A number of important studies were reported in 2006 in the area of cardiac electrophysiology. It is obviously impossible to discuss all important contributions, hence we emphasize those that we feel are most apt to break new ground relative to basic observations or clinical care.

### Molecular-Genetic Arrhythmia Syndromes

A number of studies of genetic and molecular effects on arrhythmogenesis are noteworthy.

**Long QT syndrome (LQTS).** Despite the great advances in our understanding of the role of channel disorders as causes for the LQTS, at present in at least 25% of these patients no genetic defect has been established. The identified mutant genes are responsible for coding either the alpha (membrane spanning) or rarely the beta subunits of ion channels. A very rare cause of the LQTS, for example, is caused by an abnormality in ANK2, which encodes ankyrin-B, a protein thought to be involved in the trafficking of Na+ and Ca++ channels to the cell membrane. It is the first example of a nonchannel protein disorder that affects channel function. The proteins that make up the ion channel are formed within the endoplasmic reticulum and moved (or trafficked) to the appropriate location in the myocardial cell membrane. Hence a channel disorder might be manifest not because of any intrinsic defect in the makeup of a specific ion channel, but because of an inability to transport the protein to the appropriate site on the membrane.

**Caveolin-3 mutations and LQTS.** More recently, attention has been focused on the caveolae, which are microdomains found in the sarcolemma and serve both as scaffolding for ion channels as well as in signal transduction (beta-2 adrenergic pathway).

In a recent very important study, Vatta et al. (1) analyzed blood from 905 unrelated patients who underwent genetic testing for LQTS. They also showed that caveolin-3 colocalizes with the voltage-gated Na+ channel (h Na1.5) in human myocardium and identified 4 novel mutations in CAV-3, which encodes caveolin-3 protein.

The CAV-3 mutations were associated with a 2- to 3-fold increase in late sodium current. The investigators conclude that the CAV-3 mutants simulated the LQT3 abnormality, which has been associated with mutations in the SCN5A gene (which encodes the Na+ channel). The electrocardiogram (ECG) shown in their report, however, differed from classic examples of patients with LQT3. The importance of these observations likely extends beyond the described effects on the late Na+ current because a number of cardiac ion channels have been found to localize in the caveolae. This opens up the potential for further exploring the role of nonchannel proteins as causes for disturbances in ion channel function.

**Brugada syndrome.** There were several important new findings for patients with Brugada syndrome. This syndrome is characterized by a form of right bundle branch pattern with ST elevation and coved T waves in precordial leads V1 to V3 (type I Brugada pattern) (2) (Fig. 1). This pattern may be associated with lethal ventricular arrhythmias. The type II Brugada pattern shows a saddleback configuration between the end of the QRS and the T-wave. The saddleback pattern (type II) is thought to be less specific for this syndrome.

Current evidence suggests that this syndrome is caused by a channelopathy, and approximately 20% to 30% of individuals are found to have mutations in the gene that encodes the alpha subunit of the Na+ channel (SCN5A) (3). Our current understanding is that the Brugada pattern is caused by abnormalities in the balance of ionic current flowing during phase 1 of the action potential. The currents that are active during this phase involve the inward Na+ and Ca+ + currents as opposed to the outward K+ currents, largely Ito (transient outward K+ current). Predominance of the inward current in the epicardium would produce a gradient from endocardium to epicardium resulting in a prominent notch or J-wave (4,5).

The right ventricular (RV) epicardium harbors a more intensive Ito current than the left ventricular myocardium. Hence, intensification of the outward currents or loss of the inward currents produce the J-wave and ST-segment elevation in lead V1/V2 (Fig. 1). The Brugada changes occur largely in the early precordial leads because this overlies the RV, which harbors a more intense Ito current compared with the left ventricle.
Arrhythmias are thought to be generated by phase 2 re-entry, a process initiated by voltage gradients from cells at different levels of depolarization (Fig 2). For example, cells losing the action potential dome will be strongly negative (polarized) compared with more depolarized neighboring cells (Fig. 2). It is thought that premature ventricular complexes caused by phase 2 re-entry serve as a trigger for rapid polymorphic ventricular arrhythmias.

Calcium channel abnormalities and the Brugada syndrome. A very important new finding relates to the discovery that mutant genes that encode for either the alpha (CACNA1C) or the beta (CACNB2) subunit of the Ca++ channel may result in a Brugada-like pattern (ST-segment elevation in V1 to V3) (6). These genes have been shown to result in significant loss of function of the Ca++ channel because of separate genetic mutants encoding different subunits of the L-type Ca++ channel.

In addition, these mutant genes have been associated with serious cardiac arrhythmias, and patients also tend to show a slightly shorter than normal QT interval. These findings are important support both of the channelopathy concept relating to the Brugada pattern as well as of the pathogenesis of the cardiac rhythm disturbances. One previously described abnormality in the L-type Ca++ channel was described as the Timothy syndrome, which produces a mutation involving gain of function of the Ca++ channel via impaired inactivation of the channel.

Potential drug remedy for the Brugada syndrome. Another important observation from the Antzelevitch group (7) relates to use of agents to prevent the Brugada pattern and arrhythmias in simulated Brugada-type RV perfused wedge preparations. They found that dimethyl lithospermate B (dmLSB), which is an extract of Danshen, a Chinese herbal remedy, eliminated the Brugada pattern in 3 separate experimental models of the syndrome. They showed that this agent augmented Na+ current active during phase 1 of the action potential. This agent is shown to abolish the loss of the dome of the action potential, hence eliminating phase 2 re-entry as well as differences in transmural repolarization. In addition, they found that dmLSB did not prolong action potential duration or provoke arrhythmias. These observations add to a growing list of drugs that might ultimately be useful in treating the syndrome (4). Such drugs include quinidine, isoproterenol,
phosphodiesterase inhibitors, and tedisamil. Drugs such as quinidine and tedisamil block \( I_{to} \) current, whereas the other drugs serve to augment \( \text{Na}^{+} \) and \( \text{Ca}^{++} \) currents during phase I of the action potential.

**New clinical features of the Brugada syndrome.** In addition, several important clinical features of the Brugada syndrome were analyzed. The last consensus conference (8) focused on management of patients with the Brugada syndrome and emphasized risk factors for sudden death in terms of the spontaneous Brugada pattern (type I, right bundle branch block, and coved ST/T abnormalities) (Fig. 1), history of sudden death in the family, as well as symptoms of syncope or aborted sudden death. In a recent important prospective study of patients with the Brugada syndrome, Veltmann et al. (9) pointed out the frequency of ECG changes between the different patterns in patients who had serial ECG recordings. Among 43 patients, only 1 showed a consistent coved pattern, 15 patients initially showed a coved pattern, and 14 showed nondiagnostic (either saddleback pattern or nonspecific changes). On the other hand, of 28 patients who initially showed a nondiagnostic pattern, 8 developed a typical (type I) coved pattern on follow-up. This important study emphasizes that if we are going to use the type I ECG phenotype to assess risk, multiple ECG recordings are critical.

**Genetic basis for sinus node disease.** Most of the genetic studies have focused on mutations associated with high risk for sudden cardiac death. However, over the past year several studies have described the importance of genetic mutations in nonfatal arrhythmic syndromes. For example, Milanesi et al. (10) described the genetic abnormality and pathogenetic mechanism explaining familial sinus bradycardia. They found a large family cohort with sinus bradycardia with a genetic abnormality encoding \( HCN4 \) gene. This gene encodes the pacemaker current (If) that determines the slope of diastolic depolarization in sinus node cells (11).
If channels are encoded by the hyperpolarization-activated cyclic nucleotide (HCN) gated channel, and HCN4 is highly expressed in the mammalian sinus node.

Kinetic studies of the mutant channels showed that these channels were activated at more negative voltages and deactivated faster than wild-type channels. Of interest was the finding that the mutant channels were not affected by cyclic adenosine monophosphate activation of the channel. The investigators found that these changes mimic those of low-dose acetylcholine. These important observations likely will teach us more about the pathogenesis of the sick sinus syndrome, which is the most common reason for pacemaker insertion in the U.S.

Role of somatic mutations in patients with atrial fibrillation (AF). Another potentially important study was reported by Gollob et al. (12) and focused on the role of somatic mutations in the pathogenesis of AF. Connexin 40 is expressed selectively in atrial myocytes and is encoded by the GJA5 gene. In this study, a total of 15 patients with AF were studied. The GJA5 gene was sequenced from deoxyribonucleic acid both in cardiac tissue as well as from lymphocytes in peripheral blood. They found 4 missense mutations, 3 from cardiac tissue alone (somatic) and 1 from both cardiac tissue as well as lymphocytes (germ line). The mutant genes were studied to assess protein transport and electrical coupling between cells. The mutant proteins were found to impair intracellular transport or reduce intercellular electrical coupling. This fascinating observation raises a host of issues. Could the somatic mutation be secondary to AF rather than the primary event? If these observations are confirmed, it raises the issue of whether analyses of peripheral blood (without tissue analyses) are sufficient to discern important genetic changes.

**Advances in Catheter Ablation**

Atrial tachycardia arising from the noncoronary aortic valve cusp. We thought that the most exciting article relating to catheter ablation was a study by Ouyang et al. (13), who described the clinical electrophysiological characteristics and technique of ablation of focal atrial tachycardia arising from the noncoronary cusp of the aortic valve. An earlier case report by Tada et al. (14) described successful ablation from this site in 1 patient. Ouyang et al. extended these observations to 9 patients. In the 9 patients, the right atrium showed the earliest atrial activation site and was always associated with a bundle of His deflection. They found that atrial recordings from the noncoronary cusp of the aortic valve preceded those from either the right or the left atrium and were not associated with a His bundle deflection. The tachycardia was terminated within 8 s after radiofrequency application, and none showed evidence of atrioventricular conduction prolongation. The investigators also provide beautiful anatomical drawings explaining the remarkable results. This important study highlights the importance of mapping the noncoronary sinus for patients with focal atrial tachycardia (or accessory pathways) that are parahisian. It is conceivable that such an approach may obviate the need for potentially dangerous radiofrequency applications near the His bundle.

**Ablation versus drug therapy for AF.** There continues to be a great deal of important studies relating to the role of ablative therapy for patients with AF. Jäis et al. (15) presented data of 2 patient groups with documented symptomatic AF in whom at least one trial of antiarrhythmic agents failed. They randomized 59 patients (who could receive up to 3 drugs) to the drug arm of the study and 53 patients to the ablation group. At 1 year, arrhythmia was absent in 75% of the ablation group compared with 7% of the medical group. In addition, quality of life improved in the ablation group. In this study, a mean of 1.8 procedures were required for the ablation group. This is a very exciting comparative study but is limited by small numbers, short follow-up time, and need for almost 2 ablation sessions per patient with a mean procedure time of 168 min. In addition, conceivably failure of response to one drug might preselect patients destined to have high failure rates to drug therapy.

**Tailored approaches for AF ablation.** Further attention is being directed to so-called tailored approaches for ablative cure of AF. A very interesting approach was reported from Jäis et al. (16), in which the ablative lesion were staged using noninducibility as an end point. The study included 74 patients with paroxysmal AF who were treated with a series of staged procedures using AF noninducibility as an end point. Stage 1 was pulmonary vein isolation (PVI) alone, and stage 2 involved addition of a roof line or mitral isthmus line. If AF was still inducible, a second line (either roof or mitral isthmus) was added. They found that 42 patients (57%) became noninducible after PVI alone, a single line resulted in noninducibility in an additional 20 patients, and 12 patients required 2 lines. On follow-up (18 ± 4 months) repeat procedures were required in 23 patients, and the overall long-term efficacy was 91% (including repeat procedures).

This approach, however, differed from a tailored approach previously described by Oral et al. (17) for 100 patients with paroxysmal AF. In this approach, a wide area ablation surrounding the pulmonary vein together with roof and mitral isthmus line were performed. After this procedure, 40% of patients were found to be noninducible for AF. The remaining patients either had no further ablation or had ablations designed to ablate areas of fractionated potentials. At a 6-month follow-up, 86% of patients receiving ablation of fractioned potentials remained free of arrhythmias, compared with 67% who remained inducible but did not receive further therapy. These kinds of studies are important because they are designed to find the minimal lesion set required for arrhythmia cure. One of the negative aspects of using more lesion sets is the problem of left atrial flutter rhythms, which occurred in approximately 16% of the patients in the Jäis et al. (16) study and in 23% of the Oral et al. (17) study.
rotors and fractionated potentials. There continues to be interest in use of endocardial mapping of localized rotors, which appear to drive AF. Haisaguerre et al. (18) studied 50 patients with AF who had undergone prior PVI and linear ablation. Areas of dominant frequency were found in 38 (76%) of the studied patients. Local radiofrequency ablation resulted in either prolongation of the cycle length or a terminated AF or a changed activation sequence to another rhythm. The investigators concluded that AF after prior ablation seems to emerge from localized sources that can be mapped and ablated.

In the same vein, a study by Kalifa et al. (19) evaluated the mechanism of wave fractionation in the isolated sheep heart. They found that the area of fractionated electrogams came not from the actual zone of dominant frequency (site of anchored scroll wave) but instead from adjacent areas (<3 mm away). These were the areas showing most variability of conduction velocity and fractionation. The investigators suggest that a lesion target at the areas of maximal fractionation should be extended to form a large obstacle so that the emerging wave front will be extinguished.

AF and cardiac ganglionic plexus. There continues to be an active interest in the role of the cardiac ganglionic plexus in the pathogenesis of AF. All agree that activation of the autonomic ganglia by either electrical stimulation (20) or chemical stimulation (21) can provoke AF. Under active and lively debate is the possible clinical role of ganglion plexus ablation. Pappone et al. (22) first called attention to the beneficial role of ablation of vagal efferents. This has been supported by the work of the Oklahoma group (23). In contrast, several studies have emphasized the problem of complete and long-term vagal denervation using current techniques (24,25). These findings have provoked lively interchanges (26).

Drugs

AF and renin-angiotensin system inhibition. Although no new antiarrhythmic drugs were approved in 2006, a variety of studies emphasize the growing importance of nonarrhythmic drug use for patients with cardiac arrhythmias. For example, there continues to be great interest in the effects of inhibitors of the renin-angiotensin system in the prevention of AF. Anand et al. (27) performed a meta-analysis of 9 randomized clinical trials analyzing new onset of AF in patients treated with either angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers. This study involved 72,469 patients followed for up to 5 years. In 5 trials that excluded patients with a history of AF, drug therapy was associated with a reduction in risk of AF that was even greater for those with heart failure. The investigators found that inhibition of the renin-angiotensin system reduces the risk of AF by 18% across trials, with an even greater benefit for those with heart failure (43%). This study nicely complements prior experimental work showing that activation of the renin-angiotensin system may be proarrhythmic either by direct electrophysiological effects or by enhancement of atrial fibroses.

Clopidogrel and aspirin for stroke prevention. Another important study was reported by the ACTIVE (Atrial Fibrillation Clopidogrel Trial With Irbesartan for Prevention of Vascular Events) writing group and summarized the effects of clopidogrel and aspirin versus oral anticoagulants on stroke risk for patients with AF (ACTIVE W) trials (28). In this study, patients with AF and one or more risk factors for stroke were randomized to oral anticoagulation therapy with a target international normalized ratio of 2 to 3 versus clopidogrel 75 mg/day and aspirin 75 to 100 mg/day. There were 3,371 patients randomized to the anticoagulation group and 3,335 patients to the clopidogrel/aspirin group. The study end points were stroke, other systemic embolic events, myocardial infarction, or vascular deaths. The study was discontinued prematurely because of a significant increase of vascular events in the clopidogrel/aspirin arm. The annualized risk for the clopidogrel/aspirin group was 5.6%, versus 3.93% for the group treated with oral anticoagulants. This important study showed the superiority of antithrombin therapy and emphasizes the need for such therapy in patients with AF.

Cholesterol lowering in patients with defibrillators. Another contribution on the use of nonarrhythmic drugs for patients with cardiac arrhythmias was the CLARIDI (Cholesterol Lowering and Arrhythmia Recurrences After Implantable Defibrillator Implantation) trial, which was presented at the Heart Rhythm Society (HRS) meetings (29). The study was composed of 106 patients with coronary artery disease and ventricular arrhythmias treated with an automatic implantable cardioverter-defibrillator (AICD). The groups had a mean ejection fraction of 39% and 45% (not significant), and all patients had congestive heart failure. These patients were randomized to 80 mg/day of atorvastatin or placebo. The atorvastatin group showed an almost 50% reduction of ICD intervention (from 38% to 21%) over a follow-up of 1 year. In the atorvastatin group, the low-density lipoprotein cholesterol decreased from 130 mg/dl to 65 mg/dl, and low-density lipoprotein levels were unchanged for the placebo group. Prior reports have documented the efficacy of statin therapy for prevention of AF; this report supports prior retrospective studies of statin therapy for those with ventricular arrhythmias.

Devices

AICDs and pacemakers. In 2006 there were no pivotal studies that would redefine or expand the use of device therapy in clinical practice. Most of the published works involved re-analysis of data from previous published seminal trials to refine ICD use and risk stratification. The run of device recalls and safety alerts in 2005 has practically disappeared in 2006. With that, news media coverage and scrutiny of the device industry and of our relationships with
manufacturers also have subsided. New recommendations on device performance policies and guidelines have been published by the HRS. The projected increase in device implantation and sales never materialized. In this part of the review, we examine how some of the published works may affect our approach to device implantation and clinical practice. We also examine a brewing controversy that may lead to abandonment of the traditional RV apical pacing site. Finally, we explore reasons for the relatively flat ICD insertion rate in 2006.

**HRS device performance policies and guidelines.** In response to the recent device recalls and safety alerts, an HRS task force presented recommendations to the industry, U.S. Food and Drug Administration, and physicians on device performance policies and guidelines (30). In summary, for the physicians, we are urged to return all explanted devices (including those retrieved postmortem) to the manufacturers for analysis, use a standardized Physician Device Advisory Notification format to assist assessment and characterization of a device advisory, participate in the National Cardiovascular Data Registry ICD registry, consider the risks and benefits of device replacement and alternatives in patients with an affected device, and communicate to patients device benefits and expected device performance—including rate of unexpected and unpredicted component failure. The industry is urged to adopt standard reporting of device performance, establish an independent advisory committee to determine the threshold for action, develop a standardized Physician Device Advisory Notification format, and develop wireless and remote monitoring technologies. The task force effort surely will improve tracking of device performance and management of recalls and safety alerts by all stakeholders. It is noteworthy that the physicians were not specifically asked to incorporate into their practices the remote device surveillance technologies that the industry was urged to develop. This is important because the panel recognized the limitations of the current voluntary reporting system. These systems (Manufacturer and User Facility Device Experience Database and the National Cardiovascular Data Registry ICD Registry) were not designed to perform surveillance of device function. However, wireless remote monitoring by automatically uploading extensive device performance data at defined intervals provides an excellent data repository for post-market surveillance.

**ICD Use**

**Selection of patients.** In a provocative article, Stevenson and Desai (31) essentially challenged physician use of ICDs and the selection of appropriate heart failure patients who will benefit from primary reduction of sudden death. The investigators perceived that most ICD users do not follow the American College of Cardiology/American Heart Association guidelines. One of the investigators’ main contentions is that because the benefit of an ICD is not seen until after the first year after implantation, patients with frequent hospitalizations, a systolic blood pressure below 90 mm Hg, increasing creatinine levels, an inability to administer angiotensin-converting enzyme inhibitors, or an inability to walk 2 blocks should not receive an ICD because they are unlikely to survive 2 years with a good quality of life and to reap the benefit of ICD therapy. The investigators also discussed the following points: 1) The risk of sudden cardiac death has diminished even in the absence of an ICD, and only 21% of all death were considered unexpected (with <50% in class III patients). 2) Successful shocks for ventricular tachycardia (VT) and ventricular fibrillation (VF) were associated with more than a 3-fold increase in mortality in the first year. 3) Serious ICD complications (infection and hardware problems, including manufacturer recalls and safety alerts) occurred in 4% to 15% of patients. 4) With prevention of sudden death by ICDs, the patients would “survive to suffer from crippling symptoms of end-stage hemodynamic decompensation.” 5) The patients were not probably informed of the “real” benefits of ICD therapy (the investigators preferred “the glass is half-empty” approach). Although the investigators raised some very important, provocative, and challenging observations and arguments directed toward ICD users, they should not be interpreted by health care providers and referring physicians as a “call to disarm.” There is no solid evidence showing that implanting physicians are overtly deviating from the implantation guidelines. Prevention of sudden death that may otherwise occur in 20% to 50% of heart failure patients is highly rewarding. As pointed out in the accompanying editorial, the ensuing adverse prognosis after successful device therapy clearly should not be a deterrent to ICD insertion (32).

**Timing of ICD insertion.** The Centers for Medicare and Medicaid Services (CMS) coverage policy for ICD insertion in patients with cardiomyopathy for primary prevention stipulates that the patients must not have had revascularization (coronary artery bypass graft or percutaneous coronary intervention) within past 3 months. Some clinicians are concerned that life-threatening arrhythmia events may occur during the 3-month waiting period. A re-analysis of 951 patients in the MADIT-II (Multicenter Automatic Defibrillator Implantation Trial II) trial who underwent coronary revascularization showed that patients who received ICD insertion more than 6 months after revascularization had a significant survival benefit from ICD, whereas patients who received an ICD 6 months or less after revascularization experienced none (33).

This is because the risk of sudden cardiac death is relatively low early after revascularization. The result is consistent with the initial published observation that the survival benefit of ICD in the MADIT-II trial was not seen until 1 year after implantation. This retrospective study provides strong evidence showing that ICD insertion safely can be deferred for at least 6 months after coronary revascularization in MADIT-II type patients. The timing
The strategy of empiric ICD programming for VT/VF detection results provide very compelling evidence showing that a significant reduction in inappropriate arrhythmia detection and therapy. The EMPIRIC arm (defined as no greater than 10% higher in the EMPIRIC mortality rate in the EMPIRIC arm) in comparison with the TAILORED arm. There was no difference in emergency room visits or unscheduled hospitalizations. The EMPIRIC arm devices had a higher number of shocks and a significantly lower percentage of inappropriate shocks for supraventricular tachycardia. The study results provide very compelling evidence showing that a strategy of empiric ICD programming for VT/VF detection and therapy is at least as effective as tailored programming by electrophysiologists.

**T-wave alternans in risk stratification.** One of the most important areas of investigation is delineation of risk stratification so that ICD therapy is used more appropriately. A number of recent articles strongly suggested that the microvolt T-wave alternans (MTWA) test is an independent predictor of mortality in patients with ischemic cardiomyopathy and allows us to better stratify patients at risk for sudden cardiac death, thereby improving our selection of patients for ICD insertion (36–38). The investigators of the ABCD (Alternans Before Cardioverter Defibrillator) trial recently reported that the MTWA test was as effective as electrophysiologic studies in predicting ventricular arrhythmia events at 1 year among patients with ischemic cardiomyopathy (39). Although we are still awaiting full publication of this and other trials, the negative predictive value of the MTWA test is probably near 96%, making it a potentially valuable tool in screening out patients who are less likely to benefit from ICD insertion.

It is important to note that the MTWA test becomes less predictive after about 12 to 15 months; periodic retesting may have been required. In March 2006, the CMS provided Medicare reimbursement for use of the MTWA test for risk stratification.

**Biventricular pacing versus RV apical pacing.** Even as we are well into the fifth decade of pacing for bradycardia, the controversy over single-versus dual-chamber (AV) pacing (40) has been replaced with one pitting RV pacing against biventricular pacing. A number of editorial comments and reviews appeared in 2006 addressing this controversy (40–43). Prompted by the result of the DAVID (Dual Chamber and VVI Implantable Defibrillator) trial (44), many investigators began to look for a deleterious effect of left ventricular activation delay caused by RV apical pacing, especially in the presence of abnormal QRS duration and ventricular systolic dysfunction. A number of studies and reviews decrying the harmful effects of RV apical pacing have appeared (45–47). These deleterious effects include left ventricular dysfunction, altered cardiac histology by biopsy, higher degree of intraventricular dyssynchrony, left ventricular remodeling, dilatation, hypertrophy, lower cardiac output and exercise performance, presence of regional myocardial perfusion, and wall motion abnormality in the absence of coronary artery disease (42). Most of the studies were observational or represent retrospective subgroup analysis of data initially collected for an entirely different study purpose (48). The very few randomized studies involved either a very small number of patients or a short follow-up period (49). Many reported improvements in selected parameters with biventricular pacing have not been shown and have not translated to any significant long-term clinical improvements.

Fifty years of pacing experience strongly indicates that not in every patient does RV pacing develop into left
ventricular dyssynchrony and heart failure. It is also reasonable to assume that many pacemaker patients are not undergoing ventricular pacing all of the time. It is therefore inconceivable, from both a clinical practice and a cost-benefit standpoint, to implant a biventricular pacing system in all patients to prevent heart failure induced by RV apical pacing in a very small number of patients—even if biventricular pacing would prevent heart failure in every susceptible patient.

Biventricular pacing, despite recent advances in coronary sinus lead delivery systems, remains a major technical challenge for many users and is associated with a much higher incidence of complications. At present, the best evidence in favor of biventricular pacing is limited to patients with AF, especially those with reduced LV function, who undergo AV junctional ablation for rate control (49,50).

In view of the demand on our technical skills and health dollars, a better way to avoid deleterious effects from RV apical pacing is to minimize pacing by paying attention to programming of the devices and by selecting devices with mechanisms that promote intrinsic AV conduction.

**The state of ICD implants.** The MADIT-II and SCD-HeFT (Sudden Cardiac Death in Heart Failure Trial) results led to an expansion of indications for ICD insertion for primary prevention of sudden cardiac death. The industry projected a 20% revenue growth that never materialized in 2006. Indeed, the ICD market has declined. Device recalls, loss of consumer confidence (both patients and referring physicians), and reimbursement constraints have been identified as possible causes of the decline. Furthermore, there was no recent publication of a pivotal clinical trial, which often had provided an impetus for device implantation. Referring physicians may now be more selective in referring patients for ICD insertion, and more consideration is being paid to existing comorbidities and functional status that may negate or reduce ICD survival benefit, especially in heart failure patients. This contributes to a decrease in the size of the prophylactic ICD prevalence pool. Newer risk stratification tools may or may not increase the number of ICD uses. On the one hand, application of these tools may identify patients who are at low risk and therefore do not need an ICD. On the other hand, application of these tools to a larger pool of patients may identify high-risk patients and provide more convincing evidence for ICD referral.

**Practice guidelines and expert committee reports.** Achievements in understanding and advances in the treatment warrant changes both in the evaluation and management of patients with or at risk for arrhythmias and also in definitions and standards of performance. In 2006 several committee-generated consensus documents were published. In addition to recommendations that represent the consensus of experts, these documents are valuable sources of references. Most are available online at acc.org (30,51–54).

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