Atrial Fibrillation and Heart Failure
Treatment Considerations for a Dual Epidemic

Elad Anter, MD; Mariell Jessup, MD; David J. Callans, MD

Atrial fibrillation (AF) and heart failure have emerged as new cardiovascular epidemics over the last decade. Heart failure affects ≈5 million patients in the United States, and >550,000 patients are diagnosed with new heart failure each year. Although the incidence of heart failure remained stable over the past 50 years, the prevalence of heart failure in the United States has steadily increased. Heart failure is the primary reason for 12 to 15 million office visits and 6.5 million hospital days yearly. From 1990 to 1999, the annual number of hospitalizations increased from ≈800,000 to >1 million for heart failure as a primary diagnosis and from 2.4 to 3.6 million for heart failure as a primary or secondary diagnosis. The steadily increasing number of patients with heart failure is due partially to better treatment and “salvage” of patients with acute myocardial infarctions earlier in life. As a consequence, heart failure carries a significant economic burden on our society because it is the most common discharge diagnosis and because more Medicare dollars are spent for the diagnosis and treatment of heart failure than for any other diagnosis. In 2007, the American Heart Association estimated that $33 billion was spent on heart failure alone.

AF is the most common arrhythmia in clinical practice, accounting for approximately one third of admissions resulting from cardiac rhythm disturbances. An estimated 2.3 million people in North America have AF. During the last 20 years, hospital admissions for AF have increased by 66% for a number of reasons, including the aging of the population, the rising prevalence of chronic heart disease, and more frequent diagnosis as a result of increased monitoring. The recent Anticoagulation and Risk Factors in Atrial Fibrillation (ATRIA) study projected that the prevalence of AF will increase 2.5-fold by the year 2050, affecting nearly 5.6 million Americans, an estimate based on the growing proportion of elderly individuals in the United States. The predicted future prevalence of AF was even greater in a community-based study by Miyasaka and colleagues. They observed that the age-adjusted incidence of AF increased by 12.6% over the period from 1980 to 2000. Assuming the rate of increase in incidence remains unabated and assuming that these incidence rates can be applied to the entire US population, the projected number of persons with AF in the United States could reach 15.9 million by 2050.

The Association Between AF and Heart Failure

The association between AF and heart failure was appreciated almost a century ago; Paul Dudley White noted, “Since auricular fibrillation so often complicates very serious heart disease, its occurrence may precipitate heart failure or even death, unless successful therapy is quickly instituted.” The reported prevalence of AF in modern heart failure series ranges from 13% to 27%. In the Framingham Heart Study, 1470 participants developed either new AF or heart failure between the years 1948 and 1995. Among these participants, a total of 383 individuals (26%) developed both AF and heart failure. Moreover, the prevalence of AF in patients with heart failure increased in parallel with the severity of the disease, ranging from 5% in patients with mild to 10% to 26% among patients with moderate up to 50% in patients with severe heart failure.

Although the causative relationship between the 2 conditions has not been fully determined, their coexistence can be explained to some degree by the presence of common risk factors such as age, hypertension, diabetes, and obesity, as well as valvular, ischemic, and nonischemic structural heart disease. These factors are associated with myocardial cellular and extracellular alterations, electrophysiological and neurohormonal changes that combine to create an environment that predisposes the heart to both myocardial failure and AF.

AF and Heart Failure: A Cause or a Consequence?
The pathophysiological relationship between AF and heart failure has been only partially elucidated and has therefore remained a subject of vibrant research. AF may facilitate the development or progression of heart failure in several ways (Figure 1). The increase in resting heart rate and the exaggerated heart rate response to exercise result in shorter diastolic filling time, leading to a reduction in cardiac output. This is further affected by the irregularity of the ventricular response: The reduction in left ventricular (LV) filling during short cycles is not completely compensated for by increased filling during longer cycles. The loss of effective atrial contractile function also contributes, even more importantly.
in patients with diastolic dysfunction. In a prospective study of 344 patients with heart failure and sinus rhythm, the onset of AF was associated with highly significant worsening of the New York Heart Association (NYHA) functional class, peak oxygen consumption, and cardiac index, along with increased mitral and tricuspid regurgitation. Restoration of sinus rhythm improves cardiac output, exercise capacity, and maximal oxygen consumption.

AF is the most common cause of tachycardia-induced cardiomyopathy (Figure 2). The first case of tachycardia-induced cardiomyopathy was reported in 1913 in a young man with AF and a rapid ventricular rate who developed unexplained LV dilatation and heart failure. In 1937, a similar case was reported in which heart failure was reversed after restoration of sinus rhythm. Whipple et al provided the first experimental model for this condition, demonstrating that rapid and protracted atrial pacing led to low-output heart failure. Subsequent investigations have confirmed that persistent tachycardias can cause heart failure and that elimination of these arrhythmias reverses the hemodynamic and clinical manifestations associated with this syndrome. The mechanisms responsible for tachycardia-induced cardiomyopathy have not been fully elucidated; however, experiments in animal models suggest that myocardial ischemia, myocardial energy depletion, and abnormalities in calcium regulation all may contribute. The incidence of tachycardia-induced cardiomyopathy is seen in 25% to 50% of those with LV dysfunction and AF. The detrimental effects of AF on heart failure also may derive from the antiarrhythmic therapy itself. Some antiarrhythmic drugs have negative inotropic effects, whereas others are associated with an increased proarrhythmic risk, especially in patients with structural heart disease.

Similarly, heart failure can increase the risk for the development of AF in several ways, including elevation of cardiac filling pressures, dysregulation of intracellular calcium, and autonomic and neuroendocrine dysfunction (Figure 1). Atrial stretch results in activation of stretch-activated ionic currents, leading to increased dispersion of refractoriness and alterations in anisotropic and conduction properties, facilitating AF. Inhibition of these stretch-activated currents by gadolinium can reduce the susceptibility to AF in response to atrial pressure overload. Heart failure has been associated with increased interstitial fibrosis. This increase in fibrosis can lead to abnormal conduction through the atria, creating a substrate for AF in animal models. Dysregulation of intracellular calcium, an important feature in the pathophysiology of heart failure, also has been found to be associated with AF. The key regulators of intracellular calcium metabolism, the ryanodine receptor and the sarcoplasmic reticulum Ca2+/ATPase, are downregulated in AF. In addition, heart failure is characterized by neurohormonal activation, with elevated concentrations of catecholamine and angiotensin II; the degree of neurohormonal activation correlates with the severity of heart failure and has become a target of pharmacological inhibition. Interestingly, neurohormonal activation...
also promotes structural remodeling and atrial fibrosis, thus altering atrial conduction properties and promoting AF.37,42

**AF: Independent Risk Factor or a Marker of Advanced Disease?**

The prognostic significance of AF in patients with heart failure remains controversial because no consensus exists that AF is an independent risk factor of adverse outcome (the Table).13,43–45b In the Framingham Heart Study, AF was associated with twice the cardiovascular mortality compared with sinus rhythm. However, the independent contribution of AF to mortality was not assessed.46 In the Vascular Disease Heart Failure Trial (V-HeFT), the presence of AF was not associated with a worse outcome in 1427 patients with mild to moderate heart failure.13 Two other relatively small studies also revealed no independent prognostic significance of AF in patients with heart failure.14,47 The results of these studies contrast with other, more recent, large heart failure trials. In a retrospective analysis of the Studies of Left Ventricular Dysfunction (SOLVD) trial, which enrolled 6500 patients with LV ejection fraction (LVEF) <35%, baseline AF was an independent predictor for all-cause mortality, progressive pump failure, and the combined end point of death or hospitalization for heart failure.48 In the SOLVD registry data, the odds ratio for total mortality among heart failure patients with AF compared with patients in sinus rhythm was 1.81 (P<0.0001).49 In the Valsartan in Acute Myocardial Infarction (VALIANT) trial of 14 703 patients with acute myocardial infarction complicated by heart failure, AF also served as a negative prognostic marker in patients with better cardiac function (LVEF >35%). In the Trandolapril Cardiac Evaluation (TRACE) study, Pedersen et al50 found that the presence of AF in outpatients with heart failure also was associated with increased morbidity and mortality and that AF was a stronger predictor of adverse outcome in patients with better cardiac function (LVEF >35%). In these trials, it appears that AF serves as a negative prognostic marker in patients with systolic heart failure, and the independent effect of AF on mortality is inversely related to the severity of heart failure.

Although multicenter studies in patients with heart failure have provided valuable data on the importance of AF in this setting, it is critical to realize that AF was not the focus of these studies and that the data quality with respect to the presence of AF has not been adjudicated. In most of these trials, monitoring for the onset of AF or recurrence, in the absence of hospitalization, consists of ECGs at the study onset and scheduled visits. This approach lacks the power to detail the variety of ways AF affects patients.

Even taking this limitation into account, it is interesting that many studies have found that new-onset AF carries a particularly grave prognosis in patients with heart failure. Ahmed and Perry54 found that among 944 elderly patients hospitalized with heart failure, the onset of new AF carried a significantly higher risk for death compared with patients with no AF or those with chronic AF (hazard ratio, 1.41; 95% confidence interval, 1.08 to 1.83). Over 80% of patients hospitalized with heart failure and found to have new-onset AF died within 4 years of discharge compared with only 61% to 66% in those without AF or with persistent AF. In a 21-year community-based cohort study of patients with sinus rhythm patients. Moreover, AF seemed to be a stronger predictor of negative outcome in the subset of patients with mild to moderate heart failure compared with patients with severe heart failure, in whom the contribution of AF to further impairment in survival was limited. Similarly, Corell et al52 found that the presence of AF in outpatients with heart failure also was associated with increased morbidity and mortality and that AF was a stronger predictor of adverse outcome in patients with better cardiac function (LVEF >35%). From these trials, it appears that AF serves as a negative prognostic marker in patients with systolic heart failure, and the independent effect of AF on mortality is inversely related to the severity of heart failure.

### Table. Prognostic Significance of AF in Patients With Heart Failure

<table>
<thead>
<tr>
<th>Author/Substudy</th>
<th>Year</th>
<th>NYHA Class</th>
<th>Patients, n</th>
<th>AF, %</th>
<th>Follow-Up, y</th>
<th>Patients in SR, n</th>
<th>Patients With AF, n</th>
<th>P</th>
<th>Predictor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middlekauff et al12</td>
<td>1991</td>
<td>III–IV</td>
<td>395</td>
<td>19</td>
<td>1.5</td>
<td>29</td>
<td>48</td>
<td>0.0013</td>
<td>Yes</td>
</tr>
<tr>
<td>Carson et al13</td>
<td>1993</td>
<td>II–III</td>
<td>632</td>
<td>15</td>
<td>2.5</td>
<td>64</td>
<td>54</td>
<td>0.86</td>
<td>No</td>
</tr>
<tr>
<td>V-HeFT I</td>
<td>1993</td>
<td>II–III</td>
<td>795</td>
<td>13</td>
<td>2.0</td>
<td>52</td>
<td>46</td>
<td>0.68</td>
<td>No</td>
</tr>
<tr>
<td>Dries et al50/SOLVD</td>
<td>1998</td>
<td>I–IV</td>
<td>6517</td>
<td>6</td>
<td>2.8</td>
<td>23</td>
<td>34</td>
<td>&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>Mahoney et al14</td>
<td>1999</td>
<td>III–IV</td>
<td>234</td>
<td>27</td>
<td>1.1</td>
<td>16</td>
<td>23</td>
<td>0.21</td>
<td>No</td>
</tr>
<tr>
<td>Middlekauff et al12</td>
<td>1985–1989</td>
<td>III–IV</td>
<td>359</td>
<td>20</td>
<td>2.0</td>
<td>45</td>
<td>61</td>
<td>0.002</td>
<td>Yes</td>
</tr>
<tr>
<td>Mathew/DIG46a</td>
<td>1990–1993</td>
<td>III–IV</td>
<td>391</td>
<td>24</td>
<td>2.0</td>
<td>25</td>
<td>34</td>
<td>0.09</td>
<td>No</td>
</tr>
<tr>
<td>Crijns/PRIME II33b</td>
<td>2000</td>
<td>I–IV</td>
<td>7788</td>
<td>11</td>
<td>3.0</td>
<td>32</td>
<td>43</td>
<td>0.0001</td>
<td>Yes</td>
</tr>
<tr>
<td>Kober/VALIANT</td>
<td>2006</td>
<td>I–IV</td>
<td>14703</td>
<td>15</td>
<td>3.0</td>
<td>20</td>
<td>37</td>
<td>&lt;0.0001</td>
<td>Yes</td>
</tr>
<tr>
<td>Swedberg et al33/COMET</td>
<td>2005</td>
<td>II–IV</td>
<td>3029</td>
<td>20</td>
<td>5.0</td>
<td>37</td>
<td>42</td>
<td>NS*</td>
<td>No*</td>
</tr>
</tbody>
</table>

SR indicates sinus rhythm; DIG, Digitalis Investigation Group; PRIME II, Prospective Randomized study of Ibopamine on Mortality and Efficacy.

*After adjustment for important prognostic variables.
newly diagnosed AF, the mortality risk was substantially higher within the first 4 months, with an hazard ratio of 9.62 (95% confidence interval, 8.93 to 10.32) compared with the hazard ratio of 1.66 (95% confidence interval, 1.59 to 1.73) thereafter (Figure 3). In an analysis of COMET, new-onset AF, but not baseline AF, remained an independent predictor of all-cause mortality. Development of new AF was associated with increased mortality in the Framingham Heart Study as well. Prospectively studied patients with mild heart failure in sinus rhythm and found that the onset of AF was associated with a clinical and hemodynamic deterioration, predisposition to systemic thromboembolism, and overall poorer prognosis. The association between new-onset AF and heart failure progression is not evidence for a causative relationship and may simply be a marker for disease progression. Nonetheless, few plausible mechanisms may explain how new development of AF can lead to clinical and hemodynamic deterioration. First, the adequacy of rate control both at rest and at low-level exercise, which may allow a significant metabolic demand on the myocardial tissue until compensatory metabolic pathways are upregulated.

### Therapeutic Considerations

#### Rate or Rhythm Control

AF with rapid ventricular response can lead to systolic heart failure, whereas restoration of sinus rhythm or appropriate rate control can reverse this process. Controversy still exists as to whether patients with heart failure respond better to rhythm restoration or ventricular rate control, commonly referred to as the issue of rhythm or rate control. The AF Follow-Up Investigation of Rhythm Management (AFFIRM) and the Rate Control Versus Electrical Cardioversion for Persistent AF (RACE) found that a rhythm control strategy provided no benefit and actually showed a trend toward harm in the general population of patients compared with rate control. Subsequent analyses have demonstrated a powerful benefit (hazard ratio, 0.5) of actually maintaining sinus rhythm as opposed to assignment to the rhythm control strategy, which seemed to be completely offset by the hazard of antiarrhythmic drug therapy (hazard ratio, 1.49). This response might be confounding because patients who were able to maintain sinus rhythm in AFFIRM may just be healthier than those who did not. Three other prospective randomized trials have compared rate and rhythm control. These studies include the How to Treat Chronic Atrial Fibrillation (HOT CAFE), Strategies of Treatment of Atrial Fibrillation (STAF), and Pharmacological Intervention in Atrial Fibrillation (PIAF) clinical trials. Each had similar results, showing equivalent outcomes in both arms. However, only 23% to 64% of patients assigned to rhythm control remained in sinus rhythm.

Nevertheless, extrapolation from these studies to patients with heart failure should be done with caution. These studies included older patients or young patients with increased risk for stroke who were sufficiently tolerant of AF to be randomized. LV function was normal in 76% of AFFIRM patients, and only 9% had an NYHA functional class of II or greater. A separate large study of >1000 patients with heart failure and AF similarly demonstrated no benefit on overall mortality of rhythm compared with rate control. The recently published Atrial Fibrillation and Congestive Heart Failure (AF-CHF) trial was the first prospective randomized study to examine the effect of rate versus rhythm control in a heart failure population. A total of 1376 patients with AF and systolic heart failure (mean LVEF, 27%) were randomized to rhythm control (typically with amiodarone) versus rate control. After a mean follow-up of 3 years, the investigators found that rhythm control did not improve mortality, hospitalization resulting from heart failure exacerbation, or stroke compared with rate control. This study therefore extends the findings of the AFFIRM trial to patients with heart failure, in whom the theoretical benefit of rhythm control would seem to be higher. Clinicians should be cautious in their acceptance of the AF-CHF trial as the final and definitive study about the role of rate or rhythm control in patients with heart failure. First, patients assigned to rate control were considered to be stable if they achieved adequate rate control both at rest and at low-level exercise, which may not necessarily be the case in “real-life” patients. Second, the benefit of sinus rhythm could have been counterbalanced by the harm of antiarrhythmic medications in a fashion similar to the AFFIRM study. Third, although the prevalence of sinus rhythm in the group assigned to rhythm control was as high as 80%, the actual percentage of patients free of AF after randomization may have been lower, reflecting a more
tricular ectopy after myocardial infarction. This study showed that therapy with either flecainide or encainide was associated with increased mortality.72,73 The applicability of the CAST results to other populations (eg, those with chronic heart failure and no active ischemia) or other class IC antiarrhythmic drugs such as propafenone is uncertain. However, currently, it is prudent to consider any class IC antiarrhythmic to have a significant risk in patients with structural heart disease.

The cornerstone of antiarrhythmic therapy in patients with heart failure is amiodarone, sotalol, and dofetilide. Amiodarone is among the most effective antiarrhythmic agents for the suppression of AF. Amiodarone is a class III agent (potassium channel blocker) with some overlap functional activity of class I agents such as β-blockers and calcium channel blockers. Amiodarone appears to be safe and effective in patients with heart failure.74 Despite its effectiveness, the use of amiodarone in patients with heart failure is associated with increased risk for symptomatic bradycardia requiring implantation of permanent pacemaker.75

Dofetilide, a newer class III antiarrhythmic agent, also is commonly used to suppress AF. In the Danish Investigations of Arrhythmia and Mortality on Dofetilide (DIAMOND) congestive heart failure substudy, dofetilide was significantly more effective than placebo in restoring and maintaining sinus rhythm in patients with AF and heart failure.76 In addition, dofetilide therapy was associated with reduced hospitalizations for heart failure. Therapy with dofetilide is usually initiated in the hospital with close monitoring of the QT interval and dosage adjustments in patients with impaired renal function. Nevertheless, even with careful monitoring, therapy with dofetilide has been associated with increased risk for torsades de pointes, particularly in elderly patients with heart failure.

Other, nonantiarrhythmic drug therapy has demonstrated effectiveness in reducing the incidence and recurrent rates of AF in the general population and in patients with heart failure. Inhibition of the renin-angiotensin-aldosterone system attenuates atrial electric remodeling and fibrosis, processes that are associated with an increased risk for development of AF.77–80 Clinical studies have demonstrated that renin-angiotensin-aldosterone system blockade with angiotensin receptor-1 blockers can reduce the incidence and recurrence rates of AF in patients with heart failure.81,82 In the Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity (CHARM) study, treatment with candesartan reduced the incidence of AF in a large, broadly based population with heart failure.

Therapy with β-blockers also was associated with reduced risk for AF. In a meta-analysis of 7 randomized, placebo-controlled trials including 11 952 patients with heart failure already taking angiotensin-converting enzyme inhibitors, β-blockers significantly reduced the incidence of new AF from 39 to 28 per 1000 patient-years (relative risk reduction, 27%).83

Recent studies suggest that 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase inhibitors (statin) therapy may reduce the incidence and recurrence of AF in patients with heart failure.84,85 A recent meta-analysis of randomized trials with statins showed that their use was
associated with a significant decreased risk of AF compared with control subjects (odds ratio, 0.39; 95% confidence interval, 0.18 to 0.85, p = 0.02). Moreover, the benefit of statin therapy seemed more marked in secondary prevention of AF (odds ratio, 0.33) than for new-onset or postoperative AF (odds ratio, 0.60).86

Ablation and Pacemaker Therapy
In patients with symptomatic AF and rapid ventricular response refractory to pharmacological therapy, radiofrequency atrioventricular (AV) nodal ablation with subsequent pacemaker placement can improve cardiac performance. Manolis et al87 showed that in 46 patients with atrial tachyarhythmias and rapid ventricular response refractory to medical therapy who underwent AV nodal ablation with placement of a permanent pacemaker, the LVEF improved from a mean of 42±16% to a mean of 50±14% after a 2-year follow-up. In the subgroup of patients with heart failure, the degree of improvement was even greater (32±9% to 48±8%). Moreover, the NYHA functional class improved from 2.7±0.6 to 1.4±0.8 (P<0.001).

However, long-term outcomes of the “ablate and pace” strategy have been less favorable. In a study of 71 elderly patients with pharmacologically refractory AF assigned to either AV nodal ablation with pacing or AF ablation, AV nodal ablation with pacing was associated with a higher incidence of new heart failure compared with ablation of the AF after 5 years of follow-up (53% versus 24%). AV node ablation with pacing resulted in a significantly lower LVEF (44±8% versus 51±10%) and a higher NYHA functional class (1.7±0.9 versus 1.4±0.7) compared with the group assigned to AF ablation.88

A large body of evidence has emerged recently that underscores the harmful effects of long-term right ventricular pacing. LV dyssynchrony imposed by right ventricular pacing can lead to LV remodeling with dilatation and decreases in LVEF.89 Mechanical ventricular dyssynchrony is an established contributor to heart failure, and cardiac resynchronization therapy (CRT) has emerged as an effective device-based therapy to improve symptoms and mortality in patients.90 This therapy also has proved to be effective in patients with heart failure and AF, although patients with AF show a milder degree of improvement with CRT compared with patients in sinus rhythm.91

The clinical efficacy of CRT also was assessed in patients with heart failure and AF with slow ventricular rate necessitating permanent ventricular pacing.92 Thirty-seven patients with NYHA class III heart failure underwent implantation of a biventricular pacemaker. This single-blind, randomized, controlled, crossover study compared clinical parameters during two 3-month treatment periods of conventional right ventricular and biventricular pacing. It showed that biventricular pacing improved peak oxygen uptake and exercise tolerance and reduced the number of hospitalizations for heart failure. An important issue remains whether CRT in patients with AF should be accompanied by AV nodal ablation to avoid inhibition of therapy by rapid intrinsic AV nodal conduction. A recent study compared the efficacy of CRT in patients with AF who underwent AV nodal ablation and patients in whom rate control was achieved pharmacologically. This study showed that patients who underwent AV nodal ablation with CRT achieved significantly better symptomatic relief with improvement in their LV function, a benefit that was maintained for up to 4 years.93 The effect of CRT on the incidence of new AF is still controversial. CRT can promote reverse remodeling of the left ventricle, reduce the degree of mitral regurgitation and left atrial stretching, and thus theoretically reduce the incidence of AF. However, the Cardiac Resynchronization in Heart Failure (CARE-HF) study did not demonstrate a reduction in the incidence of AF among patients randomized to CRT.94

AF Ablation
Although recent studies, including RACE, AFFIRM, and AF-CHF, suggest an equivalent outcome for pharmacological rhythm or rate control, new evidence from the AFFIRM investigators showed that the presence of sinus rhythm was associated with significantly improved survival.60 The effect of sinus rhythm on patients with heart failure remains to be determined, and we hope that further analysis from AF-CHF will help to clarify this question. It is conceivable, however, that benefits of rhythm control are counterbalanced by the lack of effective antiarrhythmic agents, coupled with their significant adverse effects. Moreover, sinus rhythm was maintained in only 63% of patients in the rhythm control arm of AFFIRM at 5 years. This highlights the difficulty of rhythm control with currently available antiarrhythmic agents and the need for effective therapy to maintain sinus rhythm while minimizing toxicity.98

One of the promising therapeutic options for AF may therefore be a curative catheter ablation. The observation that AF could be initiated by ectopic beats originating in the pulmonary veins sparked new interest in catheter-based techniques to isolate the pulmonary veins from the surrounding left atrium (Figure 4).95,96 Catheter ablation of AF also has been shown to be effective in patients with heart failure (Figure 5).97–100 In a prospective study of 58 patients with systolic heart failure, AF ablation resulted in significant improvement in LV function, exercise capacity, symptoms, and quality of life. After a mean follow-up of 1 year, 78% of the patients maintained sinus rhythm.97 This important study demonstrated that curative ablation for AF offers the unique opportunity to retain the benefits of rhythm control without the detrimental effects of antiarrhythmic drugs. More recently, the Pulmonary-Vein Isolation for AF in Patients With Heart Failure (PABA-CHF)55 demonstrated that a strategy of pulmonary vein isolation was superior to AV node ablation combined with biventricular pacing in patients with heart failure. Patients randomized to pulmonary vein isolation had a significantly higher mean LVEF (35% versus 28%), a longer distance on the walk test (340 versus 297 m), and a higher quality-of-life score.

Although AF ablation is a promising therapeutic intervention in patients with heart failure, several questions remain to be answered before this procedure is ready for prime time. First, improvement in LV function after AF ablation was more significant in patients who were inadequately rate controlled, suggesting that improvement was due partially to eliminating tachycardia-induced myopathy. The effect of AF
ablation in patients with well-controlled heart rates requires further studies. Second, ablative procedures are associated with new scar formation, paradoxically augmenting interstitial fibrosis. This effect can potentially perpetuate the progression of AF and therefore requires further investigation. Finally, the cost-effectiveness of this procedure in patients with heart failure has not yet been studied.

Catheter ablation of AF is evolving rapidly, and newer techniques to integrate electroanatomic mapping with computed tomographic and magnetic resonance imaging into the ablation procedure will likely lead to further improvements in the efficacy and safety of this procedure.

Conclusions

AF and heart failure have emerged as being among the most common cardiac disorders afflicting our society. They often occur together, and their combination is associated with increased morbidity and mortality compared with each disorder alone. AF and heart failure share common mechanisms and treatment strategies; consequently, therapies directed toward heart failure may protect the heart against the occurrence of AF. Although restoration of sinus rhythm in patients with heart failure may offer hemodynamic and clinical benefits, recent clinical trials have failed to demonstrate the clinical advantage of sinus rhythm over optimal rate control. The deleterious effects of currently available antiarrhythmic drugs, coupled with their low efficacy, may blunt the potential benefit of sinus restoration. Recent advances in catheter-based ablative therapies for AF have been demonstrated to be effective in well-selected patients with heart failure, resulting in significant improvements in cardiac function, symptoms, and quality of life.

It will be years before sufficient data are generated to specifically guide practice when these 2 common disease processes intersect. Until that time, several concepts guide our care of these patients. It is clear that optimal pharmacological therapy for heart failure has a beneficial impact on the progression of AF. The impact of new AF in the setting of heart failure can be dramatic in individual patients, and it is possible that aggressive therapy to restore sinus rhythm during this window of opportunity may have lasting benefit. We typically recognize these patients by their relative youth (raising the possibility that tachycardia-related myopathy may be a sole cause of the recognized LV dysfunction) or the presence of severe symptoms referable to AF. In patients with new-onset and persistent AF, a test of cardioversion may be helpful to investigate whether sinus rhythm improves their symptoms of heart failure. When it is demonstrated to be important, maintenance of sinus rhythm by whatever means necessary seems reasonable in individual patients.

Disclosures

Dr Callans has received honoraria from Biosense Webster, St. Jude Medical, Boston Scientific, and Sanofi-Aventis. The other authors report no disclosures.
References


**Key Words:** arrhythmia ■ atrial fibrillation ■ heart failure
Atrial Fibrillation and Heart Failure: Treatment Considerations for a Dual Epidemic
Elad Anter, Mariell Jessup and David J. Callans

Circulation. 2009;119:2516-2525
doi: 10.1161/CIRCULATIONAHA.108.821306
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2009 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/119/18/2516

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org/subscriptions/