Management and Prevention of Postoperative Atrial Fibrillation After Cardiac Surgery

Case Study and Commentary, Peter Philip McKeown, MB, MPH, FRACS, and Michael Nicolini, PA-C

New-onset postoperative atrial fibrillation is a common complication, occurring in 30% of patients after coronary artery bypass and in as many as 50% to 60% of patients after combined coronary and valve procedures. Postoperative atrial fibrillation is associated with increased risk of additional complications, including stroke, increased hospitalization time, and increased costs [1–4].

Because of the extent of the problem, the American College of Chest Physicians (ACCP), through its Health and Science Policy Committee, established a multidisciplinary panel to develop clinical practice guidelines for the prevention and management of postoperative atrial fibrillation after cardiac surgery [5].

This group focused on 4 major issues:
1. Controlling the ventricular response rate
2. Conversion to normal sinus rhythm
3. The prevention of thromboembolic complications and the possible role of anticoagulation, and
4. The role of surgical and pharmacologic prophylaxis.

In this paper, a case study is used to review and discuss the current status of clinical practice guidelines as they relate to the prevention and management of postoperative atrial fibrillation. One of the major criticisms of clinical practice guidelines is that by the time they are published they are no longer current, and the ACCP guidelines are no exception [6,7]. In this paper, recent literature to supplement the guidelines has been included where applicable. Postoperative atrial fibrillation and its complications can be significantly reduced by the appropriate application of these guidelines.

CASE STUDY

Initial Presentation

An 82-year-old man is referred for urgent coronary artery bypass grafting.

History

The patient had exertional chest pain and was referred by his primary care physician to the cardiology service for assessment. A nuclear stress test showed reversal ischemia in...
the posterolateral wall and a possible inferolateral infarct. Cardiac catheterization showed severe left main coronary artery stenosis and 3-vessel disease. Ejection fraction was reduced at 45%. He developed preinfarction angina before being referred for urgent coronary artery bypass grafting. Medical history is notable for hypertension, hyperlipidemia, and a prior left thoracotomy for asbestosis. Preoperative medications include albuterol, felodipine, and lisinopril for hypertension, quinine sulfate for leg cramps, and simvastatin for hypercholesterolemia.

- What are the preoperative risk factors and etiology of postoperative atrial fibrillation following cardiac surgery?

Atrial fibrillation, one of the most common complications following cardiac surgery, is believed to be caused by a re-entry mechanism. Advanced age, withdrawal of β blockade, prolonged surgery, the inflammatory response, elevated atrial pressures, and myocardial ischemia are considered risk factors for postoperative atrial fibrillation [8,9].

The reported rate of detection depends on how well patients are monitored. Some episodes are intermittent and some are asymptomatic, so symptoms alone are not an accurate indicator. The true incidence of postoperative atrial fibrillation after cardiac surgery is around 30% for coronary artery procedures and as much as 60% for operations involving a valve procedure and coronary artery bypass [1,9].

In some cases, atrial fibrillation is a harbinger of more serious problems, such as tamponade, renal failure, low cardiac output, or pneumonia. Although atrial fibrillation is not always the direct cause of additional serious complications, it is nonetheless an independent predictor of additional morbidity, cost of hospitalization, and prolonged length of stay. The additional cost can average $10,000 to $20,000. For this reason alone, preventative strategies are important [8].

This patient has several factors that predispose him to postoperative atrial fibrillation. His advanced age and the urgent surgery, recent myocardial infarction, and inadequate preoperative β blockade are all potential predictive risk factors.

Operation

The patient underwent an urgent 3-vessel coronary artery bypass with a sequential reversed saphenous vein graft to the diagonal and left anterior descending and a reversed saphenous vein graft to the posterior descending artery. A decision was made not to use the left internal thoracic artery because of scarring from the previous left thoracotomy. No suitable vessel was found for bypass on the lateral wall in the circumflex distribution. The procedure was performed on cardiopulmonary bypass with a cross clamp time of 75 minutes and a bypass time of 97 minutes. The patient was cooled to 34°C. Antegrade cold blood cardioplegia was given at 15-minute intervals and a “hot shot” was given prior to removing the cross clamp. Defibrillation was not required, but temporary inotropic support was required to wean the patient from bypass.

- What intraoperative factors might contribute to or prevent postoperative atrial fibrillation?

In developing the ACCP guidelines for the prevention and management of postoperative atrial fibrillation after cardiac surgery, one subcommittee examined the evidence as it related to intraoperative interventions [10]. Fifteen randomized controlled studies and a large-scale concurrent cohort study were found to be relevant to this part of the analysis. These studies included reports for a number of interventions:

**Systemic Temperature**

In a randomized controlled trial, Adams et al [11] demonstrated that mild hypothermia (34°C) was associated with significantly less postoperative atrial fibrillation than moderate hypothermia (28°C).

**Heparin-Coated Circuits**

Given that an inflammatory response may be a contributing factor in postoperative atrial fibrillation, any intervention that reduces the amount of cytokine activation should help reduce the risk for postoperative atrial fibrillation. Heparin-bonded circuits have been shown to reduce complement activation and postoperative atrial fibrillation if cardiopulmonary bypass is used [12,13]. Reducing the inflammatory response from cardiopulmonary bypass can lead to overall improved outcomes [14].

**Posterior Pericardiotomy**

In a single randomized study, posterior pericardiotomy was shown to reduce the incidence of postoperative atrial fibrillation. The mechanism for this is unclear, but it may be related to more effective drainage of a pericardial effusion. It is questionable whether the overall risk-benefit ratio warrants this approach [15].

**Off-Pump Coronary Artery Bypass**

A potential advantage to off-pump coronary artery bypass (OPCAB) includes less atrial ischemia, which might result in a decrease in postoperative atrial fibrillation and avoidance of the inflammatory response associated with
cardiopulmonary bypass. Buffolo et al [16] and Subramanian et al [17] reported lower rates of postoperative atrial fibrillation in their OPCAB cases; however, other studies showed no difference in rates [18,19]. In 2 prospective randomized trials, one showed a lower rate of atrial fibrillation for the OPCAB group, and the other showed no difference [20,21]. Hernandez et al [22] in a large-scale concurrent cohort study found that there was a statistically lower rate of atrial fibrillation in the OPCAB group, but this difference was small and it was a multicenter trial. While there does appear to be a trend towards lower rates of atrial fibrillation with OPCAB, there is insufficient evidence to make a definitive conclusion or recommendation at this stage. Meanwhile, long-term graft patency remains a major concern for the OPCAB approach [23].

GIK Solutions
Theoretically, the infusion of glucose-insulin-potassium (GIK) solution provides an enriched substrate for the heart and could help protect against postoperative atrial fibrillation. Two randomized trials were assessed, and one showed a reduction in the rate of postoperative atrial fibrillation with GIK whereas the other showed no difference [24,25].

Thoracic Epidural Anesthesia
Both randomized and nonrandomized studies have reported conflicting results and no firm recommendation can be made to support the use of thoracic epidural anesthesia to prevent postoperative atrial fibrillation [10,26,27].

In summary, the subcommittee recommended that mild hypothermia, rather than moderate hypothermia, may be effective in reducing the frequency of postoperative atrial fibrillation; the use of heparin-coated cardiopulmonary bypass circuits is associated with less postoperative atrial fibrillation; and the use of posterior pericardiotomy may be a useful adjunct to reduce the frequency of postoperative atrial fibrillation. There was conflicting or inadequate data for the other interventions.

Early Postoperative Course
The patient was extubated within 12 hours and started on the following oral medications: aspirin 325 mg/day, magnesium oxide 400 mg/day, and metoprolol 12.5 mg twice daily. Oxycodone was given as required for pain relief. His blood pressure, heart rate, and temperature were all initially normal. On the evening of the second postoperative day, the patient developed atrial fibrillation with a rapid ventricular response rate of 120 to 130 bpm, and his blood pressure was 90/40 mm Hg.

• What are the management strategies for postoperative atrial fibrillation?

In patients who are hemodynamically unstable from rapid atrial fibrillation, emergency electrocardioversion with a synchronized direct current countershock may be required. In patients who are relatively hemodynamically stable, the strategy focuses on 2 components: controlling the ventricular response rate and converting to a normal sinus rhythm. In addition to these 2 strategies, a decision about short- and long-term anticoagulation needs to be considered in patients with persistent postoperative atrial fibrillation.

Controlling Ventricular Response Rate
One of the major consequences of sudden-onset atrial fibrillation is a rapid ventricular response creating hemodynamic compromise. Class II drugs (β blockers) (Table) are recommended as the first line of therapy in controlling the rapid ventricular response rate that often occurs in atrial fibrillation. Class IV drugs (calcium channel blockers), such as

<table>
<thead>
<tr>
<th>Class</th>
<th>Action</th>
<th>Drugs</th>
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<tbody>
<tr>
<td>I</td>
<td>Sodium channel blockade</td>
<td>Quinidine, procainamide, disopyramide</td>
</tr>
<tr>
<td>IA</td>
<td>Prolong repolarization</td>
<td>Lidocaine, mexiletine, tocainide, phenytoin</td>
</tr>
<tr>
<td>IB</td>
<td>Shorten repolarization</td>
<td>Encainide, flecainide, propafenone, moricizine (?)</td>
</tr>
<tr>
<td>IC</td>
<td>Little effect on repolarization</td>
<td>Propranolol, esmolol, acebutolol, l-sotalol</td>
</tr>
<tr>
<td>II</td>
<td>β-Adrenergic blockade</td>
<td>Ibutilide, dofetilide, sotalol (d,l), amiodarone, bretylium</td>
</tr>
<tr>
<td>III</td>
<td>Prolong repolarization (potassium channel blockade, other)</td>
<td>Verapamil, diltiazem, bepridil</td>
</tr>
<tr>
<td>IV</td>
<td>Calcium channel blockade</td>
<td>Adenosine, digitalis, magnesium</td>
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verapamil and diltiazem, are recommended as a second line of therapy, but the evidence has been fairly weak. Class IC drugs, such as propafenone, may be used to control the ventricular response rate, but these drugs are contraindicated in coronary artery disease and may cause bradycardia. Class III drugs (amiodarone) may also be used to control the ventricular response rate and appear to be at least as efficacious as digoxin or propafenone for this purpose. Amiodarone may also cause bradycardia and hypotension. There is little evidence to support the use of digoxin for rate control in postoperative atrial fibrillation [28]. Flecaïnide and propafenone are contraindicated in patients with coronary artery disease, and drugs with a proarrhythmic potential, such as dofetilide, are also contraindicated [28].

The drugs for rate control are usually continued for 4 to 6 weeks after surgery, although the evidence for this is not definitive. Because β blockers have been shown to have a beneficial effect in postmyocardial infarction patients, they are often continued for a longer period in those patients or in patients in whom these agents are also useful for controlling blood pressure [29].

Conversion to Normal Sinus Rhythm
Pharmacologic or electrocardioversion to normal sinus rhythm is another strategy to mitigate the effects of atrial fibrillation. Amiodarone has been recommended as one of the first lines of therapy to pharmacologically convert a patient in atrial fibrillation to normal sinus rhythm, particularly if the left ventricular function is depressed. In cases where the left ventricular function is normal, sotalol, ibutilide, and amiodarone have all been used with some success. The class I A agents (procainamide, quinidine, and disopyramide) have also been used, but they may be associated with ventricular arrhythmias and therefore are not considered the first line of choice for pharmacologic conversion. Intravenous procainamide may be associated with hypotension as well as having a potential proarrhythmic effect. Torsades de pointes ventricular arrhythmia and bradycardia may complicate therapy, and therefore the patient should be closely monitored [30]. While amiodarone has become perhaps the most popular agent in managing atrial fibrillation in this setting, it has a potential for hypotension, bradycardia, and pulmonary toxicity and close monitoring is needed [31]. Generally it is recommended that these agents be continued for 4 to 6 weeks after surgery, although there is little evidence guiding such recommendations.

In patients who are hemodynamically unstable because of rapid atrial fibrillation, electrical cardioversion (sometimes emergently), is the treatment of choice, preferably when electrolytes and magnesium have been normalized. A diagram representing the treatment options for postoperative atrial fibrillation is displayed in the Figure.

- What are recommendations for the use of anticoagulation in postoperative atrial fibrillation?

The postoperative patient poses particular challenges in terms of anticoagulation for atrial fibrillation. While the guidelines for starting warfarin in nonsurgical patients with chronic persistent atrial fibrillation are fairly clear, the use of early anticoagulation in surgical patients is problematic. Warfarin therapy has been shown to prevent strokes in nonsurgical patients with sustained/chronic atrial fibrillation and coexisting cardiovascular disease. Female gender, age greater than 75 years, a history of hypertension (systolic blood pressure > 160 mm Hg), history of transient ischemic attacks, and left ventricular dysfunction have all been associated with an increased risk of stroke in patients with atrial fibrillation [32–35].

The lack of studies specifically addressing the benefits and risks of anticoagulation for postoperative atrial fibrillation makes it difficult to make specific recommendations. From patients having valve replacements with mechanical prostheses that require warfarin, we know that there is some risk of bleeding in early anticoagulation. Most atrial fibrillation occurs on the third or fourth postoperative day. By this stage, the risk of bleeding is somewhat reduced. In a retrospective view of 2964 patients undergoing coronary artery bypass grafting, Kollar et al [36] studied the relationship between postoperative atrial fibrillation and stroke.
They argued that early aggressive anticoagulation could not have prevented the small number of strokes occurring in their patient population [36]. In another retrospective study, Hogue et al. [37] suggested that patients with low cardiac output and atrial fibrillation appear to be at increased risk of postoperative stroke.

The trend, without specific evidence from prospective randomized trials, has been to start patients on warfarin with a target international normalized ratio of 2 to 2.5 if they have had postoperative atrial fibrillation intermittent or sustained for more than 48 hours and to continue warfarin for 4 to 6 weeks. If patients still have atrial fibrillation at that stage, they would remain on warfarin per the standard guidelines for chronic/persistent atrial fibrillation.

**Course**

The patient was given an additional 10 mg of intravenous (IV) metoprolol and a slow IV bolus of 150 mg amiodarone to avoid hypotension. An IV infusion of amiodarone was then started at 1 mg/min for 6 hours followed by 0.5 mg/min for 18 hours. The patient converted to normal sinus rhythm during the infusion of amiodarone.

The patient was switched to oral amiodarone and discharged on postoperative day 7 in normal sinus rhythm. Discharge medications included (1) amiodarone 400 mg 3 times daily for 10 days, then 400 mg twice daily for 7 days, then 400 mg once daily for 7 days, at the end of which the amiodarone was discontinued, (2) aspirin 325 mg/day, (3) lisinopril 5 mg/day, (4) magnesium oxide 400 mg/day, (5) metoprolol 12.5 mg twice daily, and (6) simvastatin 20 mg at night. Because of the early and sustained conversion to normal sinus rhythm, anticoagulation was not considered.

- Given the potential risk for postoperative atrial fibrillation in this patient, is perioperative prophylaxis against postoperative atrial fibrillation appropriate?

**Role of Surgical and Pharmacologic Prophylaxis**

β Blockers, sotalol, and amiodarone have all been shown in randomized controlled trials to be effective agents for pharmacologic prophylaxis against postoperative atrial fibrillation. The evidence for calcium channel blockers, however, is inconclusive, and there appears to be little evidence to support the use of digoxin, magnesium, GIK, or procainamide for atrial fibrillation prophylaxis [38,39].

**β Blockers**

Given that postoperative atrial fibrillation is related to increased sympathetic tone, the use of β blockers as prophylaxis makes sense. Withdrawal of β blockers in patients who were on these agents preoperatively is also a strong predictor of postoperative atrial fibrillation. In reviewing the literature for the guideline development, Bradley et al. found that in 13 of 29 trials β blockers were effective in reducing postoperative atrial fibrillation [38,40]. There have been additional studies combining β blockers and other agents, such as digoxin, diltiazem, and magnesium. In many of these trials it appears that the efficacy is probably related to the β blocker.

**Amiodarone**

Amiodarone is unique in having both β-blocking properties and class III Vaughan Williams properties as well. Daoud et al. [41] demonstrated that a 7-day preoperative oral course of amiodarone significantly reduced the incidence of postoperative atrial fibrillation. The ARCH trial showed a smaller but significant reduction in postoperative atrial fibrillation with an IV loading starting 2 days before surgery [42]. In a more recent randomized controlled trial (PAPABEAR), oral amiodarone was also used preoperatively for 6 days and postoperatively for 6 days resulting in a significant reduction in postoperative atrial fibrillation [43].

**Sotalol**

This Vaughan Williams class III agent combines both a β receptor and potassium blocking effect and therefore should have some theoretical advantages over standard β blockers. Several trials demonstrated that sotalol is effective in preventing postcardiac surgery atrial fibrillation. Unfortunately some of these studies had small sample sizes and others were conflicted because of the perioperative withdrawal of standard β blockade. While some trials have demonstrated that sotalol may be more effective than β blockers per se in patients with good left ventricular function, other trials, including the largest one, have found no such difference [44,45]. Sotalol may cause bradycardia and hypotension as well as potential malignant arrhythmias through QT prolongation. The QT interval should be monitored if this drug is used and particular caution used in the presence of renal insufficiency.

**Digitalis**

While evidence supporting the use of digoxin alone is weak, digoxin plus propranolol was found to be effective in 2 studies, but this was probably largely from the β-blocker effect [46,47]. In another study, digoxin plus metoprolol was found to be effective in prevention of postoperative atrial fibrillation compared with a control group [48]. In this same study, amiodarone given postoperatively in a third group of randomized patients was also found to be effective prophylaxis when compared with the control group. Atrial fibrillation occurred in 16.8% of the digoxin plus metoprolol group, 8.3% in the amiodarone group, and 33.6% in the control...
group. Since β blockers were not used in all patients, it seems likely the effect in the digoxin and metoprolol group may have been largely from the β blocker. It has been suggested that digoxin alone may increase the incidence of ventricular arrhythmias [46].

Magnesium
It is important to maintain normal levels of serum magnesium to prevent postoperative arrhythmias. However, in reviewing the trials for the current guidelines, there did not appear to be any additional benefit in prophylactically giving magnesium to reduce postoperative atrial fibrillation [38]. A more recent meta-analysis of 20 randomized trials suggested some benefit in reducing postoperative atrial fibrillation, but many of the studies in this meta-analysis did not control for the use of β blockers or had other methodologic weaknesses. Even in this study, while the incidence of atrial fibrillation appeared to be reduced, there was no apparent reduction in length of stay or mortality [49].

In one randomized study, magnesium was compared directly with propranolol, and the propranolol group was found to have a lower incidence of postoperative atrial arrhythmias [50]. So while it is important to maintain adequate levels of magnesium in the postoperative period, it does not appear to be an effective prophylactic agent to prevent atrial fibrillation above and beyond that provided by β blockers, which are the standard.

Atrial Pacing
While there is no evidence to support the use of right atrial pacing alone to prevent postoperative atrial fibrillation, there are several studies to support the use of biatrial pacing to decrease postoperative atrial fibrillation [51,52]. Unfortunately, for pacing to be effective it needs to be continued for at least 3 to 5 days. Many of the studies were inconsistent in pacing protocols and/or were not controlled for the use of β blockers or other pharmacologic agents. In 1 large trial comparing atrial pacing at Bachmans bundle and amiodarone (AFIST-II), atrial pacing was not effective, whereas amiodarone prophylaxis was effective. There were technical difficulties in a large number of patients [53].

Because of technical concerns and the move toward early discharge, the use of biatrial pacing seems less practical than some other preventive strategies that are equally or more effective.

CONCLUSION
Atrial fibrillation after cardiac surgery remains a major problem and is associated with increased morbidity and cost. Preoperative, intraoperative, and postoperative strategies can be used to reduce the incidence and complications of postoperative atrial fibrillation. Appropriate application of the ACCP guidelines addressing these strategies can help to ensure improved outcomes for this patient population.

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References


POSTOPERATIVE ATRIAL FIBRILLATION


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1. The incidence of postoperative atrial fibrillation (AF) after cardiac surgery is
   (A) 20%
   (B) 30%
   (C) 50%
   (D) 60%

2. Which of the following intraoperative interventions is recommended to reduce postoperative AF?
   (A) Mild hypothermia
   (B) Heparin-coated circuits
   (C) Use of posterior pericardiotomy
   (D) All of the above

3. Which of the following is considered first-line therapy to control ventricular rate?
   (A) Calcium channel blockers
   (B) β Blockers
   (C) Class III drugs
   (D) None of the above

4. Which of the following statements are concordant with guideline recommendations for use of anticoagulation therapy in postoperative AF?
   (A) Warfarin therapy may be started in patients in whom AF has persisted for more than 48 hours
   (B) Warfarin therapy may be started on the third postoperative day in patients at risk for AF
   (C) Anticoagulation therapy is contraindicated in patients older than 75 years
   (D) None of the above

5. Which of the following is recommended for routine use for prevention of postoperative AF?
   (A) Magnesium
   (B) Digitalis
   (C) Calcium channel blockers
   (D) Amiodarone
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