Practical Management of Postoperative Atrial Fibrillation after Noncardiac Surgery

Ilya M Danelich, PharmD, BCPS, Jennifer M Lose, PharmD, BCPS, Sampaguita S Wright, PharmD, BCPS, Samuel J Asirvatham, MD, Beth A Ballinger, MD, FACS, David W Larson, MD, MBA, FACS, FASCRS, Jenna K Lovely, PharmD, BCPS

Postoperative atrial fibrillation (POAF) is a common adverse event after surgical procedures. This complication has been extensively studied in the cardiothoracic surgery literature because of its high incidence (up to 60%); however, the specific incidence, pathophysiology, risk factors, and optimal management strategies are less well known in the noncardiothoracic surgery population.

According to current reports, mainly observational studies, POAF occurs in 5% to 10% of patients undergoing noncardiothoracic surgery. This estimate is likely conservative and widely variable, as most published reports base their rates on a mixed noncardiothoracic surgical population containing many surgical specialties. Unlike in cardiothoracic surgery, telemetry might not always be used during the initial postoperative period, which can also add to an underestimation of true incidence. When analyzed by type of noncardiothoracic surgery, abdominal, trauma, and vascular specialties often have higher incidence rates compared with other surgical groups. In an observational study of 370,447 patients undergoing major noncardiac surgery, patients undergoing abdominal surgery had an 82% higher risk for POAF than patients undergoing other noncardiac operations (adjusted odds ratio = 1.82; 95% CI, 1.72–1.93). Likewise, Christians and colleagues showed in their cohort of patients with POAF undergoing noncardiothoracic operations, 39% had abdominal surgery, 22% vascular surgery, and the remaining 39% consisted of orthopaedic, neurologic, plastic surgery, and ophthalmologic surgical patients.

Postoperative atrial fibrillation can lead to increased length of stay and subsequently elevated health care costs; therefore, its prevention and appropriate management are important areas to research. Several studies also cite an increased risk of mortality with POAF. Mortality remains an established association with POAF, however, causality is uncertain, as patients in whom atrial fibrillation develops generally have underlying comorbidities and greater associated cardiac risk.

Causes
One of the most commonly cited probable causes of POAF after cardiac surgery is direct manipulation of the cardiac membranes, however, this is not a plausible cause in patients undergoing noncardiothoracic operations. The exact mechanisms for development of POAF in noncardiothoracic surgery are not fully understood. Proposed causes are vast and often multifactorial (Table 1).

Surgery induces stress on the body, increasing sympathetic activity. To improve cardiac output and maintain adequate tissue oxygen delivery, the heart rate increases and catecholamines are released, leading to an increase in peripheral vascular resistance. Operative stress has also been proposed to shorten atrial refractiveness nonuniformly, favoring the perpetuation of an arrhythmia. Other mechanisms that lead to an increase in adrenergic activation include hypovolemia, intraoperative hypotension, trauma, pain, and acute anemia. Polanczyk and colleagues found that the risk of POAF was increased by 50% if a patient experienced intraoperative hypotension exceeding 10 minutes duration.

Hypoxia can also lead to POAF. In addition to increased sympathetic activity, acute hypoxia-driven pulmonary vasoconstriction can acutely overload the right ventricle and cause right atrial myocardial stretch, inducing improper myocardial conduction and...
arrhythmias. Hypoxia can also cause ischemic injury to the atrial myocardial cells, which alters electrical conduction.

Electrolyte imbalances, particularly potassium and magnesium, are another mechanism found in the literature that potentially contribute to POAF. In one study of patients older than 40 years of age in whom POAF developed, 23% had an electrolyte abnormality. Similarly, Christians and colleagues found that 63% of patients in their cohort who developed this complication had a potassium level <4 mmol/L or magnesium <2 mg/dL at the onset of POAF. In multivariate analysis, Burris and colleagues found preoperative hypokalemia was a multivariate risk factor for POAF in a US military veteran population.

Finally, hypervolemia can lead to an increased intravascular volume and cause mechanical stimulation of the right atrium or atrial stretch. Christians and colleagues found 88% of their patients with POAF had a positive fluid balance at onset of the arrhythmia, ranging from 1.9 to 6.6 L positive fluid.

Development of POAF is likely multifactorial and involves many modifiable variables. Kanji and colleagues found in their cohort of patients with new-onset POAF, 73% had at least 1 modifiable risk factor at the time of onset, 45% had at least 2 factors, and 15% had ≥3 factors. The risk factors included were hypotension, use of vasopressors or inotropes, septic shock, 24-hour fluid balance >5 L positive, pulmonary artery catheter, heart failure with pulmonary edema, potassium <3.5 mmol/L, magnesium <1.7 mg/dL, hemoglobin <8 mg/dL, arterial pH <7.25, and acute MI.

Better elucidation of exact mechanisms leading to POAF will allow more targeted and effective prophylactic and treatment management strategies to be developed and used.

**Risk factors**

Several other patient risk factors have been found to be associated with an increase in POAF. These risk factors often create an environment that facilitates the occurrence of POAF. Increased age is one of these factors, likely due to a higher incidence of chronic atrial fibrillation in this patient population, as well as an increased vulnerability of aged atrial cells to develop re-entrant atrial tachyarrhythmias. When comparing patients who developed POAF after noncardiothoracic surgery with those who did not, patients are often older. Interestingly, this does not always translate into a statistically significant difference and is only sometimes elucidated as a statistically significant risk factor in multivariate analyses.

Pre-existing atrial fibrillation can increase a patient’s risk for POAF, but it is not absolutely definitive. In a cohort of patients reviewed by Bhave and colleagues, only 67% of patients who had POAF develop had at least one episode of atrial fibrillation before surgery. Similarly, Christians and colleagues found 72.5% of their cohort with POAF had documented pre-existing atrial fibrillation; however, this estimate might be conservative, given the potentially unknown incidence of pre-existing (ie, undocumented) asymptomatic atrial fibrillation.

Other patient comorbidities, including pre-existing congestive heart failure, ischemic heart disease, hypertension, chronic renal failure, sepsis, shock, asthma, and valvular disease have all been found to be associated with an increased risk of POAF. These comorbidities are likely not the initial precipitant of POAF, but assist in the development of hypoxia, hypervolemia, stress, and electrolyte abnormalities. Finally, as discussed previously, the type of surgery often helps determine a patient’s risk for POAF.

**PHARMACOLOGICAL MANAGEMENT**

**Rate vs rhythm control**

Management of POAF is composed of two overarching decisions: choosing a rate or rhythm control strategy and determining the degree of antithrombotic therapy required based on the risk for stroke and systemic embolism. During the past 10 years, several trials have examined the efficacy and safety of rhythm vs rate control, demonstrating that rate control is noninferior to rhythm control with respect to long-term clinical outcomes. In AFFIRM (Atrial Fibrillation Follow-Up Investigation of Rhythm Management), the largest trial to date to compare rate with rhythm control, a greater number of hospitalizations (73.0% vs 80.1%; p < 0.001) and adverse effects, including torsades de pointes, pulmonary events, gastrointestinal events, bradycardia, and QT prolongation events, were observed in the rhythm control arm. Similar findings were demonstrated in patients with heart failure, where the rhythm control arm
was associated with a higher rate of hospitalizations (46% vs 39%; p = 0.001) and required more electrical cardioversions (59% vs 9%; p < 0.001), with no significant difference in mortality. However, none of these studies evaluated patients after surgery, and certain trials specifically excluded patients with recent cardiac surgery. Based on these studies, rate control is the treatment strategy of choice in the majority of patients, with a goal ventricular rate between 80 and 100 beats per minute (bpm). Although this goal heart rate might be appropriate in the majority of patients, a faster or slower heart rate can be suitable in some individuals. Rhythm control can be considered in patients who remain symptomatic despite achieving rate control, and in those unable to achieve rate control, despite using maximum tolerated doses, or those experiencing adverse effects from medication (eg, hypotension). Direct current cardioversion is the preferred treatment option in patients with hemodynamic compromise and should be considered in symptomatic individuals (ie, presence of chest pain, pulmonary edema, and/or loss of consciousness). In addition, it might be reasonable to consider elective cardioversion in patients presenting with atrial fibrillation for the first time who have a low risk of recurrence (eg, young age, no structural heart disease, no atrial enlargement). Elective cardioversion can be achieved through electrical impulse therapy or through pharmacologic antiarrhythmic administration. Vaughan Williams class IC agents, propafenone and flecainide, can be effective for conversion of atrial fibrillation with duration of <7 days in patients without structural heart disease. Class III agents, amiodarone, dofetilide, and ibutilide, can be used for patients with cardiac comorbidities. Ibutilide is only available for IV administration and dofetilide is given orally. Amiodarone can be administered IV or orally.

As rhythm control strategies have been summarized previously, this review will focus on practical pharmacologic strategies for achieving ventricular rate control in patients with POAF after noncardiac surgery. Because many patients who have POAF also have structural heart disease and, given the limited literature on the management of POAF after noncardiac surgery, it might be appropriate to extrapolate the findings from the cardiac...
surgery literature, particularly in light of some similarities in the pathophysiology for the development of this complication between the two settings. A proposed treatment algorithm is depicted in Figure 1 and specific medication regimens are outlined in Table 2.32,36-43

**Practical treatment guideline**

Determining and treating the underlying cause of the arrhythmia is critical in the appropriate management of POAF. The first step in managing POAF consists of asking whether the patient is symptomatic or asymptomatic, then determining if the patient has reduced left ventricular ejection fraction. The responses to these questions will help guide the decision to use a pharmacologic or nonpharmacologic (ie, direct current cardioversion) treatment strategy. If pharmacologic management is most appropriate, these questions will also help guide which medications are preferred and the route of medication administration.

When beginning to manage POAF, it is important to evaluate if the patient was receiving β-blocker or nondihydropyridine calcium channel blocker (NDHP-CCB) therapy before admission. If these agents have not been restarted, one should consider restarting the patient’s home regimen, especially in asymptomatic individuals. If they have been restarted, increasing the dose and/or shortening the dosing frequency might be appropriate.

When deciding to use oral vs IV route of administration, it is important to consider whether the patient is symptomatic or asymptomatic. Although the IV route is associated with a quicker onset of action, it might be appropriate to administer medications orally to asymptomatic individuals.38 This can avoid the need to transfer the patient to a monitored area, usually a telemetry floor or ICU, and could lead to considerable cost savings. On the contrary, symptomatic patients should be treated using the IV route to decrease time to symptom resolution.

β-blockers, NDHP-CCBs (ie, diltiazem and verapamil), and digoxin can be used to achieve ventricular rate control. In addition, amiodarone, although classified as an antiarrhythmic agent, can be effective at achieving rate control. Given high adrenergic tone and increased catecholamine release after surgery, β-blockers represent an appropriate first line therapy in the majority of patients who are asymptomatic and those with preserved ejection fraction.32,37,39 These agents should be used with caution in patients with systolic heart failure, particularly in those who are symptomatic and fluid overloaded, due to their negative inotropic properties in the acute setting.32,36,38,42 The use of β-blockers vs NDHP-CCBs, specifically diltiazem, for first-line therapy is often debated among clinicians. In a substudy of AFFIRM, β-blockers with or without digoxin were more efficacious at achieving goal heart rate than calcium channel blockers with or without digoxin (70% vs 54%).43 Goal ventricular rate was reached in more patients receiving β-blockers alone compared with calcium channel blockers alone (59% vs 38%). In addition, more patients who initially received calcium channel blockers were changed to an alternative medication for additional management as

**Table 2. Medication Regimens for Ventricular Rate Control**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Medication regimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metoprolol*</td>
<td>IV: 5 mg every 5 minutes for up to 3 doses. If partial response to the first set of 3 doses of metoprolol 5 mg IV, consider ordering another set of metoprol 5 mg IV every 5 minutes for up to 3 doses. po: 12.5–25 mg every 6 hours. Titr ate dose every 24 hours.</td>
</tr>
<tr>
<td>Esmolol*</td>
<td>IV: loading dose 500 μg/kg IV over 1 minute, followed by 25–300 μg/kg/min IV, titrate by 50 μg/kg/min every 5 minutes.</td>
</tr>
<tr>
<td>Atenolol*</td>
<td>IV: 2.5 mg over 5 minutes, repeat every 10 minutes. Maximum dose: 10 mg.</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>IV: 0.15 mg/kg (usual dose 10–15 mg) for up to 2 doses separated by 15 minutes. Initiate diltiazem infusion after administration of loading doses. If partial response to existing diltiazem infusion rate, consider administering loading dose (0.15 mg/kg) in addition to rate increase. po: 30 mg every 6 hours. Titr ate dose every 24 hours. Maximum total daily dose: 360 mg.</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>IV: 150 mg over 10 minutes, then 1 mg/min for 6 hours, followed by 0.5 mg/min for 18 hours. Transition to oral therapy if able or remain at 0.5 mg/min. po: Amiodarone 400 mg 3 times daily for 4 days, then 200 mg once daily.</td>
</tr>
<tr>
<td>Digoxin</td>
<td>IV/po: Loading dose 10–15 μg/kg (lean body weight), followed by maintenance dose of 62.5–250 μg once daily (adjusted for kidney function) to maintain digoxin trough of &lt;2 ng/mL. In patients with reduced ejection fraction, long-term goal digoxin trough &lt;1 ng/mL.</td>
</tr>
</tbody>
</table>

Information in this table is derived from previous literature.32,36-43

*Not preferred if patient is currently requiring inotrope/vasopressor support.

*Can also be administered rectally.

*Not preferred in the presence of systemic inflammatory response syndrome, sepsis, or vasopressor/inotrope requirement to maintain blood pressure.

*Can use an alternative loading regimen as long as total loading dose ≥5 g.
Table 3. Pharmacologic Properties of Commonly Used β-Blockers

<table>
<thead>
<tr>
<th>Drug</th>
<th>Half-life</th>
<th>Route of elimination</th>
<th>Accumulates in renal disease</th>
<th>β1 selectivity</th>
<th>α-Blockade</th>
<th>IV availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atenolol</td>
<td>6–9 h</td>
<td>Renal</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Bisoprolol</td>
<td>10–12 h</td>
<td>Renal (50% unchanged) and hepatic</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Carvedilol</td>
<td>6–10 h</td>
<td>Hepatic/biliary</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Esmolol</td>
<td>9 min</td>
<td>Erythrocytes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Labetalol</td>
<td>5–8 h</td>
<td>Hepatic</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Metoprolol tartrate</td>
<td>3–4 h</td>
<td>Hepatic</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Metoprolol succinate</td>
<td>3–7 h</td>
<td>Hepatic</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nadolol</td>
<td>14–24 h</td>
<td>Renal</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Propranolol</td>
<td>3–4 h</td>
<td>Hepatic</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Sotalol</td>
<td>9–10 h</td>
<td>Renal</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Information in this table is derived from previous literature.50,51

compared with individuals who initially received β-blockers (p < 0.0001). In a comparison of esmolol vs diltiazem in the management of POAF after cardiac surgery, more patients receiving esmolol converted to normal sinus rhythm within the first 6 hours compared with diltiazem (66.6% vs 13.3%; p < 0.05), although no differences were observed at 24 hours (80% for esmolol vs 66.6% for diltiazem; p > 0.05), suggesting that perhaps β-blockers represent an appropriate choice for initial management of the arrhythmia.49 Extrapolation from the cardiac surgery literature is not ideal, but can be appropriate in this situation given some similarities in the pathophysiology between the two settings.

Patients with POAF often have pre-existing cardiovascular disease,5,6,40 which makes β-blockers a more ideal option for long-term management. In patients with certain cardiovascular comorbidities (eg, history of myocardial infarction, heart failure with reduced ejection fraction), NDHP-CCBs are rarely an ideal strategy and are not a viable long-term solution.45-47

Although many β-blocker agents are available, metoprolol is commonly used because it provides for efficient conversion between IV and oral routes of administration, is inexpensive, and its long history of use provides familiarity to clinicians. Esmolol is often used for acute heart rate control. Its short half-life (approximately 9 minutes) and quick onset allow rapid achievement of β-blockade and the ability to fine tune blood pressure and heart rate.32,38,39,48 Adverse effects due to atrioventricular node inhibition, if they do occur, quickly dissipate after stopping this medication. However, administration of esmolol can be associated with considerable fluid burden, especially at higher doses, which are often necessary to achieve goal heart rate.68 This can be problematic in postoperative patients who might already be fluid overloaded. For patients receiving β-blockers before admission to the hospital, it would be reasonable to continue using the same agent and increase the dose and/or shorten the dosing frequency. In the setting of acute change in kidney and/or hepatic function status, the route of elimination for a given medication should be considered (eg, atenolol dosing might need to be adjusted in patients with kidney dysfunction49). Table 3 provides pertinent properties of commonly used β-blockers, including routes of elimination.50,51 Although recent publications have raised the possibility that metoprolol can be associated with increased risk of stroke compared with agents with more β1-receptor selectivity (eg, bisoprolol, esmolol) when used in the perioperative period, these preliminary findings need to be confirmed in randomized, blinded, controlled trials.52,53 Until such time, metoprolol represents an appropriate option in the majority of patients, especially in patients not previously taking a β-blocking agent. The authors hypothesize that perhaps the less β1-receptor selective agents are associated with increased risk of stroke due to impaired β2-receptor-mediated cerebral vasodilation, which can be especially important during acute surgical anemia.

Non-dihydropyridine calcium channel blockers represent an appropriate option for second-line therapy in most patients. This is intended to be used when first-line therapy (ie, usually β-blocker) is ineffective at achieving ventricular rate control, despite using maximum tolerated doses, or if the first line is contraindicated. Due to potentially more profound negative inotropic properties, higher incidence of hypotension, and greater concern for substantial drug interactions associated with verapamil, diltiazem is the predominantly used calcium channel blocker for achieving goal heart rate.54-59 In a study comparing diltiazem with amiodarone in acutely ill patients with recent-onset atrial fibrillation, more patients receiving diltiazem achieved sufficient rate
control with better heart rate reduction.60 This was offset by a higher incidence of hypotension observed in the diltiazem treatment arm. It is possible that a higher incidence of hypotension was observed due to the use of higher than recommended diltiazem infusion rates (20 mg/h vs 5–15 mg/h).61 Conversely, in a cohort study comparing diltiazem with amiodarone after noncardiac surgery, no differences in the 24-hour conversion rates and time to conversion were observed.62 In addition, there was no significant difference in the incidence of hypotension. A diltiazem regimen of bolus dose 0.25 mg/kg followed by a continuous infusion of 5 to 15 mg/h, titrated to a goal heart rate of <120 bpm, was used in the study, consistent with manufacturer’s recommendations for diltiazem.61,62 The manufacturer also recommends a second bolus dose of 0.35 mg/kg be administered if the first bolus was ineffective.61

The rate of therapeutic response and incidence of complications was evaluated in a study comparing low-dose diltiazem (≤0.2 mg/kg; mean dose 0.14 mg/kg) with standard (>0.2 mg/kg and ≤0.3 mg/kg; mean dose 0.24 mg/kg) and high dose (>0.3 mg/kg; mean dose 0.34 mg/kg).41 Although no significant difference was observed for the rate of therapeutic response (heart rate ≤100 bpm or reduction of ventricular rate by ≥20% from baseline) among the 3 treatment arms (70.5% vs 77.1% vs 77.8%; p = 0.605), patients receiving low-dose diltiazem had a lower rate of hypotension or a ≥20% reduction in systolic blood pressure compared with the other 2 treatment groups (18% vs 34.9% vs 41.7%; p = 0.025). Based on this study, a lower loading dose of diltiazem than what is recommended by the manufacturer might be appropriate.

As with β-blockers, NDHP-CCBs should be used with caution in patients with reduced ejection fraction, particularly in those who are symptomatic. However, this does not indicate there is no role for diltiazem in patients with systolic heart failure. In a study of patients with atrial fibrillation and moderate to severe congestive heart failure (New York Heart Association class III or IV), with a mean ejection fraction of 36%, acute administration of IV diltiazem (bolus doses of 0.25 mg/kg and 0.35 mg/kg followed by infusion) resulted in a therapeutic response (defined as conversion to sinus rhythm, heart <100 bpm, or ≥20% decrease in heart rate from baseline) in 95% of patients compared with none in the placebo arm.63 Hypotension was observed in 9% of patients receiving diltiazem. No cases of heart failure exacerbation were identified. This study suggests that diltiazem can be used for acute ventricular rate control in patients with reduced ejection fraction. Because diltiazem is associated with poor long-term outcomes in systolic heart failure, it should only be used in such patients if other agents are ineffective and should be transitioned to a β-blocker, amiodarone, or digoxin as soon as possible.47

Digoxin represents another option for achieving rate control. Because it predominantly exerts vagotonic activity, digoxin is generally effective when administered to patients at rest, but less effective in states of elevated sympathetic activity.32,36-40,64 As a result, this medication might have limited clinical use in the postoperative setting, where adrenergic tone is increased. In a study comparing diltiazem with digoxin in patients with new-onset atrial fibrillation, diltiazem was found to be superior to digoxin in achieving ventricular rate control.53 On the other hand, digoxin has been shown to enhance the effect of β-blockers and calcium channel blockers on reducing heart rate compared with either agent alone.43 In addition, it can be safely administered to patients with systolic heart failure because of its positive inotropic properties.66 Of note, digoxin has a narrow therapeutic window and caution should be used in dosing this medication. Based on its properties, digoxin should generally be considered when other pharmacologic options have been found to be ineffective or contraindicated.

Amiodarone is a viable option for rate control because it possesses β-blocking and calcium channel blocking properties, in addition to its antiarrhythmic effects. Given its long half-life and extensive tissue distribution, a loading strategy is used when initiating amiodarone.32,38 This medication can be used safely in patients with reduced ejection fraction.67,68 However, amiodarone is associated with potentially serious long-term adverse events requiring periodic monitoring and, in rare instances, acute pulmonary toxicity.69-75 Amiodarone is not preferred when other pharmacologic options exist, particularly in younger individuals who might need long-term therapy.

In addition to amiodarone, both sotalol and propafenone have β-blocking properties and can have immediate rate control benefits along with assistance in restoring and maintaining sinus rhythm.32,34,36 Of note, sotalol can only be used for maintenance of sinus rhythm, and not for conversion. Propafenone should not be used in patients with structural heart disease and caution should be used with sotalol in the setting of reduced left ventricular ejection fraction, especially in the absence of an automatic implantable cardioverter defibrillator.32,34,36,75 Although sotalol is also available in an IV formulation, its clinical use is limited because this formulation is not stocked and available in many hospitals. Given limited literature on the use of these agents specifically for rate control, they are infrequently used for this indication.
Most patients with new-onset POAF will convert to normal sinus rhythm before hospital discharge and >95% of patients will remain in normal sinus rhythm 2 months after surgery.\(^7\) As such, outpatient follow-up is important for patients discharged on new rate or rhythm control agents to determine if regimens for these medications need to be adjusted or if the drugs could be discontinued altogether.

**Antithrombotic therapy**

When atrial fibrillation persists for >48 hours, antithrombotic therapy should be considered to reduce the risk of stroke and systemic embolism.\(^32,33,37-39\) The clinician should consider the risk of bleeding associated with the surgical procedure, the general bleeding risk of the patient, and the patient’s thromboembolic risk when determining the degree of antithrombotic therapy required. Although assessment of the bleeding risk associated with the surgery is specific to the operation and might be physician dependent, the HAS-BLED scoring scheme can be used to determine the general bleeding risk of the patient.\(^7\) The HAS-BLED consists of the following factors: hypertension (1 point), abnormal renal/liver function (1 point for each), stroke (1 point), bleeding history or predisposition (1 point), labile INR (1 point), elderly (age older than 65 years; 1 point), and drugs/alcohol concomitantly (1 point for each), with higher scores correlating with higher risk of bleeding.\(^32,33\) A score of ≥3 indicates high bleeding risk and the patient should be closely monitored if antithrombotic therapy is initiated. The CHADS\(_2\) (congestive heart failure [1 point], hypertension [1 point], age older than 75 years [1 point], diabetes [1 point], and stroke [2 points]) scoring scheme can be used to calculate the thromboembolic risk of the patient, with higher scores correlating with higher risk of thromboembolism.\(^2,25,38,39,76,78\) A score ≥2 is considered high risk and oral anticoagulation is warranted. A score of 1 is considered intermediate risk and guidelines recommend oral anticoagulation or aspirin with preference toward anticoagulation. However, because the patient might be at an increased risk of bleeding after surgery, aspirin can be reasonable. A CHADS\(_2\) score of zero indicates low risk and no antithrombotic therapy is recommended.

Recently, the CHA\(_2\)DS\(_2\)-VASc scoring scheme has been developed to more accurately risk stratify patients with atrial fibrillation.\(^79\) Compared with CHADS\(_2\), the new scoring scheme adds the variables sex and vascular disease, and stratifies age into two categories: 1 point for 65 to 74 years and 2 points for age 75 years or older. Initial studies have demonstrated that CHA\(_2\)DS\(_2\)-VASc can have improved predictive ability compared with CHADS\(_2\).\(^79,80\)

Different guidelines provide contrasting recommendations on which risk score to use; the European guidelines advocate for use of CHA\(_2\)DS\(_2\)-VASc, and the American College of Chest Physicians favor CHADS\(_2\).\(^32,81\) It is important to note that these scoring schemes (ie, CHADS\(_2\), CHA\(_2\)DS\(_2\)-VASc, HAS-BLED) were validated in nonsurgical patients. Until they are confirmed in the surgical setting, it might be appropriate to extrapolate these tools to this patient population, given similarities exist in the pathophysiology of thrombus development caused by atrial fibrillation in both settings.

Patients post surgery are at unusually high risk for bleeding and, as a result, anticoagulation should be used with considerable caution. On the contrary, anticoagulation is required when electrical cardioversion is performed in patients with atrial fibrillation lasting >48 hours because of the high risk of stroke, beyond what is predicted with scoring tools, in this setting.

In a retrospective analysis by Makhija and colleagues, routine use of anticoagulation in patients post thoracic surgery did not result in decreased incidence of stroke compared with patients not receiving anticoagulation, but anticoagulation was associated with a higher risk of bleeding and other complications.\(^82\) The CHADS\(_2\) score did not influence the results. Although this study is hypothesis generating, it is associated with a number of limitations incumbent to its retrospective design. Until randomized studies confirm these results, it remains appropriate to consider antithrombotic therapy in patients with atrial fibrillation lasting >48 hours.

During the past 3 years, 3 new oral anticoagulants have become available in the United States: dabigatran, rivaroxaban, and apixaban.\(^32\) Although these agents potentially offer more convenience to the patient compared with warfarin, as less monitoring is required, there are currently no reliable means of reversing these medications should the patient experience bleeding or the need for emergent surgery. Because patients in the postoperative setting can be at increased risk for bleeding, these agents should be used with great caution. The pros and cons of these agents should be discussed with the patient before initiation.

**PREVENTION AND FUTURE DIRECTIONS**

Development of POAF is likely multifactorial, and there are numerous potential strategies to reduce the incidence in both cardiac and noncardiac surgery patients. The majority of published data on prevention of POAF are with cardiac or thoracic operations. \(\beta\)-blockers,\(^83-85\) sotalol,\(^86\) amiodarone,\(^87\) antioxidant vitamins,\(^88\) colchicine,\(^89\) corticosteroids,\(^90\) and IV magnesium\(^91\) have been shown in randomized controlled trials and meta-analyses to reduce
the incidence of POAF in cardiac surgery patients. Many of these trials did not investigate the effect of prophylactic medication administration on clinical outcomes, such as hospital length of stay or mortality. A meta-analysis of IV and oral medications used to prevent POAF in cardiac patients included some pooled data on length of stay and risk of stroke. In this analysis of cardiac surgery patients, β-blockers, magnesium, and sotalol did not have a significant effect on length of stay, but amiodarone administration showed significantly shorter stays (p < 0.001) when compared with control. Additionally, amiodarone was the only medication to show a significantly reduced stroke rate (2.4% to 1.2% in the amiodarone group).

Very little primary literature exists on the prevention of POAF in the noncardiac surgery setting. Besides minimizing electrolyte imbalances and hypervolemic states, little guidance exists on POAF prevention. A recent study by Raju and colleagues examined cardiovascular event reduction in noncardiac operations. This retrospective study assessed the role of statins in 752 patients undergoing intermediate-risk noncardiac, nonvascular surgery. The primary end point, a composite of in-hospital nonfatal MI, 30-day all-cause mortality, and development of atrial fibrillation within 1 month after hospital admission, was not statistically significantly different between statin users and nonusers in the univariate analysis. It is difficult to draw conclusions about POAF specifically because this represented only part of the composite primary end point. Limitations of this study include its retrospective nature, varied doses and potency of statins used, significant differences in comorbidities between statin and nonstatin groups, and a small sample size with relatively low incidence of POAF. The Bhave and colleagues study analyzed the potential effects of medications on POAF in noncardiac surgery patients. Perioperative administration of statins, angiotensin receptor blockers, and angiotensin converting enzyme inhibitors were associated with a significantly lower adjusted odds ratio of POAF. β-blocker administration, however, was not associated with a lower odds ratio of POAF in this surgical population. Additional studies are needed before conclusions can be made about medication effects on the development of POAF after noncardiac surgery.

Development of a risk-stratification tool to identify patients preoperatively with the highest risk for POAF would potentially identify patients who could benefit from a prophylactic agent. It is difficult to extrapolate POAF preventive strategies from the existing data in cardiac surgery to the noncardiac surgery setting. Prospective studies should be conducted in this patient population to examine the potential benefit of preoperative administration of medications that have shown benefits in cardiac operations. Additional trials are also needed to determine if optimal treatment of POAF differs between cardiac and noncardiac surgery patients. In addition, as new medications are being investigated for the management of atrial fibrillation, it is critical that these agents be studied in the noncardiac surgery setting to provide guidance on the appropriateness of their use in this patient population.

CONCLUSIONS
Postoperative atrial fibrillation is a relatively common adverse event after noncardiac surgery, however, little is known about the exact cause, pathophysiology, or management of this complication. Treatment strategies should be directed at correcting the proposed underlying cause of the arrhythmia, choosing rate or rhythm control strategy, and determining the degree of antithrombotic therapy necessary, based on the patient’s risk for developing a clot vs bleed. Future studies are needed to better understand this disease state and its prevention and treatment in patients undergoing noncardiac surgery.

Author Contributions
Acquisition of data: Danelich, Lose, Wright, Asirvatham Analysis and interpretation of data: Danelich, Lose, Wright, Asirvatham, Ballinger, Larson, Lovely Drafting of manuscript: Danelich, Lose, Wright Critical revision: Danelich, Lose, Wright, Asirvatham, Ballinger, Larson, Lovely

REFERENCES


