Implantable Dual-Chamber Cardioverter-Defibrillator-Pacemaker

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Introduction
Prospective trials, such as the Antiarrhythmics Versus Implantable Defibrillators (AVID) trial [1], the Canadian Implantable Defibrillator Study (CIDS) [2], the Cardiac Arrest Study of Hamburg (CASH) [3], and the Multicenter Automatic Defibrillator Implantation Trial (MADIT) [4], have shown that implantable cardioverter-defibrillators (ICD) are superior to drug therapy in the treatment of life-threatening ventricular tachyarrhythmias (VTA). Technologic developments in ICD therapy have resulted in smaller devices, improved detection and therapy algorithms, and extended diagnostic and storage functions. Double implantation of ICD and a separate pacemaker was performed in 3% of ICD patients in 1997 [5] but resulted in some risk of device interactions [6–9]. Recent progress offers the features of rate-responsive dual-chamber pacing (DDDR) with mode switching and ICD therapy in one device. This review focuses on the major advantages the fifth-generation dual-chamber pacer-defibrillator may offer to solve limitations of the systems in use at the present time, such as the following:

1. Some patients suffering from sick sinus syndrome, chronotropic incompetence, or high-grade atrioventricular (AV) block following negative chronotropic or dromotropic drugs or after AV nodal ablation have acceptable indications for dual-chamber pacing.

2. Several patients suffer from paroxysmal or persistent atrial fibrillation. Atrial fibrillation should be avoided because of documented risk of induction of VTA. Early termination of persistent atrial fibrillation needs atrial shocks. Suppression of atrial fibrillation includes antiarrhythmic drugs and often atrial pacing. Tachycardia-preventive pacing necessitates atrial pacing in patients with paroxysmal atrial fibrillation.

3. Upcoming new indications for pacing are described in patients with cardiomyopathy. There is growing evidence that biventricular pacing in advanced left heart failure in patients with dilated cardiomyopathy and left bundle branch block, for resynchronization or DDD pacing in the obstructive form of hypertrophic cardiomyopathy, may improve hemodynamic dysfunction and quality of life of the particular patient.

4. The high incidence of 20% to 25% of inappropriate interventions in single-chamber ICDs, most caused by sinus tachycardia, atrial flutter, or atrial fibrillation, may be reduced by use of atrial deflections for the detection of VTA. Other reasons described for inappropriate discharges are myopotentials [10] and T-wave oversensing. Inappropriate interventions should be suppressed because they may contribute to the proarrhythmic potential of ICDs [11].

It is estimated that more than 50,000 ICDs were implanted in 1998 worldwide [12]. Sales data provided by Guidant CPI and Biotronik suggest that dual-chamber ICDs in Europe account for up to 15% (Guidant CPI, Indianapolis, IN) [13] to 25% (Biotronik, Berlin, Germany) of all ICDs...
in 1999. Producers expect dual-chamber ICDs to account for 50% of all implanted ICDs in the next few years.

### Dual-Chamber Pacing in Implantable Cardioverter-Defibrillator Patients

It has been estimated that 15% to 20% of ICD patients require concomitant single- or dual-chamber pacing [8,14]. The potential indication for dual-chamber pacing in a ICD cohort has been analyzed in 253 patients [15•]. There were 28 patients (11%) with definite (23 implanted pacemakers), 72 (28%) with probable, and 35 (14%) with possible indications for dual-chamber pacing according to the guidelines of the American College of Cardiology and the American Heart Association (ACC/AHA) [16]. It has been determined that 29% of patients have traditional DDD indications and 55% of patients have nontypical indications such as supraventricular tachyarrhythmia (SVT) or congestive heart failure [13]. Double-generator implantation of a pacemaker and ICD is obsolete and potentially dangerous, since interferences of sensing function have been demonstrated [6–9,17], although contrary results have been published [18].

There are neither defined guidelines for indications for dual-chamber ICDs nor data about percentage requirement of DDD or DDDR-pacing in ICD patients. Trappe et al. [19] summarized indications for dual-chamber pacing in ICD patients as "benefits by general agreement" and "possible benefits" (Table 1). It is evident that patients with classic indications for dual-chamber pacing would benefit from dual-chamber ICD as well. Several reports in the literature emphasize the positive effect on morbidity and even possible positive effects on mortality by DDD pacing in patients with dilated cardiomyopathy, severe functional mitral valve regurgitation, and atrioventricular conduction disturbance [14,20]. On the other hand, a nonsignificant trend for improvement of heart failure class (New York Heart Association [NYHA]) has been demonstrated: 33% of patients improved in NYHA class after implantation of dual-chamber ICD [19]. The effect of dual-chamber pacing on prognosis and quality of life in patients with ICD is unknown. Therefore, additional clinical studies are necessary to increase our clinical experience in this field.

### Atrial Fibrillation in Implantable Cardioverter-Defibrillator Patients

Atrial fibrillation is a common arrhythmia in patients with an ICD. Atrial fibrillation occurs in elderly ICD recipients not taking class I or III antiarrhythmic drugs and without known history of atrial fibrillation; it occurs most often in the early period after thoracotomy (Table 2) [21]. Paroxysmal atrial fibrillation may cause inappropriate ICD interventions as well as VTA, resulting in appropriate discharges [22–24]. Therefore, atrial fibrillation should be as preventable by multifocal atrial/biatrical pacing as stoppable by shocks in patients with ICDs and risk for atrial fibrillation.

Detection of atrial fibrillation in single-chamber ICDs remains limited, especially in cases with 1:1 to 2:1 AV conduction [25] (Fig. 1). Despite programming of the sudden onset and rate stability criteria, a 10% to 13% rate of inappropriate interventions because of atrial fibrillation was seen [26•,27–29]. Morphologic criteria for the atrial deflection with Daubechies-6-wavelet analysis in dual-chamber ICDs may support this clinically relevant discrimination [30–32]. Newer systems (GEM DR) incorporate AV and ventriculooatrial (VA) intervals, atrial fibrillation evidence, far-field R wave exclusion, A:V dissociation, and ventricular cycle length regularity [33•]. Other generators (Ventak AVII DR) have enhanced discrimination with "AFib rate threshold", "AFib stability," and "V rate > A rate" criteria [33•] in addition to conventional criteria such as ventricular rate, duration, onset, and stability [34•].

Persistent atrial fibrillation may be treated by a new ICD using atrial shock delivery [35,36•]. Antitachycardia atrial pacing and multifocal single-chamber or biatrical pacing may prevent relapse of atrial fibrillation. The only ICD with atrial shock delivery (Jewel AF AMD 7250) has been tested in a multicenter international trial in 293 patients. The system successfully treated atrial fibrillation by shock in 75% and by antitachycardia burst pacing in 59%. The atrial fibrillation duration per week reduced significantly. New detection problems with oversensing and inappropriate atrial shock intervention are described [37].

### Newer Pacing Indications in Implantable Cardioverter-Defibrillator Patients

Congestive heart failure pacing has been documented as a tool for treating end-stage heart disease in selected patients [38]. Biventricular pacing is possible in ICD patients [39] with left ventricular epicardial [40] or coronary vein leads [41]. There are no prospective data on the use of these pacing modes in patients with an ICD. Pacemaker therapy in hypertrophic obstructive cardiomyopathy (HOCM) may reduce the left ventricular outflow tract gradient [42,43].

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**Table 1. Indications for dual-chamber pacing in patients with implantable cardioverter defibrillators**

| Sinusatrial disturbances                      |
| Sick sinus syndrome                          |
| Drug-induced bradycardia                     |
| Atrioventricular nodal conduction disturbances|
| Sinus chronotropic incompetence (DDDR pacing required) |
| Hypertrophic obstructive cardiomyopathy      |

*Possible benefits*

- Prevention of atrial fibrillation by atrial pacing
- Prevention of ventricular tachyarrhythmias by pacing
- Improvement of congestive heart failure

**DDDR**—dual-chamber pacing with rate-responsive mode.
(Adapted from Trappe et al. [19].)