiogram (ECG), or continuous telemetry monitoring are common methods for detecting POAF. However, the use of constant telemetry monitoring is more likely to detect acute AF compared to performing episodic ECGs. Several patient-based risk scores have been developed to predict the onset of acute AF in hospitalized patients. These scores include the CHA2DS2-VASc, ATRIA, HATCH, and POAF scores. Of these, the CHA2DS2-VASc score, which was created for determining stroke risk stratification and treatment recommendations in patients with non-surgical AF, is highly studied and has been used to correlate acute onset AF in hospitalized patients more consistently than HATCH or the POAF score [25].

To improve the risk stratification of surgical candidates, risk scores such as the CHA2DS2-VASc score and the ATRIA score have been utilized beyond their founding indication. The CHA2DS2-VASc score is commonly used to determine stroke risk in patients with AF, helping guide the decision to recommend AC. However, this score can be used to predict the risk of POAF after cardiac surgery. Kashani and colleagues [26] found a correlation between a higher CHA2DS2-VASc score and the risk of POAF. As the score rose from 0 to 9, the risk of POAF increased from 8.2% to 42.3% [26]. Additionally, ATRIA is another score used by providers to determine the risk of POAF. Normally, ATRIA is used to determine the bleeding risk of patients on warfarin for AF. In a study conducted with 110 patients undergoing CABG, higher ATRIA scores were associated with POAF, yielding an odds ratio of 1.24. The same study also supported the notion that a higher CHA2DS2-VASc score is associated with a higher risk of POAF, presenting an odds ratio of 1.38 [27]. However, the ATRIA and CHA2DS2-VASc scores are not the only risk calculators used for POAF. The HATCH score, which predicts the risk of AF based on certain risk factors such as chronic obstructive pulmonary disease (COPD), hypertension, and age, was also shown to be predictive of POAF as the score escalates [28]. EuroScore, typically used to predict mortality after cardiac surgery, has data supporting its use in predicting POAF. However, while univariate logistic regression analysis revealed a strong correlation between a higher EuroScore and the risk of POAF, the multivariate analysis did not present the same finding [29]. Thanks to the advancements in machine learning, algorithms are being studied to determine their ability to predict POAF. Lu and colleagues [30] investigated a gradient-boosting decision tree (GBDT) and a support vector machine (SVM) algorithm, comparing their performances with those of the traditional logistic regression model. The SVM achieved the highest accuracy (0.723), specificity (0.795), and positive predictive value (0.633) compared to the GBDT, which had the worst performance in all three categories, as well as the logistic regression models. Interestingly, the GBDT considered similar risk factors, such as left atrial diameter and age, to those considered by logistic regression [30]. Overall, while the ATRIA and CHA2DS2-VASc scores demonstrate superior efficacy in predicting POAF, further investigative studies are required to assess the independent risk factors for POAF, including surgical events and biomarkers.

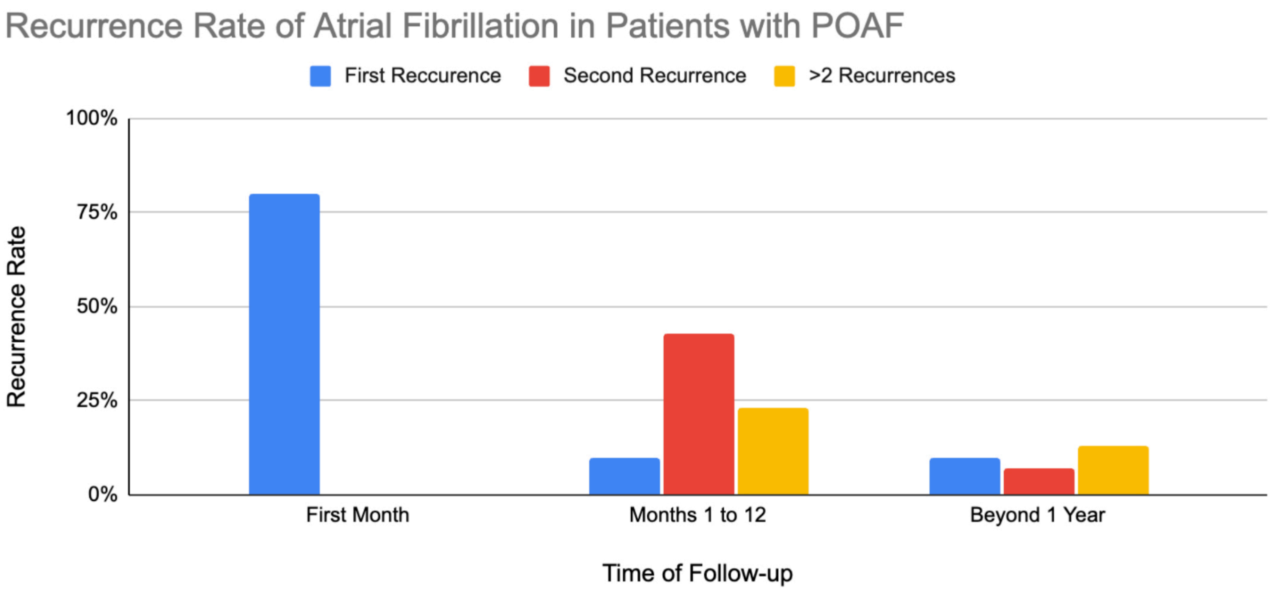

Fig. 2. A summary of the recurrence of postoperative atrial fibrillation (POAF) during follow-up. In the first month, 80% of patients experienced their first occurrence with no further recurrences. Over months 1 to 12, 10% had a first occurrence, 43% had a second, and 23% had more than two occurrences. After 12 months, 10% had a first occurrence, 7% had a second, and 13% had more than two recurrences.

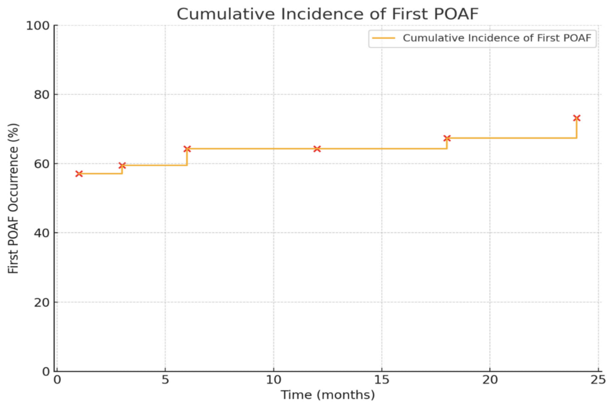

Fig. 3. Kaplan–Meier curve of the recurrence of atrial fibrillation (AF) between months 1 and 24 [24]. POAF, postoperative atrial fibrillation.

Prevention of POAF

Risk Assessment for POAF Pre-Surgery

Precipitating factors for the development of POAF include uncontrolled pain, electrolyte disturbances, missed medications, hypoxia, hypotension, infections, severe anemia, hypovolemia or dehydration, worsening heart failure or cardiac ischemia, drug withdrawal, hypothermia, or thyroid disease. The early identification of triggers is important, as the underlying cause of the POAF may make rate or rhythm control less likely to succeed [31].

General Measures for POAF Prevention

Various strategies, including beta-blocker therapy, calcium channel blocker therapy, intravenous magnesium, bi-atrial pacing, amiodarone, sotalol, colchicine, corticosteroids, sodium-glucose co-transporter-2 inhibitors, and non-pharmacological approaches, have been studied or are currently used to prevent POAF. Unfortunately, most of these interventions have limited or no evidence of efficacy [32].

Maintaining optimal electrolyte levels by replacing electrolytes promptly as needed, based on daily laboratory evaluations, is crucial for preventing POAF. Studies have demonstrated that hypomagnesemia tends to increase the POAF risk in a patient through the modulation of potassium and calcium channels. Therefore, administration of intravenous magnesium postoperatively in doses up to 60 mmol between one and five days after surgery may reduce the risk of POAF development [33]. Bi-atrial pacing has also been shown to significantly reduce POAF through the mechanism of preventing bradycardia and the subsequent development of ectopic atrial beats. A study found that bi-atrial pacing reduced POAF after cardiac surgery compared to no pacing, with a rate of 18.7% vs. 32.8% (odds ratio (OR) = 0.47, 95% confidence interval (CI): 0.36–0.61) [34].

Non-pharmacological methods for preventing AF in cardiac surgery are an emerging area of research, with a variety of techniques being explored, such as pulmonary vein isolation, botulinum toxin injections into the pulmonary veins, cryoablation (MAZE procedure), calcium autonomic

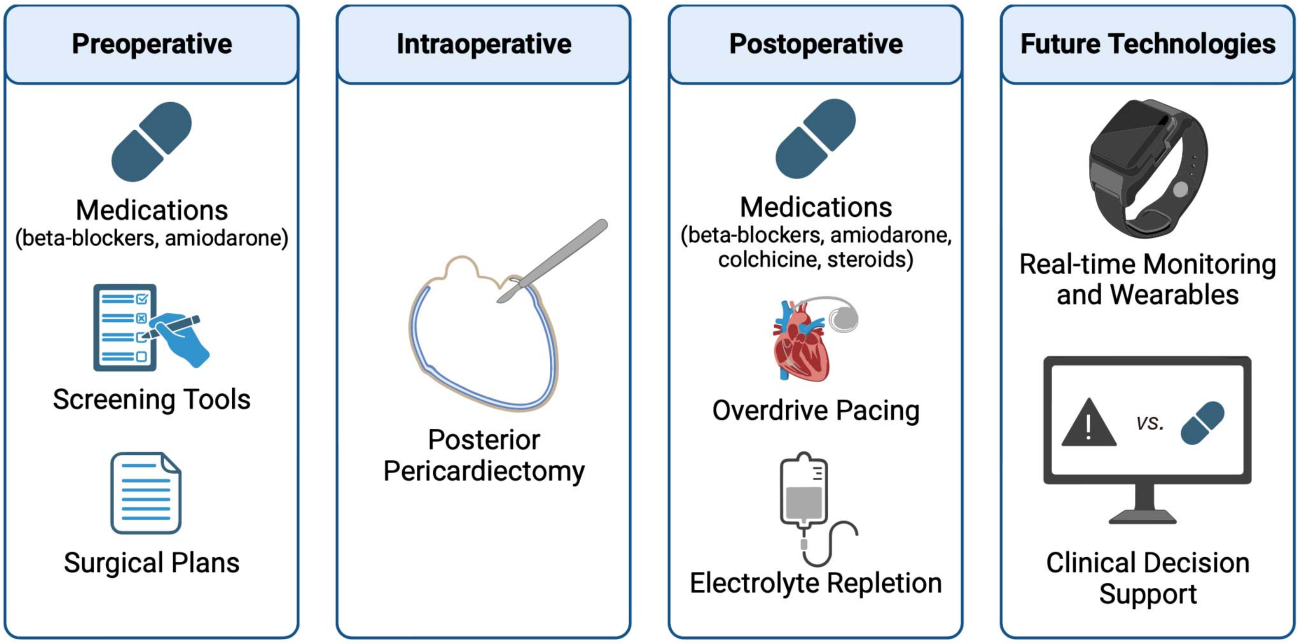

Fig. 4. Common POAF management strategies in the preoperative, intraoperative, and postoperative periods, which can be utilized to screen for POAF and treat prophylactically [38].

denervation, vagal nerve stimulation, and posterior left pericardiotomy (Section VIA) [31].

Randomized studies regarding botulinum toxin type A (BoNT/A) use in POAF prevention found that 50-unit injections into the four epicardial fat pads in proximity to the pulmonary veins caused a significant reduction in POAF occurrence over the first 30 days postoperatively, RRR 78%, and ARR 23% [35]. Others have also demonstrated the potential of BoNT as an anti-arrhythmic for use in POAD; however, the cellular and molecular biology behind BoNT is poorly understood, and presently, it has been studied in neonatal rat ventricular cardiomyocytes [36]. Meanwhile, trials examining the use of calcium autonomic denervation for the prevention of POAF found that the hazard was reduced by 63% by injecting $CaCl_2$ into the four main atrial GPs. The therapeutic effect may be due to Ca-mediated neurotoxicity inhibiting GP function; however, one study limitation mentioned that this effect could be caused by injury to the atrial myocardium, which can be unsafe. The study determined that long-term follow-up on a much larger patient population would be required to detect the significance of this intervention [37]. Some of these strategies are illustrated in Fig. 4 (Ref. [38]).

Pharmacological Strategies for POAF Prevention

The management of POAF should be individualized, considering the ability of the patient to tolerate the risks associated with elevated heart rates, atrioventricular (AV) dyssynchrony, and the potential for stroke [31]. In the context of cardiac surgery, key management strategies include controlling heart rate, managing rhythm, administering AC, and providing prophylaxis for patients at increased risk. Prophylactic pharmacological approaches involve the early reintroduction of beta-blockers, intraoperative magnesium administration, or the use of diltiazem or amiodarone after surgery [39].

Beta-blockers and amiodarone remain the agents of choice for AF management post-cardiac surgery [31]. While both rate and rhythm control approaches seem to yield similar outcomes in cardiac surgical patients, the available data remain limited and controversial. Specifically, the use of prophylactic antiarrhythmic therapy post-cardiac surgery has grown in popularity given the elevated risk of POAF, higher mortality, and long-term AF in this population. POAF prophylaxis has been shown to decrease the rate of AF, length of hospital stay, and rate of stroke [40]. Amiodarone remains the most universally accepted antiarrhythmic of choice for the prevention of POAF after cardiac surgery. Multiple studies have proven its efficacy, in both the oral and intravenous forms, despite its broad side effect profile [40]. However, sotalol is less widely used in comparison to amiodarone and beta-blocker therapy. A meta-analysis of 15 different studies from 2011, comparing sotalol with placebo, no treatment, and beta-blockers, found that sotalol demonstrated a significant reduction in POAF; however, there was no significant difference seen with sotalol use versus amiodarone or magnesium therapy [41].

Pericardial Drain Placement

Pericardial effusions can contribute to the development of POAF. Thus, preventing pericardial effusions was thought not only to prevent POAF but also to reduce postoperative mortality. Indeed, a prior meta-analysis found that drainage of pericardial effusions, whether through the insertion of a pericardial drain or pericardiotomy, was not only safe but also efficacious as it significantly reduced the risk of cardiac tamponade and pericardial effusion [42]. Furthermore, pericardial drainage reduced the instances of POAF by 60% and shortened hospital stay by 1 day [42].

The addition of a pericardial drain helped decrease the incidence of POAF by eliminating a proinflammatory source. In an observational study, the incidence of POAF in patients who underwent cardiac surgery, such as CABG or aortic valve replacement (AVR), and had a pericardial drain placed was lower compared to patients who underwent cardiac surgery without pericardial drain placement, 33% vs. 43%, respectively [43]. Furthermore, there were no noted differences in mortality, stroke, surgical site infection, sternal insufficiency, or length of hospital stay between the two groups [43]. In other randomized trials, the addition of a pericardial drain not only reduced the risk of POAF but also decreased the risk of other post-surgical complications, such as cardiac tamponade and reoperation [44,45].

Left Posterior Pericardiotomy

Posterior left pericardiotomy (PLP) is a 4–5 cm longitudinal incision of the posterior and parallel to the phrenic nerve from the left inferior pulmonary vein to the diaphragm [46]. This incision allows for drainage of fluids and blood products to the left pleural space. The technique was first described by Mulay *et al*. [47] in a 1995 study of CABG patients with favorable results for the safety and efficacy of the technique. The method itself will be validated in the Posterior Left Pericardiotomy for the Prevention of Atrial Fibrillation after Cardiac Surgery (PALACS) trial. In this single-center, anonymous randomized control trial, patients in the intervention group were found to have significantly lower rates of POAF (17%) compared to the control group (32%) [48]. Furthermore, the intervention group had similar postoperative adverse events as the control group, with no noted post-pericardiotomy-related complications. A follow-up study, called PALACS-EF, is underway to see the long-term outcomes of PLP on mortality and hospital readmissions [49]. A meta-analysis also supports the efficacy of PLP, with an incidence of POAF of 11.7% in the PLP group, compared to 23.67% in the non-PLP group, yielding an OR of 0.49 [50]. Furthermore, PLP was also found to have an advantage in reducing the risk of cardiac tamponade, pericardial effusion, and other supraventricular tachycardia [50]. Furthermore, there were no significant differences in pulmonary complications, revision surgery, intra-atrial balloon pump placement, or mortality between the PLP and control groups. However, PLP was found to have a higher rate of pleural effusion [50].

Unproven Therapies to Prevent POAF

Several therapies have been investigated for preventing POAF. While some interventions have shown promise, their efficacy and safety are not yet conclusively established. Multiple studies have been conducted to evaluate the effectiveness and safety of anti-inflammatory agents, such as colchicine. The END-AF (Effect of Low-Dose Colchicine on the Incidence of Atrial Fibrillation in Open-Heart Surgery Patients) trial showed that low-dose colchicine did not prevent POAF in patients undergoing cardiac surgery [51]. However, the study was closed prematurely due to slow recruitment and limited statistical power [51]. Perioperative AF and myocardial injury after noncardiac surgery (MINS) are more common in patients with elevated inflammatory biomarkers and have been associated with worse short- and long-term postoperative outcomes. This has generated continued interest in the potential cardioprotective effect of colchicine. Other studies have investigated the use of colchicine in preventing POAF, including the Colchicine for the Prevention of Post-pericardiotomy Syndrome (COPPS) study, which demonstrated that one month of colchicine therapy reduced the incidence of POAF, in-hospital stay, and rehabilitation after cardiac surgery [52]. The COP-AF (Colchicine for the Prevention of Perioperative Atrial Fibrillation in Patients Undergoing Thoracic Surgery) trial did not observe a reduction in clinically significant perioperative AF or MINS with colchicine compared with placebo in patients undergoing major noncardiac thoracic surgery [53]. Despite these findings, colchicine is not universally recommended due to concerns about side effects and the need for additional studies to confirm its safety and efficacy.

Statins, glucocorticoids, and polyunsaturated fatty acids (PUFAs) have been proposed for the prevention of POAF based on their anti-inflammatory effects (statins and glucocorticoids) and the electrophysiological effects of PUFAs. However, available data on their efficacy are limited, and current guidelines do not support their routine use. Considering the conflicting data on anti-inflammatory agents, a meta-analysis was performed in 2025, which included patients without a history of AF or any other supraventricular arrhythmia, randomized to either anti-inflammatory agents including colchicine, corticosteroids, N-acetylcysteine (NAC), vitamins C and E, statins, non-steroidal anti-inflammatory drugs (NSAIDs), and fish oil vs. standard care [54]. The results showed that fish oil, in combination with vitamins C and E, may reduce the risk of POAF, compared with a placebo at a low certainty level. Colchicine, corticosteroids, and NAC may also reduce the risk of POAF, with all three also presenting a low certainty level [54].

Vitamin D insufficiency or deficiency has been identified as a risk factor for POAF after CABG. A systematic review and meta-analysis conducted in 2023 of three ran-

Table 1. Common rate control agents used in POAF [25].

Drug	Dose	Pharmacokinetics	Considerations	Potential side effects
Metoprolol (II)	2.5–5 mg IV bolus slow push over 2 min; up to 3 doses	Half-life: 3–7 h Onset: 5 min	As above	Hypotension, bradycardia, and bronchospasm
Esmolol (II)	50 mcg/kg/min IV infusion; titrate by 50 mcg/kg/min Q4 h	Half-life: 9 min Onset: Immediate	As above	As above
Diltiazem (IV)	0.25 mg/kg IV bolus over 10 min	Half-life: 4–6 h Onset: 2–7 min	Use with caution when administered with other medications that depress heart rate, AV conduction, and cardiac contractility	Hypotension, bradycardia, and negative inotropic effects
Digoxin (Misc)	0.25–0.5 mg IV, then 0.25 mg Q6 hours for up to 1 mg total in 24 h	Half-life: 4–10 h Onset: >1 h	Use with caution in patients with renal disease. Consider dose reduction in older patients	Bradycardia, drug toxicity, and increased drug effect in electrolyte abnormalities

h, hour(s); d, day(s); AV, atrioventricular; IV, intravenous.

domized clinical trials from 2018 to 2022, which included 448 patients, revealed that vitamin D significantly reduced the incidence of POAF compared to the placebo [55]. However, the inclusion criteria for these studies included a baseline vitamin D deficiency [55]. Meanwhile, the significance of preventing POAF with vitamin D supplementation regardless of vitamin D levels remains uncertain.

Acute Management of POAF

Rate Control Versus Rhythm Control

The typical approach to managing POAF includes the use of rate or rhythm control strategies. Initially, a wait-and-see approach can be used in the event of self-conversion. Pharmacological management with common rate-control agents, such as calcium channel blockers, beta-blockers, and digoxin, works by increasing the refractoriness of the atrioventricular node. Refer to Table 1 (Ref. [25]) for more information regarding common rate control agents used in POAF [25]. Existing studies, such as the AF Follow-up Investigation of Rhythm Management (AFFIRM) trial, suggest a target heart rate of <110 beats per minute (BPM) for hemodynamically stable patients in the outpatient setting, as it is relatively easy to maintain while allowing for adequate diastolic filling. However, more strict rate control with a target heart rate (HR) of <100 BPM is reasonable for post-cardiac surgery patients who are asymptomatic, and <80 BPM is recommended in patients with tachycardia-mediated cardiomyopathy, poor left ventricular ejection fraction, and symptoms [56].

In POAF after noncardiac surgery, spontaneous conversion to sinus rhythm is often noted. Therefore, rate control strategies over rhythm control become reasonable if the tachycardia is not a compensatory mechanism for an underlying trigger [25]. Similar lengths of hospital stay, morbidity, and mortality are noted with rate control with a target HR <100 BPM compared with rhythm control with amiodarone infusion [25]. However, the risk of postoperative electrical complications, including atrioventricular block, must be weighed against the benefit of rate control. Literature mentions that a permissively higher rate of <100 BPM may also be acceptable with little effect on maladaptive cardiac remodeling during the short postoperative period [25].

In unstable patients, acute rhythm control with direct current cardioversion (DCCV) is the preferred therapy [25]. In hemodynamically stable patients, rhythm control can be achieved via electrical or pharmacological measures. The Trial of Electrical Versus Pharmacological Cardioversion for RAFF in the emergency departement ED (RAFF2) demonstrated high rates of success in conversion to sinus rhythm with electrical cardioversion or initial pharmacological cardioversion followed by DCCV if rhythm control could not be restored with pharmacological agents alone [25].

Chemical cardioversion is typically achieved by antiarrhythmic medications, which are selected based on multiple factors, including the patient's hemodynamics, cardiac function, presence of underlying structural heart disease, renal function, ability to tolerate oral medications, and the overall safety profile of the agent [25]. Typical agents used for acute rhythm control include amiodarone, procainamide, flecainide, and ibutilide [25]. Refer to Table 2 (Ref. [25]) for more information regarding these rhythm control agents.

Meta-analyses studying rate versus rhythm control in POAF patients after cardiac surgery showed no significant difference in mortality, bleeding, and thromboembolic events; however, these studies did note an increased rate of re-hospitalization following the use of rhythm control with amiodarone [57]. Additionally, rhythm control did not significantly reduce hospital stay, recurrence of AF in one week, one month, and three months, and mortality compared to rate control with beta-blocker therapy [57]. These

Table 2. Common rhythm control agents used in POAF [25].

Drug	Dose	Pharmacokinetics	Considerations	Potential side effects
Procainamide (IA)	15 mg/kg over 30 mins	Half-life: 2–7 h Onset: 1 h	Avoid in patients with Brugada syndrome, heart failure, hypotension, shock, high-grade AV block, prolonged QT or concomitant QT-prolonging agent use, hypokalemia, hypomagnesemia, and severe renal dysfunction.	Hypotension, bradycardia, and ventricular tachyarrhythmia
Flecainide (IC)	300 mg PO if >70 kg 200 mg PO if <70 kg May not repeat in $\lesssim$24 h	Half-life: 10–17 h Onset: 1–6 h	Avoid in patients with Brugada syndrome, structural heart disease, ischemic heart disease, high-grade AV block, hypokalemia, and hypomagnesemia.	May precipitate 1:1 conduction of atrial flutter or atrial tachycardia and ventricular tachyarrhythmias
Amiodarone (III)	150 mg IV bolus, then 60 mg/h for 6 h, then 30 mg/h for 18 h	Half-life: 13–103 d Onset: 8–12 h	Use with caution in patients with bradycardia. Consider different agents if hepatic metabolism is compromised.	Bradycardia, hypotension, thyroid toxicity, and pulmonary toxicity
Ibutilide (III)	1 mg IV over 10 min, wait 10–20 min before infusion of second 1 mg IV over 10 min.	Half-life: 6–9 h Onset: 30–60 mins	Avoid in patients with long QT syndrome, with concomitant QT-prolonging medications, hypokalemia, hypomagnesemia, and hypocalcemia.	QT prolongation and torsades de pointes

h, hour(s); d, day(s); PO, per oral.

studies determined that, given the limited available evidence, there is unlikely to be a clear advantage to either rate or rhythm control.

Heterogeneity in the patient profile, including age, comorbidities, and surgery type, may affect how patients tolerate and respond to the therapies mentioned above. Rate and rhythm control medication side effects, including hypotension and bradycardia, can cause various postoperative complications and, thus, have to be used with caution. Due to the typically transient nature of POAF and uncertainty regarding the timeline for resolution of the arrhythmia, in clinical practice, some providers may be hesitant to use aggressive rate or rhythm control therapies. Given the lack of consensus in POAF management guidelines, variation in practice between hospitals and providers is common.

Anticoagulation Considerations

Postoperatively, AC needs are met while avoiding post-surgical bleeding. When choosing an anticoagulant, it is also important to consider strategies for managing potential bleeding, such as the use of reversal or mitigating agents [25]. Specifically, for POAF after cardiac surgery, the application of these guidelines remains unclear. Post-cardiac surgery, patients tend to have a higher bleeding risk profile due to the vascular interventions performed intraoperatively with profound heparinization during cardiopulmonary bypass, along with oxidative stress causing overt platelet dysfunction [31]. Meanwhile, practices vary between hospitals and clinicians due to the lack of consensus regarding the timing, duration, and therapy of choice for POAF. Previous studies have found data to support the initiation of AC if POAF persists or recurs for 48 hours or longer [58]. Many cardiac surgeons have shifted towards performing left atrial appendage occlusion (LAAO) as a prophylactic measure against POAF.

Previously, cardioversion for AF without AC was considered safe if the duration of AF was 48 hours or less. Subsequent studies have found that cardioversions performed more than 12 hours after the onset of AF may also increase the risk of thromboembolic complications [25]. Newer recommendations regarding early AC in hospitalized patients with new-onset AF are dependent on the CHA2DS2-VASc scores, as thromboembolic risks and complications increase with higher CHA2DS2-VASc scores [25]. However, recommendations to initiate AC early after the onset of AF have not been widely studied in patients with POAF.

Specifically for post-cardiac surgery, a study protocol based on the Cardiothoracic Surgical Trials Network randomized clinical trial (RCT) recommended AC if the patient remains in AF or has recurrent AF 48 hours after study randomization [58]. Warfarin was used with a target international normalized ratio (INR) of 2.0 to 3.0, followed by low-molecular-weight heparin for bridging. AC was continued for 60 days unless complications occurred [58]. Other studies have shown that post-CABG surgery, the use of direct oral anticoagulation (DOAC) was linked to higher short- and long-term risks, including mortality, readmission, ischemic stroke, transient ischemic attack, major bleeding, myocardial infarction, and thromboembolic events [59]. However, for POAF development after noncardiac surgery, the current guidelines recommend long-term AC based on the CHA2DS2-VASc score ($\geq$2 for males or $\geq$3 for females), with a preference for DOAC over vitamin K antagonist (VKA) [56]. Mariscalco *et al.* [60] developed a POAF score to facilitate decision-making for initiating AC therapy in high-risk patients. For scores of 3 or higher, oral AC is recommended, as it has been shown to reduce mortality. Other researchers suggest that AC has a weak benefit in secondary AF, such as POAF, and may increase the risk of bleeding. For these patients, a thorough individual evaluation is necessary for making AC options [61]. A key clinical consideration for implementation is the cost of DOAC therapy, whereby uninsured or self-pay patients requiring AC typically cannot afford to cover the expenses of DOAC therapy and will have to use an alternative, such as warfarin, although it is less preferred.

Complications and Considerations

Thromboembolic Risks

New POAF is a common complication in cardiac surgeries, as mentioned earlier in this article. However, the long-term risk of thromboembolism remains unknown for patients who develop POAF after cardiac surgeries, such as coronary artery bypass graft (CABG) or valvular surgeries. Furthermore, data on stroke prophylaxis in new-onset POAF after CABG are lacking, and there are no clear recommendations for AC therapy in POAF patients [62]. A study by Butt *et al.* [62] compared patients with POAF with patients with non-valvular AF (NVAF) and the primary outcomes studied were thromboembolisms (including ischemic stroke, transient ischemic attack (TIA), and thrombosis or embolism in peripheral arteries) with the secondary outcomes being all-cause mortality and recurrent AF hospitalization. This study found that POAF after CABG was associated with a significantly lower risk of thromboembolism compared with NVAF [62]. POAF was also associated with a significantly lower risk of all-cause mortality and recurrent AF hospitalization than NVAF [62]. Another study by Gialdini *et al.* [63] found a significant association between perioperative AF and long-term risk of ischemic stroke. Another study by Butt *et al.* [64] compared patients with new-onset POAF after isolated left-sided heart valve surgery to patients with NVAF and found that POAF was associated with a similar risk of thromboembolism compared with NVAF in these patients. Additionally, this study also demonstrated that POAF after aortic valve replacement was associated with a lower risk of recurrent AF compared with NVAF, whereas POAF after mitral valve surgery had a similar risk of recurrence as NVAF [64].

POAF in patients undergoing noncardiac surgery ranges from 0.3 to 4.1%. Even though it is well established that patients with NVAF have a 5-fold increased risk of ischemic stroke and systemic embolism, the long-term thromboembolic risk in patients with POAF secondary to noncardiac surgery is not well studied [65]. Data regarding outcomes associated with oral AC (OAC) therapy in this population are also lacking, with no clear recommendations being provided by the international guidelines [65]. A study performed by Butt *et al.* [65] compared patients with POAF after noncardiac surgery and patients with NVAF and found that among patients who underwent noncardiac surgery, the highest incidence of POAF was seen in patients who underwent thoracic/pulmonary, vascular, and abdominal surgery. This study also found that POAF was associated with a similar risk of thromboembolism in patients with noncardiac surgery compared to patients with NVAF [65]. However, patients with POAF had a lower risk of AF rehospitalization compared with NVAF patients [65]. Lastly, this study also showed that OAC therapy was associated with a lowered risk of thromboembolic events in both the POAF and NVAF groups [65].

Even though there have been some studies comparing POAF in cardiac and noncardiac surgeries and the risk of thromboembolism with NVAF patients, the data currently are limited and conflicting. Moreover, there are no clear recommendations regarding the use of OAC therapy in patients with POAF.

Impact on Recovery and Length of Stay

POAF is a common, expensive, and potentially morbid complication following cardiac surgery, with peak incidence occurring on postoperative day 2 [66]. A study by Melby *et al.* [67] concluded that the onset of POAF occurs in two phases. Phase I carries the highest risk of POAF at hour zero, which is defined as the time of transfer into the intensive care unit (ICU) after surgery, and this risk rapidly declines within the first 18 hours [67]. This study also noted a second peak in the incidence of POAF, which occurred between postoperative hours 24 and 48, and then gradually declined thereafter [67]. Both of these phases also had specific risk factors associated with them. A common shared risk factor across both phases was older age at the time of surgery, although it had a stronger association in phase II [67]. However, a longer cross-clamp time and mitral valve procedure had a higher association of POAF with phase I, likely due to stress-induced ischemia and physical manipulation of the heart, while weight at the time of surgery and race were more associated with phase II [67]. Additionally, patients who develop POAF incur an average of USD 10,000 to USD 20,000 in additional treatment costs [66]. This results in a cumulative financial impact of USD 4 billion per annum in the United States [67]. In addition to the cost, these patients also experience prolonged ICU time, ranging from 12 to 24 hours, and an extended hospital stay of 2 to 5 days [66]. POAF is also an independent predictor of long-term complications such as stroke, infection, and cardiac arrest, and has also been associated with reoperation for bleeding and increased postoperative mortality [66]. Although POAF may initially appear to be a minor complication, it imposes a significant financial and physical burden on patient health.

Special Considerations in High-Risk Populations

Older Adults

As patients age, they have a higher risk of developing AF in general, and this principle also applies to POAF [67]. A study performed by Mathew *et al*. [7] showed that advanced age has been the most consistent predictor of POAF. According to that study, every 10-year increase in age was associated with a 75% increase in the odds of developing AF [7]. In older adults, the atria undergo fibrosis and scarring, which predisposes them to arrhythmias. In addition to that, older age also puts patients at risk for developing heart disease, and prolonged heart disease contributes to enlarging atria and fibrosis, which increases the risk for AF [67]. Patients who already have these predisposing risk factors for AF will be at an increased risk of developing POAF as well. Based on age alone, anyone older than 70 years is considered to be at high risk for developing AF [7]. Detailed guidelines regarding management are provided below; however, some specific considerations may be relevant to the older adult population. The goal of treatment in this population is to prevent thromboembolic events, thereby reducing mortality and improving quality of life by minimizing symptoms and hospitalizations [68]. Given that this population is at a higher risk of bleeding, AC therapy should be started at a favorable risk–benefit ratio [69]. The CHA2DS2-VASc score, in conjunction with the HAS-BLED score, should be used for risk–benefit analysis. Typically, for patients on VKA therapy, such as warfarin, an INR goal of 2–3 is recommended for adequate AC; however, in the older adult population (specifically those aged $>$75), an INR goal of 1.6–2.6 can be used [69].

Pre-Existing Heart Disease

Pre-existing heart disease has been shown to increase the risk of patients developing POAF as well. Diastolic heart dysfunction is associated with progressive left atrial enlargement and the stretching of pulmonary veins [70]. This occurs due to left atrial pressure overload resulting from diastolic dysfunction and may lead to arrhythmogenic activity [70]. The septal E/e' ratio is a reliable diastolic parameter observed on an echocardiogram, serving as a non-invasive and easy-to-use marker of left ventricular filling pressure [71]. A septal E/e' ratio $\geq$11 is an index of elevated left ventricular (LV) filling pressure with a sensitivity of 75% and a specificity of 93% [72]. A study by Fornengo *et al*. [73] showed that a septal E/e' ratio $\geq$11 was associated with the recurrence of AF after cardioversion. Another study by Hirai *et al*. [74] showed that, on average, a septal E/e' ratio $>$13 was associated with an increased risk of AF recurrence after catheter ablation.

Obesity

Left atrial enlargement is a recognized precursor of AF, and it is strongly correlated with increasing body mass index (BMI) or adiposity [75]. Obesity is also associated with ventricular remodeling, elevated plasma volume, ventricular diastolic dysfunction, and enhanced neurohormonal activation, all of which are related to left atrial dilatation and its electrical dysfunction [75]. Additionally, increased oxidative stress is observed with increasing adiposity, which may lead to myocardial structural changes, in turn increasing the likelihood of AF [75]. Numerous studies have presented a significant association between obesity and POAF. A study performed by Serban *et al*. [76] divided 156 patients undergoing cardiac surgery into obese patients (BMI $>$30 kg/m^2) and non-obese patients (BMI $<$30 kg/m^2) and found that obesity was significantly associated with a larger burden of early POAF. Another study by Sun *et al*. [77] reviewed patients undergoing isolated coronary artery bypass grafts and found that, after adjusting for confounders, obesity remained an independent predictor of POAF. Phan *et al*. [78] performed a systematic review and meta-analysis that included 29 studies involving patients undergoing cardiac surgery, and concluded that obesity (BMI $>$30 kg/m^2) was associated with a moderately higher and statistically significant risk of POAF. Regarding management, the 2023 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines recommend DOAC over VKA for stroke risk reduction in patients with AF and class III obesity [79]. These guidelines also recommend at least 10% weight loss in patients with AF who are overweight or obese (BMI $>$27 kg/m^2) to reduce AF symptoms, burden, recurrence, and progression to persistent AF [79].

Race

Racial differences in the prevalence and incidence of AF have been reported in the general population; however, few studies have examined racial and ethnic trends in new-onset POAF [80]. Nazeri *et al*. [80] conducted a study using the Texas Heart Institute Research Database (THIRDBase) and identified all patients who underwent isolated CABG from January 2000 to December 2008. After excluding patients who had undergone concomitant valvular or other surgery or had pre-existing AF, 5823 patients remained in the study [80]. This study showed that the incidence of POAF was 29.8% overall and significantly higher ($p < 0.0001$) in the Caucasian population compared to non-Caucasians [80]. Another study performed by Rader *et al*. [81] followed 27,765 patients between January 1995 and December 2005 and found that Caucasian patients had a markedly higher risk of POAF than Black and any other non-Caucasian patients. Of the included Caucasians, 35% had POAF compared to 22% of the Black patients and 29% of other non-Caucasians ($p < 0.0001$) [81]. The occurrence of POAF varied with surgery complexity, with the highest rate of occurrence amongst patients undergoing combined valve surgeries [81].

Evidence-Based Guidelines

Review of Current Clinical Guidelines

2023 ACC/AHA/ACCP/HRS Guidelines for the Management of POAF

The prevention of POAF has been highlighted through the use of prophylactic beta-blockers preoperatively, which has been shown to decrease the incidence of POAF, class 2a [79]. Amiodarone is recommended preoperatively for patients with contraindications to beta-blockers and has been shown to help prevent POAF, class 2a [79]. Non-pharmacological interventions, such as posterior pericardiotomy, may be considered in certain cardiac surgeries, as it has also been associated with a decreased incidence of POAF, class 2a [79]. A systematic review and meta-analysis of 16 RCTs that reviewed the efficacy of posterior pericardiotomy in reducing POAF and pericardial effusion in isolated CABG patients, which revealed that it significantly reduced the incidence of POAF in patients undergoing isolated CABG [82]. However, the presence of heterogeneity and publication bias warrants a cautious interpretation with further multicenter RCTs in this area.

Acute management of POAF recommendations included rate control management with beta-blockers as a first line, class 1 [79]. However, if beta-blockers are ineffective or contraindicated, then a non-dihydropyridine calcium channel blocker is recommended, class 1 [79]. Rhythm control has been an acceptable option in hemodynamically stable patients, not inferior to rate control agents [79]. A randomized clinical study involving 529 patients found that neither therapy has a distinct clinical advantage, and amiodarone was used in the rhythm-control group, class 1 [79]. Electrical cardioversion is recommended in cases of hemodynamic instability with consideration of imaging to exclude left appendage thrombus before cardioversion in those whose AF has been present > 48 hours and who have not been on AC, class 1 [79].

AC consideration is based on an assessment of thromboembolic risk, considering factors such as the CHA2DS2-VASc score. In patients with elevated risk, AC should be considered, a class 2a recommendation [79]. The decision to initiate AC, if deemed safe regarding postoperative surgical bleeding risk, requires a duration of at least 60 days [79]. A review of eight observational studies, including 15,335 patients, found a protective impact on the 5-year mortality rate, but no difference in thromboembolic events [83].

Regarding post-discharge monitoring, patients who develop POAF should be followed up to monitor for recurrence. At 30 to 60-day follow-up, rhythm assessment should be performed, and if AF does not revert to sinus rhythm spontaneously, electrical cardioversion should be considered after an adequate duration of AC, class 2a [79]. These guidelines are summarized in Table 3.

2024 European Society of Cardiology (ESC) Guidelines for Management of POAF

The ESC guidelines strongly recommend amiodarone as the primary pharmacological intervention to prevent POAF in patients undergoing cardiac surgery, class 1 [84]. The efficacy of amiodarone in reducing the incidence of AF postoperatively is well-documented. Regarding beta-blockers, no recommendations were made for prophylactic use in cardiac surgeries. However, it has been documented that amiodarone and beta-blockers are equally effective in reducing POAF [84]. It was also noted in multiple RCTs that no benefit was achieved for mortality, myocardial infarction (MI), or stroke from administering beta-blockers in cardiac surgery [84]. Non-pharmacological interventions such as concomitant surgical ablation are a reasonable strategy for patients undergoing cardiac surgery to decrease the long-term burden of AF, class 2a [84]. This intervention is especially relevant for patients with a history of AF or those at high risk for recurrent arrhythmia.

Regarding AC, the ESC made a class 2a recommendation to consider long-term AC in patients with POAF at elevated thromboembolic risk after cardiac and noncardiac surgery, to prevent ischemic stroke and thromboembolism [84]. This highlights the need for further research regarding thromboembolic risk in POAF and the need for oral AC.

Additionally, the ESC does not recommend the routine use of beta-blockers in patients undergoing noncardiac surgery for the prevention of POAF, class III [84]. This

Table 3. Summary of 2023 ACC/AHA/ACCP/HRS and 2024 ESC guidelines and recommendations specifically about POAF.

Recommendation	2023 ACC/AHA/ACCP/HRS guidelines	2024 ESC guidelines
Class I	Beta-blockers are recommended for rate control in POAF post-cardiac surgery (unless contraindicated or ineffective). Use non-dihydropyridine CCB if needed. Rate control (HR <100 bpm) with beta-blockers and/or rhythm control, with amiodarone in HDS cardiac surgery patients with POAF. Direct cardioversion combined with antiarrhythmic therapy is recommended in HDuS patients with POAF for >48 hours. Consider imaging to exclude LAAT before cardioversion and if not on AC.	Amiodarone is recommended perioperatively for POAF prevention in cardiac surgery.
Class IIa	Short-term beta-blockers or amiodarone to prevent POAF in high-risk cardiac surgery patients. Left pericardiotomy in CABG, AV operation, or ascending aortic aneurysm patients to reduce POAF incidence. AC for up to 60 days after surgery if safe, with re-evaluation for longer use or early stop depending on complications. Rhythm assessment 30–60 days after surgery; consider cardioversion if AF persists and AC is adequate.	In cardiac surgery, consider posterior pericardiotomy for POAF prevention. Long-term oral AC for elevated thromboembolism risk in POAF patients (cardiac and noncardiac surgeries).
Class III	None	Routine beta-blocker use is not recommended for POAF prevention in noncardiac surgery.

ACC, American College of Cardiology; AHA, American Heart Association; ACCP, American College of Clinical Pharmacy; HRS, Heart Rhythm Society; ESC, European Society of Cardiology; POAF, postoperative atrial fibrillation; CCB, calcium channel blocker; HR, heart rate; bpm, beats per minute; HDS, hemodynamically stable; HDuS, hemodynamically unstable; LAAT, left atrial appendage thrombus; AC, anticoagulation; CABG, coronary artery bypass graft; AV, aortic valve; AF, atrial fibrillation.

was based on a study of 98 meta-analyses, which included 284 RCTs. In noncardiac surgeries, beta-blockers were associated with reduced rates of myocardial infarction after surgery but showed a higher mortality rate and increased risk of stroke [85]. These guidelines are summarized in Table 3.

Future Directions

Novel Therapies and Technologies

Novel therapies for POAF management focus on prophylaxis against POAF. Most of the novel prophylactic therapies tend to be non-pharmacological; however, given the high burden of POAF, especially after cardiac surgery, both pharmacological and non-pharmacological POAF prevention therapies should be considered in practice. Two techniques being studied include calcium autonomic denervation, which involves the intraoperative injection of calcium chloride into the atrial ganglionated plexi during cardiac surgery, and the use of botulinum toxin injection in the epicardial fat pads to reduce nerve-ending acetylcholine release without destruction of the anatomic structures of the heart. Presently, both techniques have shown efficacy in preventing POAF, with calcium autonomic denervation reducing rates of POAF from 36% to 15% and botulinum toxin injection proving efficacy similar to that of prophylactic amiodarone administration with an absolute risk reduction of 23% [35,37].

Artificial Intelligence (AI) in POAF Prediction

In the future, more precise risk stratification will be necessary to determine the need for early POAF treatment and management versus pursuing prophylactic therapy in the absence of POAF. Enhancing the tool available to predict the occurrence of POAF with accuracy will also be beneficial in preventing POAF in the early postoperative period. Increased sensitivity of machinery used to detect early electrical activity, which typically precedes AF, such as premature ventricular beats or atrial beats originating from various foci in the atria near the pulmonary veins, could accelerate the rate at which POAF gets detected [38]. AI can be employed to recognize patterns that are not perceivable to humans, such as those found in continuous telemetry or enhanced 12-lead EKGs via multivariable models, increasing the specificity and sensitivity of POAF detection [38]. For example, an AI-based approach using atrial electrograms and surface electrocardiograms (EKGs) can be applied to calculate the risk burden of POAF, directing prophylactic therapies and promoting the early detection of POAF [86].

The early detection of POAF would facilitate the prompt initiation of treatment and could impact the degree of downstream POAF complications and overall disease severity. Regardless, the use of AI will only remain an adjunct to clinical decision-making.

Conclusion

POAF remains a common and clinically significant complication after major surgeries, in particular intrathoracic surgeries, such as cardiac surgery, intra-abdominal surgeries, and other vascular surgeries. Common techniques in the management of POAF include rate and rhythm control, alongside various agents discussed in this paper, as well as AC therapy, once it becomes appropriate based on individual patient assessment, and multiple forms of prophylactic treatment to prevent POAF. Although this topic is well studied, no formal consensus exists on the optimal management of POAF. In practice, clinicians often consider the AF time of onset, patient-specific risk factors, and the type of surgery performed before initiating POAF treatment. The purpose of POAF management is to target AF with a balance of rate and rhythm control while mitigating thromboembolic risks associated with POAF, keeping the postoperative bleeding risk for each patient in mind. This approach aims to minimize the prolongation of the hospital stay and overall drug side effects.

A multidisciplinary approach in the management of POAF would involve various specialties collaborating to optimize the immediate and long-term care of this patient population. This team would include cardiologists, anesthesiologists, surgeons, nurses, and pharmacists. Moreover, encouraging these specialties to work with each other in the postoperative period can enhance patient outcomes. However, more data must be collected on the personalized, evidence-based approach to POAF. Early recognition of and even prevention of POAF will decrease the burden of this condition on hospital systems and, more importantly, reduce poor patient outcomes.

Author Contributions

JKD, ASM, DN, RG, AS, AA, NH and TT had substantial contribution to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. All authors drafted the work or reviewed it critically for important intellectual content. All authors provided final approval of the version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

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