Optimal Management of the Patient with an Episode of Atrial Fibrillation In and Out of the Hospital: Acute Cardioversion or Not?

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Learning Objectives:

1) The indications for anticoagulation prior to cardioversion.
2) The advantages of acute cardioversion of atrial fibrillation.
3) The situations in which it is preferable to not acutely cardiovert the patient with atrial fibrillation.

Introduction

The optimal management of a patient with new-onset atrial fibrillation (AF) is highly individualized. Frequently, the key management decision is whether or not to perform acute cardioversion. This decision involves asking two questions: (1) should cardioversion be performed at all? And, if so, (2) should cardioversion be performed acutely or should it be delayed?

To answer the first question, the benefits of sinus rhythm, the risks of cardioversion, and the likelihood of recurrence must be considered. The answer to the second question depends largely on the duration of AF. In patients who have had AF for < 48 hours, there is little reason to delay cardioversion unless there is a reversible trigger that may result in an early recurrence, or unless there is a high likelihood of spontaneous conversion. In patients who have had AF for > 48 hours, or in whom the duration is unclear, an atrial thrombus must be excluded by a transesophageal echocardiogram (TEE) if acute cardioversion is being considered, unless the situation is emergent. An alternative approach is to delay cardioversion until the patient has been anticoagulated for 3 weeks. This avoids the need for a TEE and avoids hospitalization to initiate heparin, but prolongs the duration of symptoms and may diminish the probability of restoring sinus rhythm by allowing time for more atrial remodeling to occur. Indeed, the various strategies for managing an episode of AF are each associated with their own advantages and disadvantages. In this monograph, the issues surrounding the most appropriate management of an episode of AF will be reviewed.

Should Cardioversion be Performed?

Initial Evaluation

The initial evaluation of a patient with AF includes confirmation of the rhythm diagnosis, exclusion of Wolff-Parkinson-White syndrome, determination of symptom severity, evaluation for underlying heart disease, and identification of the cause. The accurate diagnosis of AF is important but is not always achieved. A recent survey of cardiologists and cardiology fellows found that 74% misdiagnosed an ECG of AF with prominent atrial activity (> 0.2 mV) in more than one lead, as atrial flutter (unpublished data). A study of internal medicine house officers found that 31% of those surveyed misdiagnosed rapid AF as paroxysmal supraventricular tachycardia.[1] The same study found that 32% of the

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arrhythmias treated with adenosine at a university medical center were AFs. Although the irregularity of the ventricular response may be less apparent when the ventricular response is rapid, the hallmarks of AF can usually be identified.

The Wolff-Parkinson-White syndrome must be diagnosed early so that the use of AV nodal blocking agents, which might accelerate accessory pathway conduction, can be avoided.[2] Furthermore, early diagnosis is important because successful ablation of the accessory pathway may prevent recurrent episodes of AF.[3,4]

Patients with AF associated with severe symptoms, such as significant angina or hemodynamic instability, should undergo immediate electrical cardioversion. This is in accordance with Advanced Cardiac Life Support guidelines.[5] For patients with moderate symptoms, ventricular rate control can significantly improve symptoms and allow time to stabilize the patient while cardioversion is being considered.

Identification of cardiac pathology such as pericarditis, acute myocardial infarction, mitral stenosis, or hypertrophic cardiomyopathy will have an impact on both acute and long-term management of a patient with AF. Therefore, a careful history must be taken and a physical examination with focused cardiac testing, which should include a transthoracic echocardiogram, should be performed in patients who present with AF. The initial evaluation should also include identification of major reversible triggers before proceeding with cardioversion. Attempts should be made to reverse triggers, such as severe hypoxemia, that might lead to an early recurrence of AF. For example, a patient with severe respiratory distress may need ventilatory support and correction of hypoxemia before cardioversion is attempted.

Benefits of Sinus Rhythm

There are many theoretical advantages to sinus rhythm. The most obvious benefit of sinus rhythm is the hemodynamic advantage that occurs with restoration of atrial mechanical function and AV synchrony. Although it is difficult to predict which patients are likely to feel better after cardioversion, patients with diastolic dysfunction, commonly seen in the elderly and those with hypertension, are dependent upon atrial contraction. It is commonly believed that patients with congestive heart failure are more likely to benefit from a return of atrial function. However, patients with advanced heart failure develop a restrictive ventricular filling pattern such that the atrial contribution to filling is minimal.[6] Restoration of sinus rhythm may not improve cardiac output. This concept is supported by a study[7] that found no improvement after 6 weeks in exercise peak VO2, cardiac dimensions, or neurohumoral status among patients with mild to moderate heart failure who underwent cardioversion for AF.

A second benefit of cardioversion is control of the ventricular rate. There is a significant risk of tachycardia-induced cardiomyopathy among patients with AF whose ventricular response cannot be controlled.[8] In fact, some patients thought to have idiopathic dilated cardiomyopathy and AF may have first developed rapid AF that subsequently led to a cardiomyopathy.[9] Any method to decrease the rate can improve ventricular function, including drugs, cardioversion,[10] AV junction ablation,[11] or modification.[12] Therefore, patients with refractory rapid ventricular rates should be strongly considered for cardioversion, regardless of the presence or absence of symptoms.

A third benefit of cardioversion is regularization of the ventricular rhythm. Even when the ventricular rate is well controlled, cardiac output is lower when the ventricular rhythm is irregular than when it is regular.[13] This may explain why patients with congestive heart failure may be more likely to benefit from AV junction ablation and pacing compared with AV node modification, despite the adverse hemodynamics caused by right ventricular apical pacing.[14]

A fourth benefit is the potential for reducing the risk of thromboembolic complications. There are no data that demonstrate a reduction in stroke risk following maintenance of sinus rhythm, but it appears that the development of left atrial thrombi is associated with left atrial enlargement and reduced atrial mechanical function. Studies have demonstrated an eventual improvement in left atrial mechanical function following cardioversion[15] and have indicated that the maintenance of sinus rhythm may prevent atrial enlargement.[16] Therefore, it is plausible that in patients with risk factors for stroke during AF, restoration of sinus rhythm reduces the risk of stroke over the long term. On the other hand, the causes of stroke in patients with AF are multifactorial, and some factors, such as complex aortic plaques, may be responsible for an ongoing

risk of stroke despite the restoration of sinus rhythm.

Likelihood of Successful Conversion and Recurrence

The likelihood of successful conversion and the likelihood of recurrent AF should be considered before an attempt at cardioversion. Most patients can be successfully converted to sinus rhythm. The primary predictors of failure to convert with external cardioversion are body mass and the duration of AF. A study of 80 patients who underwent external cardioversion found that gender, left atrial enlargement, electrode pad position, etiology of AF, presence of left ventricular failure, and prior treatment with verapamil or beta blockers did not predict cardioversion success.[17] For patients who fail pharmacologic and external cardioversion, internal cardioversion is an option.[18] Therefore, patients should not be considered ineligible for cardioversion merely because the likelihood of initial failure is perceived to be high. The use of certain terminology in reference to AF such as "chronic" in the medical literature and in patients' records has compounded the problem of patients not being given the option of cardioversions. Patients who carry a diagnosis of "chronic" AF may have a long history of self-terminating episodes of AF (paroxysmal) or have non–self-terminating AF, and have either failed cardioversion (permanent AF) or have never had an attempt at cardioversion (persistent AF).[19]

Although many factors have been associated with recurrence of AF following successful cardioversion, such as left atrial size, presence of heart disease, age, and duration of AF,[20] the predictive value of each factor is not strong in every study. For example, left atrial size and duration of AF may not predict recurrence after cardioversion among patients treated with antiarrhythmic drugs.[21] Therefore, at least one attempt at cardioversion often is appropriate before deciding that a patient should be left in AF. In some cases, however, even one attempt at cardioversion may not be worthwhile. For example, a 75-year-old man with a mechanical aortic valve who is found to be in AF with a controlled ventricular response, who has no symptoms attributable to the AF, and who has tolerated warfarin for several years may prefer to remain in AF instead of undergoing cardioversion and/or starting therapy with an additional drug to maintain sinus rhythm.

Should Cardioversion be Performed Acutely or Postponed?

Once it has been decided to perform cardioversion, it must be decided whether cardioversion should be performed acutely or should be delayed. This decision is based on many factors, but hinges upon the duration of AF.

The decrease in left atrial transport and stasis of blood that occurs with AF results in intravascular thrombogenesis, platelet activation, and thromboembolism.[22-24] In addition, the immediate postcardioversion period is associated with left atrial mechanical dysfunction that persists for a time proportional to the duration of AF,[15] appears to be calcium mediated,[24] and further increases the risk of stroke. It is unclear how much time following the onset of AF must elapse before cardioversion might result in thromboembolism. A time of 48 hours is frequently used as a cutoff point,[25] because it has been shown that cardioversion in patients with AF for < 48 hours can be performed relatively safely without anticoagulation. One study[26] followed 375 patients who presented with AF thought to be of < 48 hours in duration and who either spontaneously converted or underwent cardioversion without heparin or warfarin. One patient had a stroke, one patient had a transient ischemic attack, and one patient had a peripheral embolism, indicating an overall thromboembolic risk of $< 1\%$. However, some physicians advocate anticoagulation prior to cardioversion for all patients, regardless of the duration of AF, because clot formation may occur sooner than 48 hours and because estimates of the duration of a particular episode of AF may be inaccurate.

There is often uncertainty regarding the time of onset of an episode of AF. Patients with paroxysmal AF have been shown to have more sustained asymptomatic episodes than symptomatic episodes.[27] Therefore, it is possible that some patients who present with AF have been fibrillating for several days before the onset of symptoms.

Because some patients with AF present with insidious symptoms of weakness or dyspnea, it is usually recommended that only patients who have had AF of < 48 hours in duration and who can pinpoint the time of onset with confidence should undergo cardioversion without anticoag-

ulation. The remaining patients should undergo cardioversion only after measures have been taken to reduce the risk of stroke.

AF < 48 Hours in Duration

Acute cardioversion leads to prompt resolution of symptoms, avoids the need for anticoagulation, and prevents further electrical and mechanical remodeling in the atria. Therefore, there is little reason to delay cardioversion in patients who present with AF < 48 hours in duration. However, there are two situations in which a delay may be advantageous.

The first situation is when there is a high likelihood of spontaneous conversion. On average, the incidence of spontaneous cardioversion of new-onset AF is approximately 50%. A recent study of 356 patients with AF of < 72 hours in duration found an incidence of spontaneous conversion of 68%.[28] The only predictor of spontaneous conversion was presentation within 24 hours. Therefore, an example of a patient who may benefit from a delay in cardioversion is a young, otherwise healthy individual who develops AF after excessive alcohol consumption and who presents to the hospital within a few hours after the onset of symptoms. Another example is a patient who develops AF during a procedure such as cardiac catheterization or a dobutamine stress echocardiogram.

On the other hand, a patient in whom there is a contraindication to anticoagulation should undergo prompt cardioversion, despite a high likelihood of spontaneous conversion. For example, a patient who presents with gastrointestinal bleeding and AF of < 48 hours in duration should be cardioverted promptly, because if spontaneous conversion does not occur within 48 hours, the window of opportunity for a low likelihood of stroke will have been lost.

The second situation in which cardioversion should be postponed is when there is a persistent reversible trigger, which will probably result in an early recurrence if left uncorrected. An example is a patient with AF in the setting of thyrotoxicosis, in whom cardioversion should be deferred until the thyroid disease has been treated.

AF > 48 Hours in Duration

Patients with AF > 48 hours in duration should undergo steps to reduce the risk of embolism with cardioversion, regardless of the absence of traditional risk factors that have been associated with stroke during chronic AF. There are two general approaches to reduce the risk of thromboembolism. The first approach is anticoagulation with warfarin for 3 weeks prior to cardioversion. An alternative strategy is to perform a TEE and perform cardioversion after intravenous heparin is started if no thrombus is found.[29] Anticoagulation for at least 4 weeks after conversion to sinus rhythm must be administered regardless of which approach is chosen. Both approaches are acceptable and are recommended by recently published ACC/AHA guidelines.[30] The decision of which approach to follow depends on several factors.

There are advantages and disadvantages of early cardioversion using a TEE-guided approach for patients with AF > 48 hours in duration. One advantage is that symptomatic patients will benefit from the prompt resolution of symptoms. Another advantage is the avoidance of the risk and inconvenience associated with anticoagulation for 3 weeks prior to cardioversion. Although the bleeding risk during this 3-week period may be low, the precardioversion period of anticoagulation is often > 3 weeks because of the time required to achieve therapeutic anticoagulation with warfarin in some patients. Therefore, early cardioversion may avoid several weeks of delay.

A theoretical advantage of early cardioversion is a lower incidence of recurrence. It has been shown that an episode of AF results in shortening of atrial refractoriness (electrical remodeling) that promotes a recurrent episode of AF,[31,32] and repeated cardioversions may be associated with progressively longer arrhythmia-free intervals. Therefore, early cardioversion allows less time for electrical remodeling to occur and may be more likely to be followed by sustained sinus rhythm.

A disadvantage of the TEE-guided approach is the need for the patient to undergo a TEE. However, this is a safe procedure and often provides other valuable information. Therefore, for patients who are already in the hospital, there is little disadvantage to early cardioversion. The TEE-guided approach has been shown to be cost-effective for inpatients.[33] However, the early approach to cardioversion requires hospitalization to initiate heparin while starting warfarin. Therefore, a patient with AF who is minimally symptomatic and who has likely been in AF chronically would obtain little benefit from early

cardioversion. An approach using a TEE-guided cardioversion followed by outpatient subcutaneous low-molecular weight heparin offers the advantages of early cardioversion and the benefit of avoiding hospitalization. This strategy awaits further study.

The other disadvantage of the TEE-guided approach is the dilemma created when a patient is found to have an atrial thrombus. It is clear that patients with a thrombus who have not been anticoagulated should not undergo cardioversion acutely, if possible. However, it is not clear when, if ever, cardioversion can be safely performed. It is possible that cardioversion could be safely performed following 3 weeks of anticoagulation, even if the atrial thrombus is still present. However, some investigators recommend a repeat TEE and more aggressive anticoagulation prior to cardioversion if a clot is still present. Aggressive steps to minimize an embolic stroke must be weighed against the risks of delaying cardioversion, the risks of hemorrhagic complications, and how likely the patient is to benefit from sinus rhythm.

AF Following Cardiac Surgery

Postoperative AF deserves special mention. AF is a common problem after open heart surgery and has unique features. AF occurs in patients who are in the hospital and monitored, is secondary to triggers that often resolve over time, may occur in patients who have a contraindication to anticoagulation, and often prolongs the hospital length of stay. AF following noncardiac surgery is less common, with an incidence of approximately 6%, but shares many of these features.[34]

Although there are effective prophylactic regimens for postoperative AF, such as beta blockers,[35] sotalol,[36] and orally administered amiodarone,[37] AF continues to be a significant problem. Much of the pathology contributing to the initiation and perpetuation of AF following cardiac surgery, such as pericarditis and elevated catecholamines, resolves spontaneously over time. Therefore, a successful cardioversion may be followed by an early recurrence, and a delay in cardioversion may be followed by spontaneous conversion. In a study using temporary epicardial wires placed at the time of cardiac surgery for atrial defibrillation, the incidence of early recurrence (< 60 sec after defibrillation) following successful conversion of postoperative AF was 50%.[38]

The decision of whether to perform cardioversion acutely depends on the anticipated length of stay and often is governed by logistical factors. For example, if a patient develops AF on the day of anticipated discharge and ventricular rate control is achieved within a short period of time, it may be preferable to initiate therapy with warfarin, continue drugs to control the rate, and discharge the patient when the cardioversion process is expected to prolong the hospital stay. In a recent study,[39] 12 patients with postoperative AF who were discharged from the hospital with warfarin and drugs for rate control but without any attempts at cardioversion were compared with 67 patients discharged after cardioversion. Patients discharged in AF had a shorter length of stay and lower hospital costs compared with patients discharged in sinus rhythm. However, if the resources to promptly perform cardioversion are available, the patient can be discharged on the same day and avoid the need for anticoagulation.

Cardioversion Technique and Risks

Cardioversion of AF can be achieved either pharmacologically or electrically. Pharmacologic cardioversion is associated with proarrhythmia, including sustained polymorphic ventricular tachycardia with drugs that prolong repolarization such as sotalol, incessant monomorphic ventricular tachycardia as seen with flecainide, and bradycardia. It remains controversial which outpatients should be hospitalized prior to initiation of oral antiarrhythmic therapy. It is likely that patients without structural heart disease can be safely treated as outpatients. However, a recent retrospective study found clinically significant complications during in-hospital monitoring in 1 of 5 patients started on sotalol, and absence of heart disease failed to distinguish a low-risk group.[40] Although not approved for use in the United States for AF, amiodarone appears to be safe when started in low doses and can be started on an outpatient basis even in the presence of heart disease.

For patients who are already hospitalized and monitored, intravenous options include procainamide, ibutilide, and amiodarone. Digoxin has no role in the conversion of AF. The Digitalis in Acute AF (DAAF) Trial included 239 patients and found that 51% of patients who received digoxin converted to sinus rhythm after 16 hours,

compared with 46% of patients who received placebo.[41] Ibutilide has recently been compared with procainamide and was found to have a higher cardioversion success rate than procainamide (51% vs 21%, P = 0.005).[42] The risk of sustained polymorphic ventricular tachycardia is approximately 2%, and appears to occur more commonly in women and in patients with congestive heart failure. An additional advantage of ibutilide is that when conversion is not initially achieved, the energy required to cardiovert may be lowered by ibutilide (unpublished data). Although initial trials suggested that amiodarone was effective in cardioversion, a randomized placebo-controlled trial of 100 patients found no benefit.[43]

Electrical cardioversion is safe and highly effective.[44] No antiarrhythmic drug therapy has a higher success rate. Electrical cardioversion was initially shown to be associated with more significant atrial "stunning" compared with pharmacologic cardioversion in nonrandomized trials.[45] Therefore, it was felt that pharmacologic cardioversion might be associated with a lower risk of embolism. However, more recent studies[46] have found no difference in the effect on atrial function between electric and pharmacologic cardioversion. Complications associated with electrical cardioversion, including ventricular fibrillation and postconversion bradycardia, are rare. In fact, in a prospective study of 1,152 patients who underwent either pharmacologic or electrical cardioversion, only five patients died, all of whom were related to quinidine therapy for pharmacologic cardioversion.[47] Therefore, if the facilities are readily available, there is little reason to delay electrical cardioversion while treatment with antiarrhythmic drugs is instituted.

When there is a high likelihood of recurrence, it may be of value to have therapeutic plasma drug levels present at the time of cardioversion to avoid an early recurrence of AF. Therefore, in this case, it may be useful to delay electrical cardioversion. On the other hand, prophylactic drug therapy can usually be initiated after cardioversion, and in some patients can be avoided altogether. For example, it would be acceptable to use no antiarrhythmic drugs following cardioversion of a patient who presents with his or her first episode of AF.

Given the inefficiency of transthoracic energy delivery, high energies are required for successful external cardioversion. Therefore, sedation is required when the procedure is performed elective. Several anesthetics have been shown to be useful in this setting, including intravenous midazolam, propofol, and etomidate.[48-50] Electrophysiologists who are experienced with conscious sedation can safely administer sedation for the delivery of painful shocks.[51] However, because some agents such as propofol are associated with a high incidence of apnea,[49] their use is often restricted by hospitals to anesthesiologists. Low-energy transvenous cardioversion using specially designed catheters is an option for patients who cannot receive sedation.[52,53] This concept has recently been expanded to the postoperative setting. Liebold et al.[38] were able to successfully initially convert 80% of patients who developed AF after cardiac surgery with a mean energy of 5 J delivered through temporary epicardial wires that were placed intraoperatively. Only 30% of the patients required sedation.

Conclusion

There is increasing evidence to support acute cardioversion in patients with AF. Acute cardioversion results in prompt resolution of symptoms, reduces the time allowed for electrical remodeling to occur, reduces the duration of postcardioversion atrial mechanical dysfunction, and avoids the need for anticoagulation when performed within 48 hours of onset of AF. When acute cardioversion is being considered in a stable patient with AF $>$ 48 hours, a TEE should be performed to exclude an atrial thrombus prior to cardioversion, and 4 weeks of warfarin therapy should be continued after cardioversion.

The management of AF must be individualized and must consider the duration of AF, the perceived benefit of sinus rhythm, the likelihood of a spontaneous conversion, the presence of ongoing triggers, the need for hospital admission, and logistical factors. Although clinical judgment will always play an important role in determining the optimal treatment strategy in individual patients, additional prospective studies are needed to clarify unsettled issues related to AF. For example, it is unclear whether acute cardioversion or rate control/anticoagulation is the safer and least costly strategy in patients with postoperative AF. In addition, the role of newer agents for anticoagulation such as subcutaneous low-molecular weight heparin, and the role of newer techniques that permit low-energy cardio-

version without sedation remain to be determined.

References

1. Knight BP, Zivin A, Souza J, et al: Use of adenosine in patients hospitalized in a university medical center. Am J Med 1998;105:275-280.
2. Klein GJ, Bashore TM, Sellors TB, et al: Ventricular fibrillation in the Wolff-Parkinson-White syndrome. N Engl J Med 1979;301:1080-1085.
3. Kalbfleisch SJ, El-Atassi R, Calkins H, et al: Inducibility of atrial fibrillation before and after radiofrequency catheter ablation of accessory atrioventricular connections. J Cardiovasc Electrophysiol 1993;4:499-503.
4. Haïssaguerre M, Fisher B, Labbe T, et al: Frequency of recurrent atrial fibrillation after catheter ablation of overt accessory pathways. Am J Cardiol 1992;69:493-497.
5. Cummins RO, ed: *Textbook of Advanced Cardiac Life Support*. American Heart Association, Texas,1994, p. 33.
6. Pinamonte B, Di Lenardi A, Sinagra G, et al, and the Heart Muscle Disease Study Group: Restrictive left ventricular filling pattern in dilated cardiomyopathy assessed by Doppler echocardiography: Clinical, echocardiographic and hemodynamic correlations and prognostic implications. J Am Coll Cardiol 1994;23:1535-1540.
7. van den Berg MP, Tuinenburg AE, van Veldhuisen DJ, et al: Cardioversion of atrial fibrillation in the setting of mild to moderate heart failure. Int J Cardiol 1998;63:63-70.
8. Fenelon G, Wijns W, Andries E, et al: Tachycardiomyopathy: Mechanisms and clinical implications. PACE 1996;19:95-106.
9. Grogan M, Smith H, Gersh B, et al: Left ventricular dysfunction due to atrial fibrillation in patients initially believed to have idiopathic dilated cardiomyopathy. Am J Cardiol 1992;69:1570-1573.
10. Peters K, Kienzle M: Severe cardiomyopathy due to chronic rapidly conducted atrial fibrillation: Complete recovery after restoration of sinus rhythm. Am J Med 1988;85:242-244.
11. Gottfried H, Siostrzonek P, Kreiner G, et al: Improvement in left ventricular systolic function after successful radiofrequency His bundle ablation for drug refractory, chronic atrial fibrillation and recurrent atrial flutter. Am J Cardiol 1992;69:489-492.
12. Morady F, Hasse C, Strickberger SA, et al: Long-term follow-up after radiofrequency modification of the atrioventricular node in patients with atrial fibrillation. J Am Coll Cardiol 1997;29:113-121.
13. Daoud EG, Weiss R, Bahu M, et al: Effect of an irregular ventricular rhythm on cardiac output. Am J Cardiol 1996;78:1433-1436.
14. Twidale N, McDonald T, Nave K, et al: Comparison of the effects of AV nodal ablation versus AV nodal modification in patients with congestive heart failure and uncontrolled atrial fibrillation. PACE 1998;21:641-651.
15. Manning WJ, Silverman DI, Katz SE, et al: Impaired left atrial mechanical function after cardioversion: Relation to the duration of atrial fibrillation. J Am Coll Cardiol 1994;23:1535-1540.
16. Sanfilippo AJ, Abascal VM, Sheehan M, et al: Atrial enlargement as a consequence of atrial fibrillation. Circulation 1990;82:792-797.
17. Dalzell GW, Anderson J, Adgey AA: Factors determining success and energy requirements for cardioversion of atrial fibrillation: Revised version. Q J Med 1991;78:85-95.
18. Schmitt C, Alt E, Plewan A, et al: Low-energy intracardiac cardioversion after failed conventional external cardioversion of atrial fibrillation. J Am Coll Cardiol 1996;28:994-999.
19. Levy S: Nomenclature of atrial fibrillation or the Tower of Babel. J Cardiovasc Electrophysiol 1998;9(Suppl):S83-S85.
20. Dittrich HC, Erickson JS, Schneiderman T, et al: Echocardiographic and clinical predictors for outcome of elective cardioversion of atrial fibrillation. Am J Cardiol 1989;63:193-197.
21. Duytschaever M, Haerynck F, Tavernier R, et al: Factors influencing long-term persistence of sinus rhythm after a first electrical cardioversion for atrial fibrillation. PACE 1998;21:284-287.
22. Rubin DN, Katz SE, Riley MF, et al: Evaluation of left atrial appendage anatomy and function in recent-onset atrial fibrillation by transesophageal echocardiography. Am J Cardiol 1996;78:774-778.
23. Lip GY, Lip PL, Zarifis J, et al: Fibrin D-dimer and beta-thromboglobulin as markers of thrombogenesis and platelet activation in atrial fibrillation: Effects of introducing ultra-low dose warfarin and aspirin. Circulation 1996;94:425-431.
24. Sun H, Gaspo R, Leblanc N, et al: Cellular mechanisms of atrial contractile dysfunction caused by sustained atrial tachycardia. Circulation 1998;98:719-727.
25. Laupacis A, Albers G, Dunn M, et al: Antithrombotic therapy in atrial fibrillation. Chest 1992;102(Suppl 4):426S-433S.
26. Weigner MJ, Caulfield TA, Danias PG, et al: Risk for clinical thromboembolism associated with conversion to sinus rhythm in patients with atrial fibrillation lasting less than 48 hours. Ann Intern Med 1997;126:615-620.
27. Page RL, Wilkinson WE, Clair WK, et al: Asymptomatic arrhythmias in patients with symptomatic paroxysmal atrial fibrillation and paroxysmal supraventricular tachycardia. Circulation 1994;89:224-227.
28. Danias PG, Caulfield TA, Weigner MJ, et al: Likelihood of spontaneous conversion of atrial fibrillation to sinus rhythm. J Am Coll Cardiol 1998;31:588-592.
29. Manning WJ, Silverman DI, Kieghley CS, et al: Transesophageal echocardiography facilitated early cardioversion from atrial fibrillation using short-term antico-

agulation: Final results of a prospective 4.5-year study. J Am Coll Cardiol 1995;25:1354-1361.
30. Prystowsky EN, Benson W, Fuster V, et al: Management of patients with atrial fibrillation. A statement for healthcare professionals from the subcommittee on electrocardiography and electrophysiology: American Heart Association. Circulation 1996;93:1262-1277.
31. Wijffels MCEF, Kirchof CJHJ, Dorland R, et al: Atrial fibrillation begets atrial fibrillation: A study in awake, chronically instrumented goats. Circulation 1995;92: 1954-1968.
32. Daoud EG, Bogun F, Goyal, et al: Effect of atrial fibrillation on atrial refractoriness in humans. Circulation 1996;94:1600-1606.
33. Seto TB, Taira DA, Tsevat J, et al: Cost-effectiveness of transesophageal echocardiographic-guided cardioversion: A decision analytic model for patients admitted to the hospital with atrial fibrillation. J Am Coll Cardiol 1997;29:122-130.
34. Polanczyk CA, Goldman L, Marcantonio ER, et al: Supraventricular arrhythmia in patients having noncardiac surgery: Clinical correlates and effect on length of stay. Ann Intern Med 1998;129:279-285.
35. Lamb RK, Prabhakar G, Thorpe JAC, et al: The use of atenolol in the prevention of supraventricular arrhythmias following coronary artery surgery. Eur Heart J 1988;9:32-36.
36. Suttorp MJ, Kingma JH, Peels HOJ, et al: Effectiveness of sotalol in preventing supraventricular tachyarrhythmias shortly after coronary artery bypass grafting. Am J Cardiol 1991;68:1163-1169.
37. Daoud EG, Strickberger SA, Man KC, et al: Preoperative amiodarone as prophylaxis against atrial fibrillation after heart surgery. N Engl J Med 1997;337:1785-1791.
38. Liebold A, Wahba A, Birnbaum DE: Low-energy cardioversion with epicardial wire electrodes: New treatment of atrial fibrillation after open heart surgery. Circulation 1998;98:883-886.
39. Solomon AJ, Kouretas PC, Hopkins RA, et al: Early discharge of patients with new-onset atrial fibrillation after cardiovascular surgery. Am Heart J 1998;135:557-563.
40. Chung MK, Schweikert RA, Wilkoff BL, et al: Is hospital admission for initiation of antiarrhythmic therapy with sotalol for atrial arrhythmias required? Yield of in-hospital monitoring and prediction of risk for significant arrhythmia complications. J Am Coll Cardiol 1998;32:169-176.
41. The Digitalis in Acute Atrial Fibrillation (DAAF) Trial Group: Intravenous digoxin in acute atrial fibrillation. Results of a randomized, placebo-controlled multicentre trial in 239 patients. Eur Heart J 1997;18:649-654.
42. Volgman AS, Carberry PA, Stambler B, et al: Conversion efficacy and safety of intravenous ibutilide compared with intravenous procainamide in patients with atrial flutter or fibrillation. J Am Coll Cardiol 1998;31: 1414-1419.
43. Galve E, Rius T, Ballester R, et al: Intravenous amiodarone in treatment of recent-onset atrial fibrillation: Results of a randomized, controlled study. J Am Coll Cardiol 1996;27:1079-1082.
44. Ricard P, Levy S, Trigano J, et al: Prospective assessment of the minimum energy needed for external electrical cardioversion of atrial fibrillation. Am J Cardiol 1997;79:815-816.
45. Manning WJ, Silverman DI, Katz SE, et al: Temporal dependence of the return of atrial mechanical function on the mode of cardioversion of atrial fibrillation to sinus rhythm. Am J Cardiol 1995;75:624-626.
46. Falcone RA, Morady F, Armstrong WF: Transesophageal echocardiographic evaluation of left atrial appendage function and spontaneous contrast formation after chemical or electrical cardioversion of atrial fibrillation. Am J Cardiol 1996;78:435-439.
47. Tebbe U, Carlsson J, Seidl K, et al: Cardioversion in atrial fibrillation: Results and complications in 1,152 prospective patients. Study Group of the Working Society of Leading Cardiologic Hospital Physicians. Med Klin 1995;90:681-687.
48. Khan AH, Malhotra R: Midazolam as intravenous sedative for electrocardioversion. Chest 1989;95:1068-1071.
49. Canessa R, Lema G, Urzua J, et al: Anesthesia for elective cardioversion: A comparison of four anesthetic agents. J Cardiothorac Vasc Anesth 1991;5:566-568.
50. Gale DW, Grissom TE, Mirenda JV: Titration of intravenous anesthetics for cardioversion: A comparison of propofol, methohexital and midazolam. Crit Care Med 1993;21:1509-1513.
51. Pacifico A, Cedillo-Salazar FR, Nasir N, et al: Conscious sedation with combined hypnotic agents for implantation of implantable cardioverter-defibrillators. J Am Coll Cardiol 1997;30:769-773.
52. Alt E, Ammer R, Lehmann G, et al: Efficacy of a new balloon catheter for internal cardioversion of chronic atrial fibrillation without anesthesia. Heart 1998;79: 128-132.
53. Levy S, Ricard P, Lau CP, et al: Multicenter low energy transvenous atrial defibrillation (XAD) trial results in different subsets of atrial fibrillation. J Am Coll Cardiol 1997;29:750-755.