The Society of Thoracic Surgeons Practice Guideline on the Prophylaxis and Management of Atrial Fibrillation Associated With General Thoracic Surgery: Executive Summary

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Atrial fibrillation (AF) occurs in between 12% and 44% of patients after pulmonary and esophageal surgery. Its occurrence is associated with increased pulmonary complications, increased length of stay, and increased mortality [1, 2]. Although numerous articles have been written on postoperative AF, specific recommendations for the prophylaxis and treatment of AF related to general thoracic surgery (GTS) do not exist. Therefore, The Society of Thoracic Surgeons (STS) Workforce on Evidence Based Surgery formed a taskforce to derive practice recommendations from the literature.

What follows is an executive summary of the full guideline available at http://www.sts.org/resources-publications/clinical-practice-credentialing-guidelines. The full guideline includes the complete references and detailed analysis that fully supports the recommendations listed here.

REPORT

Methods

Taskforce members reviewed all identifiable published reports related to the prophylaxis and management of AF after GTS as well as selected reports related to medical AF and AF after cardiac and general surgical procedures. Publications for review were selected to inform recommendations in three areas: (1) prophylaxis, (2) treatment, and (3) anticoagulation. Levels of evidence were assigned to each publication, and recommendations were made regarding each intervention using the American College of Cardiology/American Heart Association guideline methodology. The document was reviewed and approved according to the "STS Approval Process for Practice Guidelines."

Evidence-based guidelines must not be viewed as absolutes. Guidelines are intended to assist health care providers in decision-making by providing a range of acceptable approaches for the management of specific conditions. The ultimate judgment regarding care of a particular patient under specific circumstances must be made by the provider. There are certainly circumstances in which management that falls outside of these guidelines will be appropriate.

Etiology and Risk Factors

Risk factors for postoperative AF include male sex, increasing age, magnitude of lung resected, magnitude of esophagus resection, history of congestive heart failure, concomitant lung disease, preoperative episodes of AF, length of procedure [3–15], and procedures associated with pericardial inflammation, especially dissection around the atria [12, 16]. Reproducibly, the highest rates of postoperative AF occur after pneumonectomies, extrapleural pneumonectomies, and adult lung transplants [17, 18]. After minimally invasive thoracic surgical procedures, the incidence of AF has been as low as 0.6% [19]. In one study, 4 of 110 thoracoscopic lobectomy patients (3.6%) had AF [20]. Atrial fibrillation can also develop postoperatively secondary to a wide variety of medical

The Society of Thoracic Surgeons Clinical Practice Guidelines are intended to assist physicians and other health care providers in clinical decision making by describing a range of generally acceptable approaches for the diagnosis, management, or prevention of specific diseases or conditions. These guidelines should not be considered inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the same results. Moreover, these guidelines are subject to change over time, without notice. The ultimate judgment regarding the care of a particular patient must be made by the physician in light of the individual circumstances presented by the patient.

For the full text of this and other STS Practice Guidelines, visit http://www.sts.org/resources-publications/clinical-practice-credentialing-guidelines at the official STS Web site (www.sts.org).

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conditions including hyperthyroidism, pulmonary emboli, pneumonia, or pericarditis.

The onset of AF occurs most commonly on postoperative days 2 and 3 [1, 7, 21, 22]. The risk of arrhythmias decreases substantially over the first postoperative month, with nearly all patients reverting to preoperative risk of AF by 6 weeks after coronary surgery, regardless of treatment [23].

Pharmacologic Prophylaxis of Postoperative Atrial Fibrillation

Class I recommendation: Patients taking β-blockers before GTS should have β-blockade continued (at reduced dose if epidural analgesia is used) in the postoperative period. (Level of evidence B)

Class IIa recommendation: Diltiazem prophylaxis is reasonable in most patients undergoing major pulmonary resection who are not taking a β-blocker preoperatively. As with β-blockers, hypotension may develop in some patients receiving diltiazem prophylaxis, and dose reduction or other pressure-elevating therapies may be required. (Level of evidence B)

Class IIa recommendation: Amiodarone prophylaxis is reasonable to reduce the incidence of atrial fibrillation after GTS (excluding pneumonectomy), according to strict dosing regimens. For patients undergoing pulmonary lobectomy, the recommended dose is 1,050 mg by continuous infusion over the first 24 hours after surgery (43.75 mg/h), followed by 400 mg orally twice daily for 6 days. For patients undergoing esophagectomy, the recommended dose is continuous intravenous (IV) infusion at a rate of 43.75 mg/h (1,050 mg daily) for 4 days. (Level of evidence B)

Class III recommendation: Amiodarone is not recommended, outside of clinical studies, for patients undergoing pneumonectomy, until additional data addressing its potential toxicity in this setting are available. (Level of evidence B)

Class IIa recommendation: Magnesium supplementation is reasonable to augment the prophylactic effects of other medications. (Level of evidence B)

Class IIb recommendation: It may be reasonable to initiate new β-blockers for prophylaxis against postoperative AF after GTS, but their use is more limited by side effects than diltiazem and thus less broadly applicable. (Level of evidence B)

Class III recommendation: Flecainide is not recommended for prophylaxis of postoperative atrial fibrillation after GTS. (Level of evidence B)

Class III recommendation: Digitalis should not be used as a prophylactic agent against atrial fibrillation after GTS. (Level of evidence A)

Given the morbidity, mortality, and costs associated with postoperative AF, it would be beneficial to prevent it, if that is possible, with an agent that incurs minimal adverse effects.

In a meta-analysis of randomized controlled studies of AF prophylaxis in GTS, Sedrakyan and colleagues [24] included 11 studies [25–35], and we are aware of two randomized studies published since that time [36, 37]. There have been three trials using digitalis [26, 28, 31], five trials with calcium-channel blockers [25, 26, 32, 34, 35], two trials of prophylactic β-blockers [27, 29], three trials of amiodarone [34, 36, 37], and single trials of flecainide [30] and magnesium [33]. These trials collectively include more than 1,300 participants.

The recommendation to avoid abrupt β-blocker withdrawal is extrapolated from convincing data in the cardiac surgery literature attributing postoperative AF to a propranolol withdrawal syndrome [38]. A meta-analysis of randomized studies of AF prophylaxis clearly demonstrated elevated AF rates in patients whose β-blockers were withdrawn [39].

Because GTS patients with epidural analgesia tend to be mildly hypotensive, we recommend that preoperative β-blockers be restarted postoperatively at one half the preoperative dose, with "hold parameters." The dose can then be gradually increased as tolerated.

For patients who were not taking β-blocking medication preoperatively, the most broadly effective and safe drug prophylaxis for AF after GTS is diltiazem. Five randomized, double-blinded controlled trials have compared the efficacy of calcium-channel blockers to control in the prophylaxis of postoperative AF after GTS (Table 1) [25, 26, 32, 34, 35]. In these studies, the incidence of AF is reduced by approximately one half: 10.6% versus 21.5% (relative risk 0.50; 95% confidence interval: 0.34 to 0.73) [24]. Because diltiazem is associated with a far lower rate of hypotension than verapamil, diltiazem is the recommended calcium-blocking agent. Although the only placebo-controlled study of diltiazem for prevention of AF after GTS administered it with an IV loading dose and 24-hour infusion, only then followed by oral therapy, it may be reasonable to administer prophylactic diltiazem orally alone. Oral diltiazem begun in the recovery room is a reasonable approach after lung resection. A reasonable dose is 30 to 60 mg every 6 hours, depending upon a patient's body mass, age, and other factors. As with β-blockers, diltiazem orders should include "hold parameters."

Prophylactic amiodarone is a reasonable alternative to diltiazem, but it should be used in limited doses and should likely be avoided for certain patients. Prophylactic amiodarone significantly reduces the incidence of AF after cardiac [39], pulmonary [34, 36], and esophageal [37] surgery. Among lung resection patients, the incidence of AF was reduced by amiodarone from 21.9% to 3.1% in one study [34] and from 32.3% to 13.8% in the other study versus placebo [36]. However, the first of these studies, which used a higher dose of the drug, was terminated early because of an incidence of acute respiratory distress syndrome (ARDS) of 9.4% in those receiving amiodarone

Table 1. Randomized Trials of Calcium Channel Blocker Prophylaxis of Atrial Fibrillation (AF) in Pulmonary Resection Patients[a]

Authors [Reference], Year	Drug	AF Rate, Treated Versus Control	Subjects
Lindgren et al [32], 1991	IV followed by oral verapamil	0% versus 31% ($p < 0.05$)	Lung resection
Van Miegham et al [34], 1994	IV verapamil	0% versus 22% (p = NR)	Pneumonectomy/lobectomy
Van Miegham et al [35], 1996	IV verapamil	8% versus 15% ($p > 0.05$)	Pneumonectomy/lobectomy
Amar et al [26], 1997	IV followed by oral diltiazem	14% versus 31% ($p = 0.035$)	Pneumonectomy
Amar et al [25], 2000	IV followed by oral Diltiazem	15% versus 25% ($p = 0.03$)	"High risk" lobectomy/pneumonectomy

[a] All studies are versus placebo, except Amar 1997, which is versus digoxin.

IV = intravenous; NR = not reported.

(versus 0% in the placebo group). Among pneumonectomy patients, the ARDS rate was 27%.

Amiodarone-induced pulmonary toxicity appears to occur not only after chronic administration, but also occasionally after brief periods of IV administration on the order of days. Acute pulmonary toxicity related to amiodarone appears to be most common perioperatively. That may be because intraoperative and perioperative high inspired oxygen concentrations potentiate the free radicals that may be etiologic. In one series, 3 of 8 patients had ARDS after cardiac surgery after preoperative high-dose IV amiodarone therapy (1,200 mg for 7 days), and ARDS developed in 6 of 11 patients who were receiving long-term amiodarone therapy before cardiac surgery [40]. In another series including various operations, 4 of 33 patients receiving prolonged preoperative amiodarone therapy had postoperative ARDS [41]. Preexisting pulmonary disease is associated with a higher risk of diagnosed amiodarone pulmonary toxicity [42].

Conversely, in the study by Tisdale and colleagues [36] of amiodarone prophylaxis after lung resection, and in their study of amiodarone prophylaxis after esophageal resection [37] (both of which used lower doses of amiodarone), no increased pulmonary toxicity was observed. The pulmonary resection series included 65 patients in the experimental arm, 25% of whom underwent pneumonectomy. It appears likely that amiodarone at the lower dose used in these studies represents safe and effective AF prophylaxis. But given that this has been demonstrated in only a single study in the lung resection population, and given the evidence of pulmonary toxicity related to perioperative use of amiodarone at higher doses—particularly in patients undergoing pneumonectomy, patients with chronic obstructive pulmonary disease (COPD), and theoretically, patients requiring high levels of inspired oxygen or mechanical ventilation—we believe that prophylactic amiodarone use must be considered and planned carefully. It should likely be avoided for patients with significant preexisting lung disease, patients who remain intubated or require high inspired oxygen concentrations, and patients who have undergone pneumonectomy. It should also likely not be started preoperatively. It may well be proven ultimately that there is no pulmonary toxicity related to amiodarone using the dosing regimens employed by Tisdale and coworkers, but until additional data are available on this issue, it is prudent, outside of studies, to limit the use of amiodarone for pulmonary resection patients to those undergoing lobectomy.

Newly initiated β-blockade is clearly effective prophylaxis against AF after cardiac surgery [39]. In the GTS population, however, only two randomized controlled trials of this approach have been published [27, 29]. Although this treatment does reduce AF to a similar degree as calcium-channel blockers, morbidity is substantially higher, with a 49% incidence of hypotension, a 25% incidence of bradycardia, and a 14.1% incidence of pulmonary edema.

An additional, important concern with newly initiated β-blockers is the small but real risk of precipitating bronchospasm with β-blockade in COPD patients. (For details on this risk, which is more of a concern with patients who are β-blocker naïve, see the Treatment of Postoperative Atrial Fibrillation section.)

In the cardiac surgery population, magnesium supplementation reduces postoperative AF [43]. The only prospective randomized trial involving GTS patients also demonstrated a significant reduction in the incidence of AF without substantial adverse events [33].

Although it is a good choice as therapy for postoperative AF in patients without structural heart disease (see Treatment section), experience with flecainide as a prophylactic agent has been limited and mixed. Oral flecainide has not been studied in this setting, and the small trials using IV flecainide (which has limited availability) report rates of hypotension as high as 57% [30]. Furthermore, that the use of flecainide would need to be strictly limited to patients without structural heart disease substantially limits its applicability [44]. Three randomized studies have demonstrated that digitalis prophylaxis ac-

tually increases the incidence of postoperative AF versus placebo after GTS [26, 28, 31].

Pharmacologic Treatment of Postoperative Atrial Fibrillation

Rate Control Versus Rhythm Control

Class I recommendation: Patients with hemodynamically unstable postoperative AF should be electrically cardioverted. (Level of evidence C)

Class I recommendation: Patients with hemodynamically stable but symptomatically intolerable AF should be chemically cardioverted, with electrical cardioversion if chemical cardioversion fails. (Level of evidence C)

Class I recommendation: Patients with hemodynamically stable and symptomatically acceptable postoperative AF should receive a trial of rate control lasting approximately 24 hours. (Level of evidence B)

Class IIa recommendation: For patients with hemodynamically stable, continuous or recurrent, paroxysmal postoperative AF ongoing more than 24 hours after initiation of rate control, it is reasonable to attempt chemical cardioversion. (Level of evidence C)

Class IIb recommendation: Patients with hemodynamically stable, continuous or recurrent, paroxysmal postoperative AF ongoing after adequate levels of a chemical cardioverting agent have been achieved may be considered for an attempt at electrical cardioversion. (Level of evidence C)

A substantial number of patients will, despite prophylaxis, have AF after GTS. If there is associated hemodynamic instability, electrical cardioversion should be carried out urgently. Most patients, however, will have hemodynamically stable AF. For patients who, despite hemodynamic stability, find the symptoms of AF intolerable even with rate control, an early attempt at chemical cardioversion is reasonable. If that fails to convert the patient to sinus rhythm after the initial load, then electrical cardioversion is reasonable.

The vast majority of patients have AF that creates neither hemodynamic instability nor intolerable symptoms. These patients are the focus of our recommendations. Since new-onset postoperative AF is often transient and self-limited, and since rate control agents are generally safer than agents designed to achieve cardioversion, it is appropriate to treat stable patients initially with rate control agents alone. One study involving 200 lung resection patients reported that 98% of AF resolved within 1 day of hospital discharge with rate control alone [4]. Seventy-three percent of patients with AF after aortic surgery in one study had converted at a mean of 48 hours [45]. Two small randomized studies compared rate control and cardioversion strategies for AF after cardiac surgery [46, 47], and neither demonstrated a significant difference in ultimate outcome between the two approaches.

Choice of Agent: Rate Control Drugs

Class I recommendation: A selective β1-blocking agent is recommended as the initial drug for rate control in the absence of moderate-severe chronic obstructive pulmonary disease or active bronchospasm. (Level of evidence B)

Class I recommendation: Diltiazem should be the first agent used in the presence of moderate-severe chronic obstructive pulmonary disease or active bronchospasm. (Level of evidence B)

Class III recommendation: Digoxin as a single agent should not be used for rate control, although it may be effective in combination with a β1-blocker or diltiazem. (Level of evidence A)

Diltiazem has been proven to be more effective than digoxin in the treatment of AF after coronary artery bypass surgery [48], and β-blockade has been proven to be more effective than either calcium-blockade or digoxin in rate control of AF in the medical population [49]. Beta-blockers also appear to more effective than calcium-blockers in converting AF to sinus rhythm after noncardiac surgery [50]. No studies have compared these drugs after GTS specifically. Given its shorter duration of action, its relative β1-receptor specificity, and its availability in intravenous form, metoprolol is probably the appropriate initial agent.

The potential concern with the use of β-blockers for COPD patients, who constitute a large proportion of the patients undergoing GTS, is that nonspecific blockade may precipitate bronchospasm. Although that occurs with some frequency with nonspecific β-blockers such as propranolol, β1-specific agents such as metoprolol have a very low risk of inducing clinically significant bronchospasm [51, 52], although they may increase airway hyperresponsiveness [53]. A selective β1-antagonist thus seems a reasonable first-line rate control agent for all patients but those with active bronchospasm or more than moderate COPD. These latter patients should be rate controlled with diltiazem. If diltiazem is being used for AF prophylaxis, it is reasonable to either add metoprolol or increase the diltiazem dose if postoperative AF develops.

Choice of Agent: Rhythm Control (Antiarrhythmic) Drugs

Class IIa recommendation: When chemical cardioversion is employed in the setting of continuous or recurrent paroxysmal postoperative AF, the most reasonable initial drugs are intravenous followed by oral amiodarone or oral flecainide. Several other agents can be considered when these are contraindicated. (Level of evidence B)

Class III recommendation: Amiodarone is not currently recommended in patients who are mechanically venti-

lated, who have undergone pneumonectomy, or who have substantial pre-existing lung disease. (Level of evidence B)

Class III recommendation: Flecainide should not be used in patients with any history of structural cardiac disease including ventricular hypertrophy, systolic dysfunction, or any valve or coronary disease. (Level of evidence A)

Antiarrhythmic drugs with the ability to convert AF to sinus rhythm include amiodarone, disopyramide, dofetilide, flecainide, ibutilide, procainamide, propafenone, quinidine, and sotalol. A series of comparative studies of medical AF patients has established broadly that flecainide, ibutilide, dofetilide, propafenone, and amiodarone are the most effective agents [54]. Ibutilide, quinidine, and dofetilide are less favored because of substantial rates of development of torsades des pointes. Ibutilide is available in the United States only in IV bolus form, and dofetilide's IV form is available only investigationally. The high prevalence of COPD among GTS patients leads to a preference for agents without nonspecific β-blocking activity. The cardioverting agents with significant β-blockade activity (propafenone and sotalol) are nonselective β-blockers.

This selection process leaves us with amiodarone and flecainide as the leading candidates for chemical cardioversion in GTS-associated AF. Rates of cardioversion that have been reported with amiodarone after GTS are as high as 86% [6], with a meta-analysis of amiodarone including studies of both medical and postoperative AF yielding a conversion rate of 76% [55]. With flecainide, conversion rates are between 56% [56] and 93% [57], but in the 80% range in most studies. Conversion tends to occur more rapidly with flecainide than with amiodarone.

Importantly, flecainide is contraindicated for patients with any form of structural heart disease—including coronary artery disease, significant valvular disease, systolic dysfunction, or ventricular hypertrophy. The primary basis of this limited application of flecainide is the randomized Cardiac Arrhythmia Suppression Trial (CAST), which focused on ventricular arrhythmias after myocardial infarction [44]. Patients who received flecainide had an approximately doubled rate of mortality or cardiac arrest, likely due to a proarrhythmic effect on the ventricle. Although these results are of unclear relevance to postoperative patients with atrial arrhythmias, the consensus remains that this drug should not be used in patients with structural heart disease. It should also be noted that flecainide is not effective against atrial flutter.

The unique side effect of amiodarone that has, appropriately, received substantial attention and is highly relevant to the GTS population is its pulmonary toxicity. As mentioned previously, the toxicity of amiodarone has been reported mainly in patients receiving large doses of the drug over prolonged periods (and may occur in 1% to 10% of patients so treated), but it is also occurs more rarely in a fulminant, acute form during IV administration. In the prophylactic setting, IV amiodarone was associated in one study with a far higher than expected rate of ARDS (27%) among patients undergoing pneumonectomy [34]. This finding was not confirmed in another, also small, study that used lower doses and a shorter period of IV administration [36]. It has been suggested that acute amiodarone-induced lung injury is more likely in lungs that have been exposed to other physical insults [58].

The possibility of significant amiodarone-induced pulmonary toxicity in patients after pulmonary resection leads us to recommend flecainide or another agent when chemical cardioversion is indicated for patients who are mechanically ventilated, for patients with severe COPD, and for patients after pneumonectomy.

Amiodarone and flecainide are highly effective and relatively safe drugs, but the specific contraindications to their use must be kept in mind. For patients with both structural heart disease and substantial pulmonary dysfunction for whom cardioversion is indicated, one of the other cardioverting drugs, electrical cardioversion, or simple anticoagulation therapy with rate control can be carried out.

Duration of Antiarrhythmic Therapy

Class IIa recommendation: Once initiated, it is reasonable to continue successful antiarrhythmic therapy for a minimum of 1 week and no longer than 6 weeks beyond the time of discharge. (Level of evidence B)

The only study that has evaluated optimal length of therapy with antiarrhythmic drugs, once initiated, for postoperative AF (after coronary artery bypass graft surgery) found that there was no difference in the rate of recurrent AF whether the treatment was continued for 1, 3, or 6 weeks after discharge [59].

Anticoagulation Therapy for Postoperative Atrial Fibrillation

Because none of the randomized studies evaluating anticoagulation approaches in AF was carried out with GTS patients, none of the recommendations in this section can be considered Class I.

Anticoagulation Therapy Versus Antiplatelet Therapy

Class IIa recommendation: For patients with two or more risk factors for stroke (age >75 years, hypertension, impaired left ventricular function, prior stroke or transient ischemic attack) who have postoperative AF that recurs or persists for more than 48 hours, anticoagulation therapy is reasonable if not otherwise contraindicated. (Level of evidence A)

Class IIa recommendation: For patients with fewer than two risk factors for stroke and patients considered not suitable for warfarin who have postoperative AF that recurs or persists for more than 48 hours, aspirin, 325 mg daily, is reasonable if not otherwise contraindicated. (Level of evidence A)

The risk of stroke associated with medical AF is affected by a number of risk factors: prior stroke or transient ischemic attack, history of hypertension or systolic pressure greater than 160 mm Hg, diabetes mellitus, a combination of female sex and age more than 75 years, and impaired left ventricular function [60–62]. A stroke risk classification, $CHADS_2$ (an acronym for congestive heart failure, hypertension, age, diabetes mellitus, and stroke or transient ischemic attack), integrates these elements [63]. Patients can be classified as low risk, intermediate risk, or high risk, with rates of stroke ranging from 1.2 to 18.2 per 100 patient-years [64]. Warfarin is usually recommended for patients with $CHADS_2$ scores of 2 or higher.

Keeping these risk factors in mind, a number of randomized trials have looked at the efficacy of anticoagulation. These trials have included randomized comparisons of oral vitamin K antagonists versus no therapy or aspirin [65–69]. Pooled together, these trials have demonstrated a reduction in yearly stroke rate from 4.5% to 1.4% by treating patients with warfarin. The overall relative risk reduction was 68% (Table 2). Evidence supporting the use of aspirin is weaker than for warfarin (Table 3). In a meta-analysis of 16 randomized trials, warfarin was found to decrease the relative risk of stroke by 62%, compared with aspirin, which only reduced this by 22% [70]. In terms of the optimal aspirin dose, the most compelling data are from the Stroke Prevention in Atrial Fibrillation (SPAF) investigators using 325 mg, in which the relative risk of stroke was decreased by 42% [67]. The addition of clopidogrel to aspirin for medical AF patients thought unsuitable for warfarin does not appear to provide any benefit on balance [71].

The concern over an increased risk of bleeding with anticoagulation therapy becomes more relevant for the postoperative patient. Warfarin increases the risk of major extracranial bleeding by 70% even for medical AF patients [72]. Given the additional fact that the duration of AF in the postoperative setting is often short, it may be that the risk of bleeding with warfarin for these patients outweighs the risk of embolism. We do not, unfortunately, have any data that directly address this question. However, it would not be unreasonable, for patients considered to be at greater risk of having postoperative bleeding, to use aspirin rather than warfarin as the initial antithrombotic agent for AF, even for those at higher risk for stroke.

Table 2. Randomized Trials Evaluating Oral Anticoagulation Therapy for Medical Atrial Fibrillation Patients

Trial [Reference]	Relative Risk Reduction for Cerebral Event	Significance (p Value)
Peterson et al [65]	56%	< 0.050
SPAF Investigators [61]	67%	0.010
Boston Area Investigators [66]	86%	0.002
Connolly et al [69]	26%	0.250
Eskowitz et al [68]	79%	0.001

SPAF = Stroke Prevention in Atrial Fibrillation study.

Table 3. Randomized Trials Evaluating Aspirin for Medical Atrial Fibrillation Patients

Trial [Reference]	Relative Risk Reduction for Cerebral Event	Significance (p Value)
Peterson et al [65]	16%	Not significant
SPAF Investigators [61]	42%	0.020
Diener et al [80]	18%	0.013

SPAF = Stroke Prevention in Atrial Fibrillation study.

What Is the Optimal International Normalized Ratio When Anticoagulation Is Used?

Class IIa recommendation: A target international normalized ratio (INR) of 2.0 to 2.5 is reasonable when using warfarin for AF in postoperative general thoracic surgical patients. (Level of evidence B)

This question is difficult to address as most AF anticoagulation studies have involved nonsurgical patients.

In a meta-analysis of randomized trials involving medical AF patients, anticoagulation therapy was associated with a 0.9% risk of extracranial hemorrhage compared with a 0.6% risk with placebo [70]. In a cohort study of 144 cardiac surgical patients in which follow-up echocardiography was used, there was a 16% incidence of tamponade among patients who received warfarin compared with 0% among control patients [73]. It is unclear how to extrapolate this information to the GTS patient. Additionally, the risk of bleeding will likely be different between a patient who has undergone a video-assisted thoracoscopic wedge resection compared with one who has undergone an esophagectomy with extensive dissection.

Two case-control studies have demonstrated that the risk of ischemic stroke when AF is present was higher when the INR was less than 2.0 compared with when the INR was higher than 2.0 [74, 75]. The poor efficacy of lower INR (7.9% versus 1.9% stroke plus systemic embolism rate) was also demonstrated in a randomized study involving 1,044 patients [76]. Most trials demonstrating efficacy of anticoagulation therapy for AF have used a target INR of 2 to 3. For thoracic surgical patients, who likely have an increased risk of bleeding as compared with medical patients, it seems reasonable to use a target INR of 2.0 to 2.5, at the low end of the range that has been proven to be successful.

What Is the Optimal Duration of Anticoagulation Therapy?

Class IIa recommendation: It is reasonable to continue anticoagulation therapy for 4 weeks after the return of sinus rhythm. (Level of evidence C)

A number of reviews and guidelines have suggested that anticoagulation therapy should be continued for

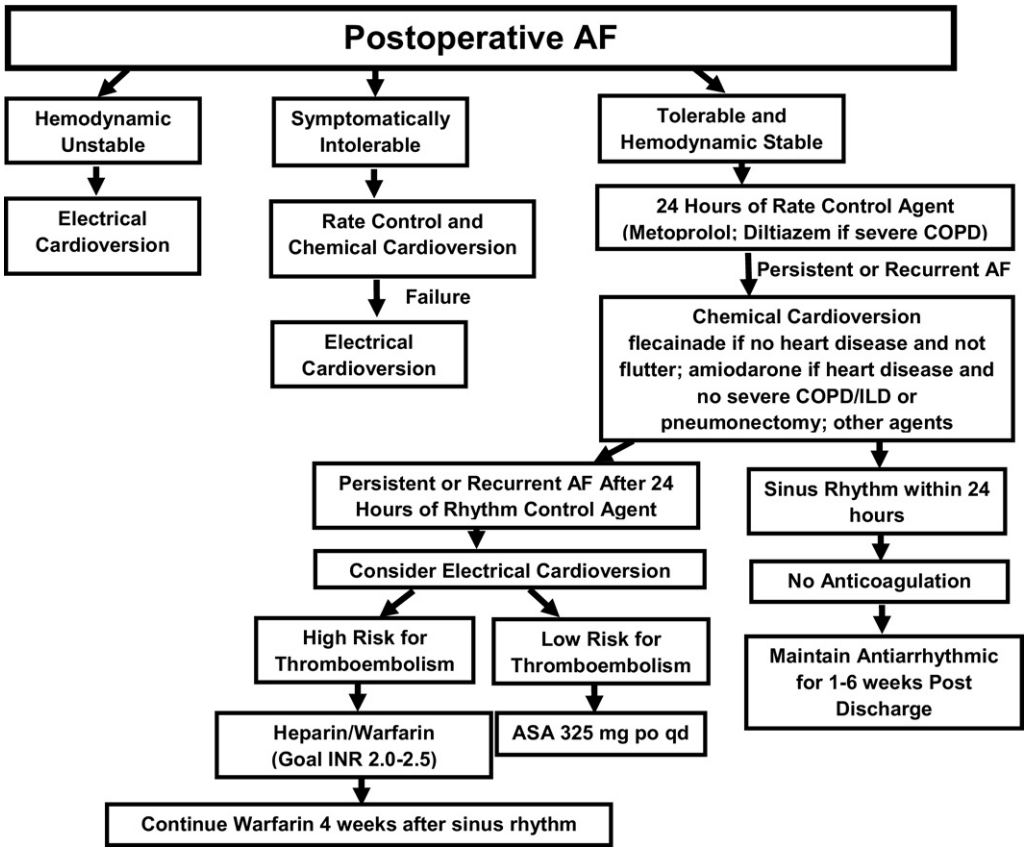

Fig 1. Postoperative atrial fibrillation (AF) flowchart. (ASA = acetylsalicylic acid [aspirin]; COPD = chronic obstructive pulmonary disease; ILD = interstitial lung disease; INR = international normalized ratio.)

approximately 4 weeks after return of sinus rhythm (established by electrocardiogram) [77–80]. The basis for the 4-week recommendation is that atrial contraction can be impaired for some time beyond the termination of AF. No level A or B evidence, however, is available for this issue. A suggested decision-tree, to manage atrial fibrillation when this occurs postoperatively, using the guidelines discussed for treatment and anticoagulation is outlined in Figure 1.

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References

1. Roselli EE, Murthy SC, Rice TW, et al. Atrial fibrillation complicating lung cancer resection. J Thorac Cardiovasc Surg 2005;130:438–44.
2. Irshad K, Feldman LS, Chu VF, Dorval JF, Baslaim G, Morin JE. Causes of increased length of hospitalization on a general thoracic surgery service: a prospective observational study. Can J Surg 2002;45:264–8.
3. Asamura H, Naruke T, Tsuchiya R, Goya T, Kondo H, Suemasu K. What are the risk factors for arrhythmias after thoracic operations? A retrospective multivariate analysis of 267 consecutive thoracic operations. J Thorac Cardiovasc Surg 1993;106:1104–10.
4. Rena O, Papalia E, Oliaro A, et al. Supraventricular arrhythmias after resection surgery of the lung. Eur J Cardiothorac Surg 2001;20:688–93.
5. Curtis JJ, Parker BM, McKenney CA, et al. Incidence and predictors of supraventricular dysrhythmias after pulmonary resection. Ann Thorac Surg 1998;66:1766–71.
6. Barbetakis N, Vassiliadis M. Is amiodarone a safe antiarrhythmic to use in supraventricular tachyarrhythmias after lung cancer surgery? BMC Surg 2004;4:7.
7. Stougård J. Cardiac arrhythmias following pneumonectomy. Thorax 1969;24:568–72.
8. Luketich JD, Nguyen NT, Weigel T, Ferson P, Keenan R, Schauer P. Minimally invasive approach to esophagectomy. J Surg Laparosc Surg 1998;2:243–7.
9. Sabel MS, Smith JL, Nava HR, Mollen K, Douglass HO, Gibbs JF. Esophageal resection for carcinoma in patients older than 70 years. Ann Surg Oncol 2002;9:210–4.
10. Gotley DC, Beard J, Cooper MJ, Britton DC, Williamson RC. Abdominocervical (transhiatal) oesophagectomy in the management of oesophageal carcinoma. Br J Surg 1990;77:815–9.
11. Murthy SC, Law S, Whooley BP, Alexandrou A, Chu KM, Wong J. Atrial fibrillation after esophagectomy is a marker for postoperative morbidity and mortality. J Thorac Cardiovasc Surg 2003;126:1162–7.
12. Krowka MJ, Pairolero PC, Trastek VF, Payne WS, Bernatz PE. Cardiac dysrhythmia following pneumonectomy. Clinical correlates and prognostic significance. Chest 1987;91:490–5.

13. Polanczyk CA, Goldman L, Marcantonio ER, Orav EJ, Lee TH. Supraventricular arrhythmia in patients having noncardiac surgery: clinical correlates and effect on length of stay. Ann Intern Med 1998;129:279–85.
14. Ciriaco P, Mazzone P, Canneto B, Zannini P. Supraventricular arrhythmia following lung resection for non-small cell lung cancer and its treatment with amiodarone. Eur J Cardiothorac Surg 2000;18:12–6.
15. Vaporciyan AA, Correa AM, Rice DC, et al. Risk factors associated with atrial fibrillation after noncardiac thoracic surgery: analysis of 2588 patients. J Thorac Cardiovasc Surg 2004;127:779–86.
16. Foroulis CN, Kotoulas C, Lachanas H, Lazopoulos G, Konstantinou M, Lioulias AG. Factors associated with cardiac rhythm disturbances in the early post-pneumonectomy period: a study on 259 pneumonectomies. Eur J Cardiothorac Surg 2003;23:384–9.
17. Harpole DH, Liptay MJ, DeCamp MM, Mentzer SJ, Swanson SJ, Sugarbaker DJ. Prospective analysis of pneumonectomy: risk factors for major morbidity and cardiac dysrhythmias. Ann Thorac Surg 1996;61:977–82.
18. Nielsen TD, Bahnson T, Davis RD, Palmer SM. Atrial fibrillation after pulmonary transplant. Chest 2004;126:496–500.
19. Allen MS, Deschamps C, Jones DM, Trastek VF, Pairolero PC. Video-assisted thoracic surgical procedures: the Mayo experience. Mayo Clin Proc 1996;71:351–9.
20. Daniels LJ, Balderson SS, Onaitis MW, D'Amico TA. Thoracoscopic lobectomy: a safe and effective strategy for patients with stage I lung cancer. Ann Thorac Surg 2002;74:860–4.
21. Kalman JM, Munawar M, Howes LG, et al. Atrial fibrillation after coronary artery bypass grafting is associated with sympathetic activation. Ann Thorac Surg 1995;60:1709–15.
22. Aranki SF, Shaw DP, Adams DH, et al. Predictors of atrial fibrillation after coronary artery surgery. Current trends and impact on hospital resources. Circulation 1996;94:390–7.
23. Kowey PR, Taylor JE, Rials SJ, Marinchak RA. Meta-analysis of the effectiveness of prophylactic drug therapy in preventing supraventricular arrhythmia early after coronary artery bypass grafting. Am J Cardiol 1992;69:963–5.
24. Sedrakyan A, Treasure T, Browne J, Krumholz H, Sharpin C, van der Meulen J. Pharmacologic prophylaxis for postoperative atrial tachyarrhythmia in general thoracic surgery: evidence from randomized clinical trials. J Thorac Cardiovasc Surg 2005;129:997–1005.
25. Amar D, Roistacher N, Rusch VW, et al. Effects of diltiazem prophylaxis on the incidence and clinical outcome of atrial arrhythmias after thoracic surgery. J Thorac Cardiovasc Surg 2000;120:790–8.
26. Amar D, Roistacher N, Burt ME, et al. Effects of diltiazem versus digoxin on dysrhythmias and cardiac function after pneumonectomy. Ann Thorac Surg 1997;63:1374–82.
27. Jakobsen CJ, Bille S, Ahlburg P, Rybro L, Hjortholm K, Andresen EB. Perioperative metoprolol reduces the frequency of atrial fibrillation after thoracotomy for lung resection. J Cardiothorac Vasc Anesth 1997;11:746–51.
28. Ritchie AJ, Tolan M, Whiteside M, McGuigan JA, Gibbons JR. Prophylactic digitalization fails to control dysrhythmia in thoracic esophageal operations. Ann Thorac Surg 1993;55:86–8.
29. Bayliff CD, Massel DR, Inculet RI, et al. Propranolol for the prevention of postoperative arrhythmias in general thoracic surgery. Ann Thorac Surg 1999;67:182–6.
30. Borgeat A, Biollaz J, Bayer-Berger M, Kappenberger L, Chapuis G, Chioléro R. Prevention of arrhythmias by flecainide after noncardiac thoracic surgery. Ann Thorac Surg 1989;48:232–4.
31. Kaiser A, Zünd G, Weder W, Largiadèr F. [Preventive digitalis therapy in open thoracotomy]. Helv Chir Acta 1994;60:913–7.
32. Lindgren L, Lepäntalo M, von Knorring J, Rosenberg P, Orko R, Scheinin B. Effect of verapamil on right ventricular pressure and atrial tachyarrhythmia after thoracotomy. Br J Anaesth 1991;66:205–11.
33. Terzi A, Furlan G, Chiavacci P, Dal Corso B, Luzzani A, Dalla Volta S. Prevention of atrial tachyarrhythmias after noncardiac thoracic surgery by infusion of magnesium sulfate. Thorac Cardiovasc Surg 1996;44:300–3.
34. Van Mieghem W, Coolen L, Malysse I, Lacquet LM, Deneffe GJ, Demedts MG. Amiodarone and the development of ARDS after lung surgery. Chest 1994;105:1642–5.
35. Van Mieghem W, Tits G, Demuynck K, et al. Verapamil as prophylactic treatment for atrial fibrillation after lung operations. Ann Thorac Surg 1996;61:1083–6.
36. Tisdale JE, Wroblewski HA, Wall DS, et al. A randomized trial evaluating amiodarone for prevention of atrial fibrillation after pulmonary resection. Ann Thorac Surg 2009;88:886–95.
37. Tisdale JE, Wroblewski HA, Wall DS, et al. A randomized, controlled study of amiodarone for prevention of atrial fibrillation after transthoracic esophagectomy. J Thorac Cardiovasc Surg 2010;140:45–51.
38. Nattel S, Rangno RE, Van Loon G. Mechanism of propranolol withdrawal phenomena. Circulation 1979;59:1158–64.
39. Burgess DC, Kilborn MJ, Keech AC. Interventions for prevention of post-operative atrial fibrillation and its complications after cardiac surgery: a meta-analysis. Eur Heart J 2006;27:2846–57.
40. Greenspon AJ, Kidwell GA, Hurley W, Mannion J. Amiodarone-related postoperative adult respiratory distress syndrome. Circulation 1991;84(Suppl 3):407–15.
41. Kay GN, Epstein AE, Kirklin JK, Diethelm AG, Graybar G, Plumb VJ. Fatal postoperative amiodarone pulmonary toxicity. Am J Cardiol 1988;62:490–2.
42. Olshansky B, Sami M, Rubin A, et al. Use of amiodarone for atrial fibrillation in patients with preexisting pulmonary disease in the AFFIRM study. Am J Cardiol 2005;95:404–5.
43. Shiga T, Wajima Z, Inoue T, Ogawa R. Magnesium prophylaxis for arrhythmias after cardiac surgery: a meta-analysis of randomized controlled trials. Am J Med 2004;117:325–33.
44. The Cardiac Arrhythmia Suppression Trial (CAST) Investigators. Preliminary report: effect of encainide and flecainide on mortality in a randomized trial of arrhythmia suppression after myocardial infarction. N Engl J Med 1989;321:406–12.
45. Valentine RJ, Rosen SF, Cigarroa JE, Jackson MR, Modrall JG, Clagett GP. The clinical course of new-onset atrial fibrillation after elective aortic operations. J Am Coll Surg 2001;193:499–504.
46. Soucier R, Silverman D, Abordo M, et al. Propafenone versus ibutilide for post operative atrial fibrillation following cardiac surgery: neither strategy improves outcomes compared with rate control alone (the PIPAF study). Med Sci Monit 2003;9:PI19–23.
47. Lee JK, Klein GJ, Krahn AD, et al. Rate control versus conversion strategy in postoperative atrial fibrillation: trial design and pilot study results. Card Electrophysiol Rev 2003;7:178–84.
48. Tisdale JE, Padhi ID, Goldberg AD, et al. A randomized, double-blind comparison of intravenous diltiazem and digoxin for atrial fibrillation after coronary artery bypass surgery. Am Heart J 1998;135:739–47.
49. Olshansky B, Rosenfeld LE, Warner AL, et al. The Atrial Fibrillation Follow-up Investigation of Rhythm Management (AFFIRM) study: approaches to control rate in atrial fibrillation. J Am Coll Cardiol 2004;43:1201–8.
50. Balser JR, Martinez EA, Winters BD, et al. Beta-adrenergic blockade accelerates conversion of postoperative supraventricular tachyarrhythmias. Anesthesiology 1998;89:1052–9.
51. Ormiston TM, Salpeter SR. Beta-blocker use in patients with congestive heart failure and concomitant obstructive airway disease: moving from myth to evidence-based practice. Heart Fail Monit 2003;4:45–54.
52. Khosla S, Kunjummen B, Khaleel R, et al. Safety of therapeutic beta-blockade in patients with coexisting bronchospastic airway disease and coronary artery disease. Am J Ther 2003;10:48–50.

53. van der Woude HJ, Zaagsma J, Postma DS, Winter TH, van Hulst M, Aalbers R. Detrimental effects of beta-blockers in COPD: a concern for nonselective beta-blockers. Chest 2005; 127:818–24.
54. McNamara RL, Tamariz LJ, Segal JB, Bass EB. Management of atrial fibrillation: review of the evidence for the role of pharmacologic therapy, electrical cardioversion, and echocardiography. Ann Intern Med 2003;139:1018–33.
55. Hilleman DE, Spinler SA. Conversion of recent-onset atrial fibrillation with intravenous amiodarone: a meta-analysis of randomized controlled trials. Pharmacotherapy 2002;22:66–74.
56. Reisinger J, Gatterer E, Lang W, et al. Flecainide versus ibutilide for immediate cardioversion of atrial fibrillation of recent onset. Eur Heart J 2004;25:1318–24.
57. del Arco C, Martín A, Laguna P, Gargantilla P, for the Investigators in the Spanish Atrial Fibrillation in Emergency Medicine Study Group (GEFAUR). Analysis of current management of atrial fibrillation in the acute setting: GEFAUR-1 study. Ann Emerg Med 2005;46:424–30.
58. Ashrafian H, Davey P. Is amiodarone an underrecognized cause of acute respiratory failure in the ICU? Chest 2001;120: 275–82.
59. Izhar U, Ad N, Rudis E, et al. When should we discontinue antiarrhythmic therapy for atrial fibrillation after coronary artery bypass grafting? A prospective randomized study. J Thorac Cardiovasc Surg 2005;129:401–6.
60. Risk factors for stroke and efficacy of antithrombotic therapy in atrial fibrillation. Analysis of pooled data from five randomized controlled trials. Arch Intern Med 1994; 154:1449–57.
61. Risk factors for thromboembolism during aspirin therapy in patients with atrial fibrillation: the Stroke Prevention in Atrial Fibrillation study. J Stroke Cerebrovasc Dis 1995;5: 147–57.
62. Hart RG, Pearce LA, McBride R, Rothbart RM, Asinger RW, for the Stroke Prevention in Atrial Fibrillation (SPAF) Investigators. Factors associated with ischemic stroke during aspirin therapy in atrial fibrillation: analysis of 2012 participants in the SPAF I-III clinical trials. Stroke 1999;30:1223–9.
63. Gage BF, Waterman AD, Shannon W, Boechler M, Rich MW, Radford MJ. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. JAMA 2001;285:2864–70.
64. Gage BF, van Walraven C, Pearce L, et al. Selecting patients with atrial fibrillation for anticoagulation: stroke risk stratification in patients taking aspirin. Circulation 2004;110:2287–92.
65. Petersen P, Boysen G, Godtfredsen J, Andersen ED, Andersen B. Placebo-controlled, randomised trial of warfarin and aspirin for prevention of thromboembolic complications in chronic atrial fibrillation. The Copenhagen AFASAK study. Lancet 1989;1:175–9.
66. The Boston Area Anticoagulation Trial for Atrial Fibrillation Investigators. The effect of low-dose warfarin on the risk of stroke in patients with nonrheumatic atrial fibrillation. N Engl J Med 1990;323:1505–11.
67. Stroke Prevention in Atrial Fibrillation Study. Final results. Circulation 1991;84:527–39.
68. Ezekowitz MD, Bridgers SL, James KE, et al, for the Veterans Affairs Stroke Prevention in Nonrheumatic Atrial Fibrillation Investigators. Warfarin in the prevention of stroke associated with nonrheumatic atrial fibrillation. N Engl J Med 1992;327:1406–12.
69. Connolly SJ, Laupacis A, Gent M, Roberts RS, Cairns JA, Joyner C. Canadian Atrial Fibrillation Anticoagulation (CAFA) study. J Am Coll Cardiol 1991;18:349–55.
70. Hart RG, Benavente O, McBride R, Pearce LA. Antithrombotic therapy to prevent stroke in patients with atrial fibrillation: a meta-analysis. Ann Intern Med 1999;131:492–501.
71. Connolly SJ, Pogue J, Hart RG, et al. Effect of clopidogrel added to aspirin in patients with atrial fibrillation. N Engl J Med 2009;360:2066–78.
72. Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. Ann Intern Med 2007;146:857–67.
73. Malouf JF, Alam S, Gharzeddine W, Stefadouros MA. The role of anticoagulation in the development of pericardial effusion and late tamponade after cardiac surgery. Eur Heart J 1993;14:1451–7.
74. Hylek EM, Skates SJ, Sheehan MA, Singer DE. An analysis of the lowest effective intensity of prophylactic anticoagulation for patients with nonrheumatic atrial fibrillation. N Engl J Med 1996;335:540–6.
75. Brass LM, Krumholz HM, Scinto JM, Radford M. Warfarin use among patients with atrial fibrillation. Stroke 1997;28: 2382–9.
76. Stroke Prevention in Atrial Fibrillation Investigators. Adjusted-dose warfarin versus low-intensity, fixed-dose warfarin plus aspirin for high-risk patients with atrial fibrillation: Stroke Prevention in Atrial Fibrillation III randomised clinical trial. Lancet 1996;348:633–8.
77. Daoud EG. Management of atrial fibrillation in the post-cardiac surgery setting. Cardiol Clin 2004;22:159–66.
78. Epstein AE, Alexander JC, Gutterman DD, Maisel W, Wharton JM, for the American College of Chest Physicians. Anticoagulation: American College of Chest Physicians guidelines for the prevention and management of postoperative atrial fibrillation after cardiac surgery. Chest 2005; 128(Suppl):24–7.
79. Dunning J, Nagarajan DV, Amanullah M, Nouraei SM. What is the optimal anticoagulation management of patients post-cardiac surgery who go into atrial fibrillation? Interact Cardiovasc Thorac Surg 2004;3:503–9.
80. Diener HC, Cunha L, Forbes C, Sivenius J, Smets P, Lowenthal A. European Stroke Prevention Study. 2. Dipyridamole and acetylsalicylic acid in the secondary prevention of stroke. J Neurol Sci 1996;143:1–13.