2011 accf/ aha/ hrs atrial fibrillation guidelines

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Anticoagulant therapy in atrial fibrillation based on the ACCF/AHA/HRS 2011 update, the ESC 2012 update, and the CCS 2011 update of AF guidelines

Valvular AF* — Yes

No (i.e. non-valvular AF)

< 65 years and lone AF (including females) — Yes

No

Initial stroke risk assessment (CHADS₂ factors)
prior stroke/TIA: 2 points
age ≥ 75 years, hypertension, diabetes, heart failure: 1 point

0–1 | ≥2

Further assessment of low- to intermediate stroke risk patients
(ACCF/AHA/HRS: 'less validated risk factors',
CCS: 'VASc factors', ESC: 'CHA₂DS₂VASc score')
age 64–74, vascular disease, female gender: 1 point each

1 | ≥2

CCS: aspirin for females or vascular disease <65 years
ACCF/AHA/HRS: either ASA or nothing

ESC: OAC preferred (all patients)
CCS: OAC for age 65–74 or vascular disease and female
ACCF/AHA/HRS: either ASA or OAC

Oral anticoagulation

ACCF/AHA/HRS: no preference
CCS: NOAC preferred
ESC: NOAC preferred

No antithrombotics | Aspirin | NOAC | VKA

First detected

Paroxysmal[1,4] (Self-terminating) | Persistent[2,4] (Not self-terminating)

Permanent[3]

ACCF/AHA/HRS: AF Guideline 2011

Maintenance of sinus rhythm

No (or minimal) heart disease | Hypertension | Coronary artery disease | Heart failure

Dronedarone Flecainide Propafenone Sotalol | Substantial LVH | Dofetilide Dronedarone Sotalol | Amiodarone Dofetilide

No | Yes

Dronedarone Flecainide Propafenone Sotalol | Amiodarone | Amiodarone | Catheter ablation

Amiodarone Dofetilide | Catheter ablation

Amiodarone Dofetilide | Catheter ablation | Catheter ablation

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2011 ACCF/AHA/HRS Guidelines
Antithrombotic Therapy for Patients with Atrial Fibrillation

Risk Category	Recommended Therapy
No risk factors	Aspirin, 81 to 325 mg daily
One **moderate** risk factor	Aspirin, 81 to 325 mg daily, or warfarin (INR 2.0 to 3.0, target 2.5)
Any **high** risk factor or > 1 moderate-risk factor	Warfarin (INR 2.0 to 3.0, target 2.5)*

Less Validated / Weaker Risk Factors	Moderate Risk Factors	High Risk Factors
Female gender	Age ≥75 years	Previous stroke, TIA or embolism
Age 65 to 74 years	Hypertension	Mitral stenosis
Coronary artery disease	Heart failure	Prosthetic heart valve*
Thyrotoxicosis	LV ejection fraction ≤35%	*If mechanical valve, target international normalized ratio (INR) > 2.5
	Diabetes mellitus	

2011 Focused Update Recommendation Class I*	Comments
Dabigatran is useful as an alternative to warfarin for the prevention of stroke and systemic thromboembolism in patients with paroxysmal to permanent AF and risk factors for stroke or systemic embolization who do not have a prosthetic heart valve or hemodynamically significant valve disease, severe renal failure (creatinine clearance <15 mL/min) or advanced liver disease (impaired baseline clotting function). (Level of Evidence: B)	New Recommendation

1. Fuster V, Circulation. 2011 Mar 15;123(10): Pub Med PMID: 21382897.
2. Wann LS, et al. J Am Coll Cardiol. 2011 Mar 15;57(11):1330-7. Pub Med PMID: 21324629.

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Aha/acc/hrs guidelines for atrial fibrillation. 2011 accf/aha/hrs guidelines for the management of patients with atrial fibrillation. 2019 aha/acc/hrs guidelines for atrial fibrillation. 2014 aha/acc/hrs guidelines for atrial fibrillation.

Smith Sidney C., MD, FACC, FAHA, FESCCChair, ACC/AHA Task Force on Practice GuidelinesPriori Silvia G., MD, PhD, FESCChair, ESC Committee for Practice Guidelines
For new or updated text, view the 2011 Focused Update and the 2011 Focused Update on Dabigatran. Text supporting unchanged recommendations has not been updated.It is important that the medical profession play a significant role in critically evaluating the use of diagnostic procedures and therapies as they are introduced and tested in the detection, management, or prevention of disease states. Rigorous and expert analysis of the available data documenting absolute and relative benefits and risks of those procedures and therapies can produce helpful guidelines that improve the effectiveness of care, optimize patient outcomes, and favorably affect the overall cost of care by focusing resources on the most effective strategies.The American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA) have jointly engaged in the production of such guidelines in the area of cardiovascular disease since 1980. The ACC/AHA Task Force on Practice Guidelines, whose charge is to develop, update, or revise practice guidelines for important cardiovascular diseases and procedures, directs this effort. The Task Force is pleased to have this guideline developed in conjunction with the European Society of Cardiology (ESC). Writing committees are charged with the task of performing an assessment of the evidence and acting as an independent group of authors to develop or update written recommendations for clinical practice.Experts in the subject under consideration have been selected from all 3 organizations to examine subject-specific data and write guidelines. The process includes additional representatives from other medical practitioner and specialty groups when appropriate. Writing committees are specifically charged to perform a formal literature review, weigh the strength of evidence for or against a particular treatment or procedure, and include estimates of expected health outcomes where data exist. Patient-specific modifiers, comorbidities, and issues of patient preference that might influence the choice of particular tests or therapies are considered as well as frequency of follow-up and cost-effectiveness. When available, information from studies on cost will be considered; however, review of data on efficacy

...proved efficacious, in part because of concern about the risk of bleeding.[411] Special consideration of these older patients is therefore a critical aspect of effective stroke prophylaxis.[405] Figure 8. Stroke rates in relation to age among patients in untreated control groups of randomized trials of antithrombotic therapy. Data are from the Atrial Fibrillation Investigators. 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.[47] Female gender has emerged as an independent predictor of stroke in 3 cohort studies of patients with AF but not in several others.[47,268,404]

The relative increase was 1.6 in the largest study of the ATRIA cohort.[262] In the SPAF analyses of aspirin-treated patients, gender interacted with age such that women over 75 y old were at particularly high risk, but this interaction was not apparent in the AnticoagulAtion and Risk factors In Atrial fibrillation (ATRIA) cohort.[262,412] Similarly, hypertension is a consistent, powerful predictor of stroke, with a history of hypertension independently predictive in 5 studies (median relative risk approximately 2.0) and systolic blood pressure significant in 2 others (mean relative risk approximately 2.0). A history of hypertension and systolic blood pressure were significant as independent predictive of stroke in the SPAF analyses although this was a significant independent predictor in 8 studies, associated with an average relative risk of 1.8, but not in 2 other studies...

[Dense body text continues — ACC/AHA/ESC guidelines on the management of patients with atrial fibrillation, discussing risk factors for stroke, antithrombotic therapy, echocardiography, and pharmacological agents for cardioversion and maintenance of sinus rhythm.]

Copenhagen Atrial Fibrillation, Aspirin, Anticoagulation [AFASAK] 1[413]198900VKA, ASA, placebo   Stroke Prevention in Atrial Fibrillation I [SPAF I][414]199011100VKA, ASA   Stroke Prevention in Atrial Fibrillation II [SPAF II][401]199611640VKA, LDA + ASA   Stroke Prevention in Atrial Fibrillation III [SPAF III][402]199611064VKA, LDA + ASA   Boston Area Anticoagulation Trial for Atrial Fibrillation [BAATAF][281]199004200VKA, control   Canadian Atrial Fibrillation Anticoagulation [CAFA][363]199137830VKA, placebo   Stroke Prevention in Nonrheumatic Atrial Fibrillation [SPINAF][415]199214097VKA, placebo   European Atrial Fibrillation Trial [EAFT][403]199310007VKA, ASA, placebo   Studio Italiano Fibrillazione Atriale [SIFA][416]199791VKA, indobufen   Minidose Warfarin in Nonrheumatic Atrial Fibrillation[442]199830300VKA, LDA[*]   Prevention of Arterial Thromboembolism in Atrial Fibrillation [PATAF][441]199972VKA, LDA[*], ASA   European Atrial Fibrillation Trial [EAFT]

underlying heart disease.741 In one study of patients with persistent AF, the 4-y arrhythmia-free survival rate was less than 10% after single-shock direct-current cardioversion without prophylactic drug therapy.735 Predictors of recurrences within that interval included hypertension, age over 55 y, and AF duration longer than 3 mo. Serial cardioversions and prophylactic drug therapy resulted in freedom from recurrent AF in approximately 30% of patients,735 and with this approach predictors of recurrence included age over 70 y, AF duration beyond 3 mo, and HF.735 Other risk factors for recurrent AF include LA enlargement and rheumatic heart disease.8.3.1.4. Future Directions in Catheter-Based Ablation Therapy for Atrial Fibrillation (NEW SECTION)For new or updated text, view the 2011 Focused Update. Text supporting unchanged recommendations has not been updated.8.3.2. General Approach to Antiarrhythmic Drug TherapyBefore administering any antiarrhythmic agent, reversible precipitants of AF should be identified and corrected. Most are related to coronary or valvular heart disease, hypertension, or HF. Patients who develop HF in association with alcohol intake should abstain from alcohol consumption. Indefinite antiarrhythmic treatment is seldom prescribed after a first episode, although a period of several weeks may help stabilize sinus rhythm after cardioversion. Similarly, patients experiencing breakthrough arrhythmias may not require a change in antiarrhythmic drug therapy when recurrences are infrequent and mild. Beta-adrenergic antagonist medication may be effective in patients who develop AF only during exercise, but a single, specific inciting cause rarely accounts for all episodes of AF, and the majority of patients do not sustain sinus rhythm without antiarrhythmic therapy. Selection of an appropriate agent is based first on safety, tailored to whatever underlying heart disease may be present, considering the number and pattern of prior episodes of AF.742In patients with lone AF, a beta blocker may be tried first, but flecainide, propafenone, and sotalol are particularly effective. Amiodarone and dofetilide are recommended as alternative therapies. Quinidine, procainamide, and disopyr-amide are not favored unless amiodarone fails or is contra-indicated. For patients with vagally induced AF, however, the anticholinergic activity of long-acting disopyramide makes it a relatively attractive theoretical choice. In that situation, flecainide and amiodarone represent secondary and tertiary treatment options, respectively, whereas propafenone is not recommended because its (weak) intrinsic beta-blocking activity may aggravate vagally mediated paroxysmal AF. In patients with adrenergically mediated AF, beta blockers represent first-line treatment, followed by sotalol and amiodarone. In patients with adrenergically mediated lone AF, amiodarone represents a less desirable selection. Vagally induced AF can occur by itself, but more typically it is part of the overall patient profile. In patients with nocturnal AF, the possibility of sleep apnea should be considered (see Fig. 15).When treatment with a single antiarrhythmic drug fails, combinations may be tried. Useful combinations include a beta blocker, sotalol, or amiodarone with a class IC agent. The combination of a calcium channel blocker, such as diltiazem, with a class IC agent, such as flecainide or propafenone, is advantageous in some patients. A drug that is initially safe may become proarrhythmic if coronary disease or HF develops or if the patient begins other medication that exerts a proarrhythmic interaction. Thus, the patient should be alerted to the potential significance of such symptoms as syncope, angina, or dyspnea and warned about the use of noncardiac drugs that might prolong the QT interval. A useful source of information on this topic is the Internet site optimum method for monitoring antiarrhythmic drug treatment varies with the agent involved as well as with patient factors. Prospectively acquired data on upper limits of drug-induced prolongation of QRS duration or QT interval are not available. Given recommendations represent the consensus of the writing committee. With class IC drugs, prolongation of the QRS interval should not exceed 50%. Exercise testing may help detect QRS widening that occurs only at rapid heart rates (use-dependent conduction slowing). For class IA or class III drugs, with the possible exception of amiodarone, the corrected QT interval in sinus rhythm should be kept below 520 ms. During follow-up, plasma potassium and magnesium levels and renal function should be checked periodically because renal insufficiency leads to drug accumulation and predisposes to proarrhythmia. In individual patients, serial noninvasive assessment of LV function is indicated, especially when clinical HF develops during treatment of AF.8.3.3. Selection of Antiarrhythmic Agents in Patients With Cardiac DiseasesPharmacological management algorithms to maintain sinus rhythm in patients with AF (see Figs. 13, 14, 15, and 16) and applications in specific clinical disease states are based on available evidence and extrapolated from experience with these agents in other situations.8.3.3.1. Heart FailurePatients with HF are particularly prone to the ventricular proarrhythmic effects of antiarrhythmic drugs because of myocardial vulnerability and electrolyte imbalance. Randomized trials have demonstrated the safety of amiodarone and dofetilide (given separately) in patients with HF.501,743 and these are the recommended drugs for maintenance of sinus rhythm in patients with AF in the presence of HF.In a subgroup analysis of data from the Congestive Heart Failure Survival Trial of Antiarrhythmic Therapy (CHFSTAT) study,738 amiodarone reduced the incidence of AF over 4 y in patients with HF to 4% compared with 8% with placebo. Conversion to sinus rhythm occurred in 31% of patients on amiodarone versus 8% with placebo and was associated with significantly better survival.The Danish Investigations of Arrhythmias and Mortality on Dofetilide in Heart Failure (DIAMOND-CHF) trial randomized 1518 patients with symptomatic HF. In a substudy of 506 patients with HF and AF or atrial flutter,501,588 dofetilide (0.5 mg twice daily initiated in hospital) increased the probability of sinus rhythm after 1 y to 79% compared with 42% with placebo. In the dofetilide group, 44% of patients with AF converted to sinus rhythm compared with 39% in the placebo group. Dofetilide had no effect on mortality, but the combined endpoint of all-cause mortality and HF hospitalization was lower in the treated group than with placebo.501,588 Torsades de pointes developed in 25 patients treated with dofetilide (3.3%), and three-quarters of these events occurred within the first 3 d of treatment.Patients with LV dysfunction and persistent AF should be treated with beta blockers and ACE inhibitors and/or angiotensin II receptor antagonists, because these agents help control the heart rate, improve ventricular function, and prolong survival.744–747 In patients with coronary disease who have not developed MI or HF, however, it is uncertain whether the benefit of beta blockers outweighs this risk, and more experience is needed before this drug can be recommended even as a second-line agent in such patients.8.3.3.3. Hypertensive Heart DiseaseHypertension is the most prevalent and potentially modifiable independent risk factor for the development of AF and its complications, including thromboembolism.760,761 Blood pressure control may become an opportune strategy for prevention of AF. Patients with LVH may face an increased risk of torsades de pointes related to early ventricular after-depolarizations.742,762,763 Thus, class IC agents and amiodarone are preferred over type IA and type III antiar-rhythmic agents as first-line therapy. In the absence of ischemia or LVH, propafenone or flecainide is a reasonable choice. Proarrhythmia with these agents does not predict this response to another, and patients with LVH who develop torsades de pointes during treatment with a class III agent may tolerate a class IC agent. Amiodarone prolongs the QT interval but carries a very low risk of ventricular proarrhythmia. Its extracardiac toxicity relegates it to second-line therapy in patients with MI, HF, and hypertension. Compared with patients with lone AF, those with hypertension are more likely to maintain sinus rhythm after cardio-version of persistent AF when treated with a beta blocker.764 Drugs modulating the renin-angiotensin system reduce structural cardiac changes,765 and ACE inhibition was associated with a lower incidence of AF compared with calcium channel blockade in patients with hypertension during 4.5 y of follow-up in a retrospective, longitudinal cohort study from a database of 8 million patients in a managed care setting.42 In times at increased risk of cardiovascular events, therapy with either the ACE inhibitor trandolapril766–768 or angiotensin II receptor antagonist losartan769,770 lowered the risk of stroke. A similar benefit has been reported with perindopril in a subset of patients with AF treated for prevention of recurrent stroke.771 New-onset AF and stroke were significantly reduced by losartan compared with atenolol in hypertensive patients with ECG-documented LVH, despite a similar reduction of blood pressure.41 The benefit of losartan was greater in patients with AF than those with sinus rhythm for the primary composite endpoint (cardiovascular mortality, stroke, and MI) and for cardiovascular mortality alone.772 Presumably, the beneficial effects of beta blockers and drugs modulating the renin-angiotensin system are at least partly related to lower blood pressure.8.3.4. Nonpharmacological Therapy for Atrial FibrillationThe inconsistent efficacy and potential toxicity of antiarrhythmic drug therapies have stimulated exploration of a wide spectrum of alternative nonpharmacological therapies for the prevention and control of AF.8.3.4.1. Surgical AblationOver the past 25 y, surgery has contributed to understanding of the pathophysiology and electrophysiology of commonly encountered arrhythmias, including the WPW syndrome, AV nodal reentry, ventricular tachycardia, and atrial tachycardia. A decade of research in the 1980s identified the critical elements necessary to cure AF surgically, including the techniques that entirely eliminate macroreentrant circuits in the atria while preserving sinus node and atrial transport functions. The surgical approach was based on the concept of a geographical maze, accounting for the term "maze" procedure used to describe this type of cardiac operation.774Since its introduction, the procedure has gone through 3 iterations (maze I, II, and III) using cut-and-sew techniques that ensure transmural lesions to isolate the PV, connect these dividing lines to the mitral valve annulus, and create electrical barriers in the RA that prevent macroentrant rhythms—atrial flutter or AF—from becoming sustained.775 Success rates of around 95% over 15 y of follow-up have been reported in patients undergoing mitral valve surgery.776 Other studies suggest success rates around 70%.777 Atrial transport function is maintained and, when combined with amputation or obliteration of the LAA, postoperative thromboembolic events are substantially reduced. Risks include death (less than 1% when performed as an isolated procedure), the need for permanent pacing (with right-sided lesions), recurrent bleeding requiring reoperation, impaired atrial transport function, delayed atrial arrhythmias (especially atrial flutter), and atrioesophageal fistula.Variations of the maze procedure have been investigated at several centers to determine the lesion sets necessary for success. Studies in patients with persistent AF have demonstrated the importance of complete lesions that extend to the mitral valve annulus; electrical isolation of the PV alone is associated with a lower success rate. Bipolar radiofrequency,778 cryoablation, and microwave energy have been used as alternatives to the "cut-and-sew" technique. In one study, maintenance of sinus rhythm following the maze procedure in patients with AF was associated with improvement in some aspects of quality of life.348Despite its high success rate, the maze operation has not been widely adopted other than for patients undergoing cardiac surgery because of the need for cardiopulmonary bypass. A wide variety of less invasive modifications are under investigation, including thoracoscopic and catheter-based epicardial techniques.777 If the efficacy of these adaptations approaches that of the endocardial maze procedure and they can be performed safely, they may become acceptable alternatives for a larger proportion of patients with AF.8.3.4.2. Catheter AblationEarly radiofrequency catheter ablation techniques emulated the surgical maze procedure by introducing linear scars in the atrial endocardium.779 While the success rate was approximately 40% to 50%, a relatively high complication rate and need for multiple procedures limited enthusiasm for catheter-based ablation.105 Initially, areas of automaticity within the PV were targeted, and in a series of 45 patients with paroxysmal AF, 62% became free of symptomatic AF over a mean follow-up of 8 mo, but 70% required multiple procedures.105 In another study, the success rate was 86% over a 6-mo follow-up.780 Subsequent research has demonstrated that potentials may arise in multiple regions of the RA and LA, including the LA posterior wall, superior vena cava, vein of Marshall, crista terminalis, interatrial septum, and coronary sinus,109 and modification of the procedures has incorporated linear LA ablation, mitral isthmus ablation, or both for selected patients.781The technique of ablation has continued to evolve from early attempts to target individual ectopic foci within the PV to circumferential electrical isolation of the entire PV musculature. In a series of 70 patients, 73% were free from AF following PV isolation without antiarrhythmic medications during a mean follow-up of 4 mo, but 29 patients required a second procedure to reach this goal. However, postablation AF may occur transiently in the first 2 mo.782 Advances involving isolation of the PV at the antrum using a circular mapping catheter, guided by intracardiac echocardiography, have reportedly yielded approximately 80% freedom of recurrent AF or atrial flutter after the first 2 mo in patients with paroxysmal AF,783 although postablation AF may occur transiently in the first 2 mo.782 Another anatomic approach to radiofrequency catheter ablation targets complex fractionated electrograms,789 with 91% efficacy reported at 1 y. Restoration of sinus rhythm after catheter ablation for AF significantly improved LV function, exercise capacity, symptoms, and quality of life (usually within the first 3 to 6 mo), even in the presence of concurrent heart disease and when ventricular rate control was adequate before ablation.790 While that study lacked a control group of patients with HF, in another study catheter ablation of AF was associated with reduced mortality and morbidity due to HF and thromboembolism.791In selected patients, radiofrequency catheter ablation of the AV node and pacemaker insertion decreased symptoms of AF and improved quality-of-life scores compared with medication therapy.363,387,388,792–794 Baseline quality-of-life scores are generally lower for patients with AF or atrial flutter than for those undergoing ablation for other arrhythmias.795 A meta-analysis of 10 studies of patients with AF389 found improvement in both symptoms and quality-of-life scores after ablation and during. Although these studies involved selected patients who remained in AF, the consistent improvement suggests that quality of life was impaired before intervention. Two studies have described improvement in symptoms and quality of life after radiofrequency catheter ablation of atrial flutter.796,797 New studies comparing strict versus lenient rate control are under way to investigate this issue further.Despite these advances, the long-term efficacy of catheter ablation to prevent recurrent AF requires further study. Available data demonstrate 1 y or more free from recurrent AF is most (albeit carefully selected) patients.798–800 It is important to bear in mind, however, that AF can recur without symptoms and be unrecognized by the patient or the physician. Therefore, it remains uncertain whether apparent cures represent elimination of AF or transformation into an asymptomatic form of paroxysmal AF. The distinction has important implications for the duration of anticoagulation therapy in patients with risk factors for stroke associated with AF. In addition, little information is yet available about the late success of ablation in patients with HF and other advanced structural heart disease, who may be less likely to enjoy freedom from AF recurrence.8.3.4.2.1. Complications of Catheter-Based Ablation.Complications of catheter ablation include the adverse events associated with any cardiac catheterization procedure in addition to those specific to ablation of AF. Major complications have been reported in about 6% of procedures and include PV stenosis, thromboembolism, atrioesophageal fistula, and LA flutter.788 The initial ablation approach targeting PV ectopy was associated with an unacceptably high rate of PV stenosis,780,801 but the incidence has dramatically decreased as a result of changes in technique. Current approaches avoid delivering radiofrequency energy within the PV and instead target areas outside the veins to isolate the ostia from the remainder of the LA conducting tissue. Use of intracardiac echocardiographically detected microbubble formation to titrate radiofrequency energy has also been reported to reduce the incidence of PV stenosis.783Embolic stroke is among the most serious complications of catheter-based ablation procedures in patients with AF. The incidence varies from 0% to 5%. A higher intensity of anticoagulation reduces the risk of thrombus formation during ablation.802 A comparison of 2 heparin dosing regimens found LA thrombus in 11.2% of patients when the activated clotting time (ACT) was 250 to 300 s compared with 2.8% when the ACT was kept greater than 300 s. Based on these observations, it seems likely that more aggressive anticoagulation may reduce the incidence of thromboembolism associated with catheter-based ablation of AF.Atrioesophageal fistula has been reported with both the circumferential Pappone approach803,804 and the Haissaguerre PV ablation techniques804 but is relatively rare. This complication may be more likely to occur when extensive ablative lesions are applied to the posterior LA wall, increasing the risk of atrial perforation. The typical manifestations include sudden neurologic or endocarditis, and the outcome in most cases is, unfortunately, fatal.Depending on the ablation approach, LA flutter may develop during treatment of AF,805 and this is typically related to scars created during catheter ablation. An incomplete line of ablation is an important predictor of postprocedural LA flutter, and extending the ablation line to the mitral annulus may reduce the frequency of this complication. In most cases, LA flutter is amenable to further ablation.8068.3.4.2.2. Future Directions in Catheter-Based Ablation Therapy for Atrial Fibrillation.Catheter-directed ablation of AF represents a substantial achievement that promises better therapy for a large number of patients presently resistant to pharmacological or electrical conversion to sinus rhythm. The limited available studies suggest that catheter-based ablation offers benefit to selected patients with AF, but these studies do not provide convincing evidence of optimum catheter positioning or absolute rates of treatment success. Identification of patients who would benefit most from ablation must take into account both potential benefits and short- and long-term risks. Rates of success and complications vary, sometimes considerably, from one study to another because of patient factors, patterns of AF, criteria for definition of success, duration of follow-up, and technical aspects. Registries of consecutive case series should incorporate clear and prospectively defined outcome variables. Double-blind studies are almost impossible to perform, yet there is a need for randomized trials in which evaluation of outcomes is blinded as to treatment modality. A comprehensive evaluation of the favorable and adverse effects of various ablation techniques should include measures of quality of life and recurrence rates compared with pharmacological strategies for rhythm control and, when this is not successful, with techniques of rate control as AV node ablation and pacing. Generation of these comparative data over relatively long periods of observation would address the array of invasive and conservative management approaches available for management of patients with AF and provide a valuable foundation for future practice guidelines.8.3.4.3. Suppression of Atrial Fibrillation Through PacingSeveral studies have examined the role of atrial pacing, either in the RA alone or in more than one atrial location, to prevent recurrent paroxysmal AF. In patients with symptomatic bradycardia, the risk of AF is lower with atrial than with ventricular pacing.807 In patients with sinus node dysfunction and normal AV conduction, data from several randomized trials support atrial pacing for prevention of AF.808–811 The mechanisms by which atrial pacing prevents AF in patients with sinus node dysfunction include prevention of bradycardia-induced dispersion of repolarization and suppression of atrial premature beats. Atrial or dual-chamber pacing also maintains AV synchrony, preventing retrograde ventriculoatrial conduction that can cause valvular regurgitation and stretch-induced changes in atrial electrophysiology. When ventricular pacing with dual-chamber devices is unavoidable because of concomitant disease of the AV conduction system, the evidence is less clear that atrial-based pacing is superior.While atrial pacing is effective in preventing development of AF in patients with symptomatic bradycardia, its utility as a treatment for paroxysmal AF in patients without conventional indications for pacing has not been proved.812 In the Atrial Pacing Peri-Ablation for the Prevention of AF (PA3) study, patients under consideration for AV junction ablation received dual-chamber pacemakers and were randomized to atrial pacing versus no pacing. There was no difference in time to first occurrence of AF or total AF burden.812 In a continuation of this study comparing atrial pacing with AV synchronous pacing, patients were randomized to DDDR versus VDD node pacing after ablation of the AV junction. Once again, there was no difference in time to first recurrence of AF or AF burden, and 42% of the patients lapsed into permanent AF by the end of 1 y.813It has been suggested that the incidence of AF may be lower with atrial septal pacing or multisite atrial pacing than with pacing in the RA appendage.814 Pacing at right interatrial septal sites results in preferential conduction to the LA via Bachmann's bundle. Pacing from this site shortens P-wave duration and interatrial conduction time. Clinical trials of pacing in the interatrial septum to prevent episodes of paroxysmal AF have yielded mixed results.815–817 While 2 small randomized trials found that atrial septal pacing reduced the number of episodes of paroxysmal AF and the incidence of persistent AF at 1 y compared with RA appendage pacing,815,816 a larger trial showed no effect on AF burden despite reduction in symptomatic AF.817Both bi-atrial (RA appendage and either the proximal or distal coronary sinus) and dual-site (usually RA appendage and coronary sinus ostium) pacing have been studied as means of preventing AF. A small trial of biatrial pacing to prevent recurrent AF found no benefit compared with conventional RA pacing,818 and a larger trial revealed no benefit from dual-site compared with single-site pacing, except in certain subgroups.819 The greater complexity and more extensive apparatus required have limited the appeal of dual-site pacing.Several algorithms have been developed to increase the percentage of atrial pacing time to suppress atrial premature beats, prevent atrial pauses, and decrease atrial cycle length variation in the hope of preventing AF. Prospective studies of devices that incorporate these algorithms have yielded mixed results. In one large trial, these pacemaker algorithms decreased symptomatic AF burden, but the absolute difference was small, and there was no gain in terms of quality of life, mean number of AF episodes, hospitalizations, or mean duration of AF detected by the pacemaker's automatic mode-switching algorithm.820 Other trials have failed to show any benefit of atrial pacing in preventing AF.817,821In addition to pacing algorithms to prevent recurrent AF found no benefit compared with conventional RA pacing. While efficacy has been shown for termination of atrial tachyarrhythmias, there has been little demonstrated effect on total AF burden.821,822In summary, atrial-based pacing is associated with a lower risk of AF and stroke than ventricular-based pacing in patients requiring pacemakers for bradyarrhythmias, but the value of pacing as a primary therapy for prevention of recurrent AF has not been proven.8.3.4.4. Internal Atrial DefibrillatorsIn a sheep model of internal cardioversion of AF,354 delivery of synchronous shocks between the high RA and coronary sinus effectively terminated episodes of AF. A clinical trial of a low-energy transvenous atrial cardioverter that delivered a 3/3-ms biphasic waveform shock synchronized to the R wave established the safety of internal atrial cardioversion, but the energy required in patients with persistent AF was relatively high (mean 3.5 J).355 Intense basic and clinical research to find more tolerable shock waveforms led to evaluation of an implantable device capable of both atrial sensing and cardioversion and ventricular sensing and pacing in 290 patients with mean LV ejection fraction greater than 50% who had not responded satisfactorily to therapy with 4 antiarrhythmic drugs.355 In total, 614 episodes of AF were treated with 1497 shocks (mean 2.4 shocks per episode), and the rate of conversion to sinus rhythm was 93%. As spontaneous episodes were treated quickly, the interval between episodes of AF lengthened.Several available devices combining both atrial cardioversion and ventricular defibrillation capabilities with dual-chamber sensing and pacing have been designed to treat both atrial and ventricular arrhythmias by pacing before delivering low- or high-energy shocks. A number of other techniques to terminate AF by pacing are also under investigation, but indications for pacing to find more tolerable devices a clinical trial value represents appropriate discharge energies over 1 J uncomfortable without sedation requiring a medical setting, and the mean cardioversion threshold is approximately 3 J, making such devices in their current form unacceptable for wide clinical use. Optimal devices would use atrial pacing to maintain sinus rhythm after cardioversion, and some patients require additional therapy to avoid frequent paroxysms of AF. Candidates for atrial cardioverters with infrequent episodes of poorly tolerated AF are typically also candidates for catheter ablation. As a result, implanted devices have limited utility, except for patients with LV dysfunction who are candidates for implantable ventricular defibrillators.8.4. Special Considerations8.4.1. Postoperative AFRECOMMENDATIONSCLASS IUnless contraindicated, treatment with an oral beta blocker to prevent postoperative AF is recommended for patients undergoing cardiac surgery. (Level of Evidence: A)Administration of AV nodal blocking agents is recommended to achieve rate control in patients who develop postoperative AF. (Level of Evidence: B)CLASS IIaPreoperative administration of amiodarone reduces the incidence of AF in patients undergoing cardiac surgery and represents appropriate prophylactic therapy for patients at high risk for postoperative AF. (Level of Evidence: A)It is reasonable to restore sinus rhythm by pharmacological cardioversion with ibutilide or direct-current cardioversion in patients who develop postoperative AF as advised for nonsurgical patients. (Level of Evidence: B)It is reasonable to administer antiarrhythmic medications in an attempt to maintain sinus rhythm in patients with recurrent or refractory postoperative AF, as recommended for other patients who develop AF. (Level of Evidence: B)It is reasonable to administer antithrombotic medication in patients who develop postoperative AF, as recommended for nonsurgical patients. (Level of Evidence: B)CLASS IIbProphylactic administration of sotalol may be considered for patients at risk of developing AF following cardiac surgery. (Level of Evidence: B)Although AF may occur after noncardiac surgery, the incidence of atrial arrhythmias including AF after open-heart surgery is between 20% and 50%,823–825 depending on definitions and methods of detection.8.4.1.1. Postoperative AFCorrelatesPostoperative AF usually occurs within 5 d of open-heart surgery, with a peak incidence on the second day. A number of studies have examined the predictors of AF. One study,826 length of hospital stay, and the effects of various prophylactic interventions aimed at reducing the incidence of AF.824,826–830 but many of these reflect earlier patient management. In an observational study of 4657 patients undergoing coronary artery bypass graft (CABG) surgery at 70 centers between 1996 and 2000, predictors of AF included age, a history of AF, COPD, valvular heart disease, atrial enlargement, perioperative HF, and withdrawal of either beta blocker or ACE inhibitor medications before or after surgery831 (Table 24). Many patients have none of these factors, however, and it is likely that the greater collagen content of the atria in older patients or other factors related to the biology of aging are responsible825 for the greater propensity of elderly patients to develop AF after cardiac surgery832 (Table 24). Other contributing factors are pericarditis826 and increased sympathetic tone. In a review of 8051 consecutive patients of those over age 85 y, compared with 6.2% of patients younger than 40 y. Among the extremely obese, the relative risk of postoperative AF was 2.39. "Off-pump" CABG was associated with 39% lower likelihood of developing AF than conventional on-pump surgery, and the risk of AF correlated with the duration of cardiopulmonary bypass.833 The arrhythmia is usually self-correcting, and sinus rhythm resumes in more than 90% of patients by 6 to 8 wk after surgery.832 a rate of spontaneous resolution higher than for other forms of AF. Patients with postoperative AF have a higher inpatient mortality than patients without this arrhythmia (4.7% vs. 2.1%) and longer hospital stay (median difference 2 d).831 In another study, postoperative AF was an independent predictor of long-term mortality (adjusted odds ratio [OR] 1.5, P less than 0.001 in retrospective cohort, and OR 3.4, P=0.0018 in a case-control analysis) over 4 to 5 y.834Table 24. Multivariate Predictors of Postoperative Atrial Arrhythmias in Patients Undergoing Myocardial Revascularization SurgeryAdvanced ageMale genderDigoxinPeripheral arterial diseaseChronic lung diseaseValvular heart diseaseLeft atrial enlargementPrevious cardiac surgeryDiscontinuation of beta-blocker medicationPreoperative atrial tachyarrhythmiasPericarditisElevated postoperative adrenergic tone8.4.1.2. Prevention of Postoperative AFA meta-analysis of 13 randomized trials of prophylactic antiarrhythmic therapy involving 1783 patients undergoing cardiac surgery in which effects on hospital length of stay were addressed found that while these consistently showed decreases in the incidence of AF, the effects on hospital stay were less concordant and amounted to a 1.0 plus or minus 0.2 d overall decrease in length of hospital stay (P less than 0.001).835 A systematic Cochrane database review found 58 studies with a total of 8565 participants in which interventions included amiodarone, beta blockers, sotalol, and pacing. By meta-analysis, the effect size for prevention of stroke by prophylactic treatment for AF was not statistically significant, nor was the effect on length or cost of hospital stay. Beta blockers had the greatest magnitude of effect across 28 trials (4074 patients).836 In a meta-analysis of 24 trials825 limited to patients with ejection fraction greater than 30% undergoing CABG, prophylactic administration of beta-blocker medication protected against supraventricular tachycardia (OR 0.28, 95% CI 0.21 to 0.36). In a meta-analysis of 27 trials including 3840 patients, sotalol (80 or 120 mg twice daily) was more effective in reducing postoperative AF than either other beta-blocker medication or placebo,829 but the results were not confirmed in another study,491 in which the difference between sotalol and beta-blocker treatment was small.When the prophylactic value of amiodarone, 600 mg per day, initiated at least 7 d preoperatively, was evaluated in 124 patients undergoing cardiac surgery, the incidence of AF was 25% in the treated group compared with 53% in patients randomized to placebo (P=0.003).837 This approach is impractical unless patients are identified and treatment started at least 1 wk before surgery. The Amiodarone in Coronary Heart (ARCH) trial involving 300 patients found that postoperative intravenous administration of amiodarone (1 g daily for 2 d) reduced the incidence of postoperative AF from 47% to 35% compared with placebo (P=0.01). This approach is impractical higher overall incidence of postoperative AF and less pronounced prophylactic effect than in other studies may have been partly related to less-frequent use of beta blockers.838 More convincing evidence of the efficacy of amiodarone for prevention of AF in patients undergoing cardiac surgery comes from the Prophylactic Oral Amiodarone for the Prevention of Arrhythmias that Begin Early after Revascularization, Valve Replacement, or Repair (PAPABEAR) trial, in which a 13-d perioperative course of oral amiodarone (10 mg/kg daily beginning 6 d before and continuing for 6 d after surgery) halved the incidence of postoperative atrial tachyarrhythmias, including AF patients undergoing CABG, valve replacement, or valve repair surgery with or without CABG surgery.839 Although this potent prophylactic regimen may obviate this need, concurrently, rates of beta-blocker therapy withdrawal were not reported; hence, differential withdrawal of beta blockers from nonusers in the placebo group may have exaggerated the apparent effect of amiodarone.840Pretreatment with either digoxin or verapamil does not reliably prevent postoperative AF.825,841,842 Results with procainamide have been inconsistent, and this drug is not widely used for prevention of postoperative AF.843 One report suggested that n-3 polyunsaturated fatty acids may be effective for prevention of AF in patients undergoing CABG surgery.844There is limited evidence that single-chamber and biatrial overdrive pacing prevents postoperative AF. In a randomized trial involving 132 patients undergoing CABG, postoperative biatrial pacing significantly reduced the incidence of AF in the biatrial pacing group by 12.5% compared with the other 3 groups (36% LA pacing, 33% RA pacing, and 42% without pacing; P

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