Possible Advantages of Dual-Chamber Implantable Cardioverter Defibrillator Therapy

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Summary

Decreasing inappropriate therapy, atrial tachyarrhythmia prevention, atrioventricular (AV) pacing, discrimination, and diagnostic capabilities are the advantages of dual-chamber implantable cardioverter defibrillators (ICDs) over single-chamber ICDs. Since January 1998, 22 patients (age: 58.7 ± 11.7 years, ejection fraction: 25 ± 7.7%, NYHA: 2.9 ± 0.6, coronary disease: 14 pts, dilatative cardiomyopathy: 8 pts) received dual-chamber ICDs in our department. Ejection fraction < 35% was observed in 20, bradycardia in 7, paroxysmal atrial tachyarrhythmia in 4, slow ventricular tachycardia (VT) (< 140/min) in 7 cases. Indications were: sustained ventricular tachycardia (14), ventricular fibrillation (VF, 5), or VT with VF (3). Mean implantation time was 72.4 ± 12.0 min. During the follow-up examinations, (7.3 ± 3.8 months) 26 spontaneous VFs and 298 VTs were terminated by cardioversion-defibrillation (90) or antitachycardia stimulation (ATS, 234). ATS was effective in 88%, cardioversion in 100%. IEGM revealed VA dissociation in 82%, partial retrograde conduction in 14%, 1:1 VA conduction in 4.0 % of spontaneous VTs. Effective AV discrimination was observed in 45, inappropriate shocks in 2 cases using SMART™ algorhythm. NYHA class improved in 11 patients following echocardiographic AV-delay optimization. In conclusion, dual chamber ICDs provide optimal AV pacing, sensing and discrimination, further improving the efficacy of ICD therapy.

Key Words

Implantable cardioverter defibrillator therapy, dual chamber

Introduction

Implantable defibrillator is the treatment of choice in patients at risk of sudden cardiac death. Single-chamber implantable cardioverter defibrillators are able to successfully and safely detect and terminate most episodes of ventricular tachyarrhythmias. The current challenge is to further improve safety and effectiveness of this device, for the therapy with ICDs is only safe if all true VTs are detected and treated.

The analysis of stored intracardiac electrograms, Holter data and anamneses showed that there is a significant fraction of about 25% of inadequate therapies delivered due to supraventricular tachycardias (SVT), which are interpreted and treated as ventricular tachyarrhythmias [7,10]. Since the origin of these SVTs is not located in the ventricle, ventricular based therapies such as antitachycardia pacing (ATP) or unipolar defibrillation are not effective. Moreover, these therapies may induce episodes of VT which did not exist before. The potential proarrhythmic effect of single-chamber ICDs and inappropriate therapies should be avoided.

Due to the improving technology of ICDs, the new fifth generation of implantable cardioverter/defibrillators are able to sense, pace and defibrillate both in the atria and in the ventricles. Dual-chamber cardioverter defibrillator therapy may have several benefits for ICD patients. These DDD devices and the additional atrial electrode provide the physician advanced capabilities for discrimination and adequate therapy of ventricular and supraventricular tachyarrhythmias.

This report describes our own clinical experience with an ICD capable of dual-chamber detection for arrhythmia diagnosis and dual-chamber pacing function.

Materials and Methods

Defibrillation system

The Phylax AV has an AV discrimination algorhithm called SMART™ with 2 VT and 1 VF zone. It provides full DDD bradycardia support with automatic mode conversion, up to 16 minutes of stored dual-chamber electrograms, approximately 2,500 stored P-P and R-R intervals.

In the Phylax AV device, arrhythmia detection is based on the examination of P-P-, P-R- and R-R-intervals which are extracted from the dual-chamber IEGM. The SMART Detection Algorithm investigates the average ventricular and atrial rate, the stability and onset of the atrial and ventricular rate, the multiplicity of the atrial rate compared to the ventricular rate. The regularity and the monotonic change of P-R intervals are also included in the algorithm.

The basic detection strategy is illustrated in Figure 1. Only ventricular arrhythmias are treated automatically. As always, VF detection takes priority. For lower ventricular rates, the discrimination algorithm is applied in two different zones. The basic principle is that the heart chamber with the higher rate is the source of the tachyarrhythmia. If the ventricular rate in the VT-zone exceeds the atrial rate, a VT is declared and appropriate therapy initiated. A SVT is nominally detected with an atrial rate faster than the ventricular rate (Figure 2). In Figure 2 you can see a 150/min sinus. Inadequate therapy is not delivered despite the ventricular rate is in the VT zone. But, beside SVT, concurrent VT episodes might exist, occurring independently or as a result of the SVT. Thus, while in general ventricular therapy is withheld, constant monitoring of the ventricular rhythm is carried out for detecting the occurrence of VTs. This is the case for atrial flutter with 2:1 or 3:1 conduction block. The requirements are stable rates and an integer ratio relationship between both rates.

With identical rates in both chambers, further tests are required to detect the source of the tachyarrhythmia. The key point here is to differentiate between sinus tachycardia, AV-nodal tachycardia, low-rate atrial tachycardia with 1:1 conduction rate, and VT with retrograde conduction: In these cases, rate and P-R interval stability and sudden-onset criteria can be discriminated. Figure 3 shows the detection and ATS therapy of a spontaneous 1:1 VA conduction VT (150/min) by a dual chamber ICD (Figure 3). In case of 1:1 AV-ratio, the ICD device can also be differentiated by giving a premature ventricular stimulus. The premature ventricular stimulus does not change the PP-intervals during sinus tachycardia, but changes them during VT with retrograde conduction.

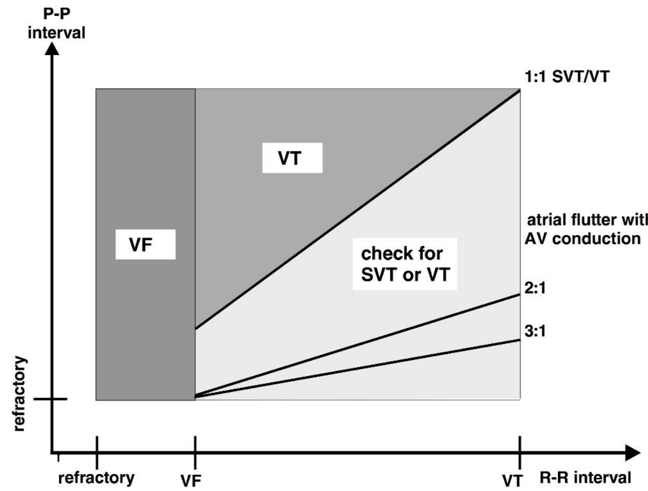

Figure 1. The basic detection strategy of SMART™ algorithm.

Subjects

Starting from January 1998, 22 dual-chamber ICDs (Phylax AV, BIOTRONIK) have already been implanted in our department. Patient characteristics included an average age of 58.7 ± 11.7 years, ejection fraction 25 ± 7.7%, NYHA class 2.9 ± 0.6. At the time of the implantation, 3 patients (14%) were in NYHA class II, 17 (77%) patients in NYHA class III, and 2 patients (9%) in NYHA class IV. Patient history revealed an ejection fraction lower than 35% in 20 cases, bradycardia in 7 cases, paroxysmal atrial tachyarrhythmia in 4 cases and slow VT (< 140/min) in 7 instances. The underlying diseases were coronary artery disease (14 patients) and dilatative cardiomyopathy (8 patients). Indications were: sustained ventricular tachycardia (14), ventricular fibrillation (5), ventricular tachycardia with sudden cardiac death (3). Three patients were on the transplantation waiting list.

According to the electrophysiological study and Holter data in 8 patients, atrial fibrillation, flutter or sinus tachycardia and sustained ventricular tachycardia resulted in identical ventricular rates. Only 1 patient had 1:1 retrograde conduction during slow VT, and 6 patients had 1:1 retrograde conduction during 150/min ventricular stimulation.

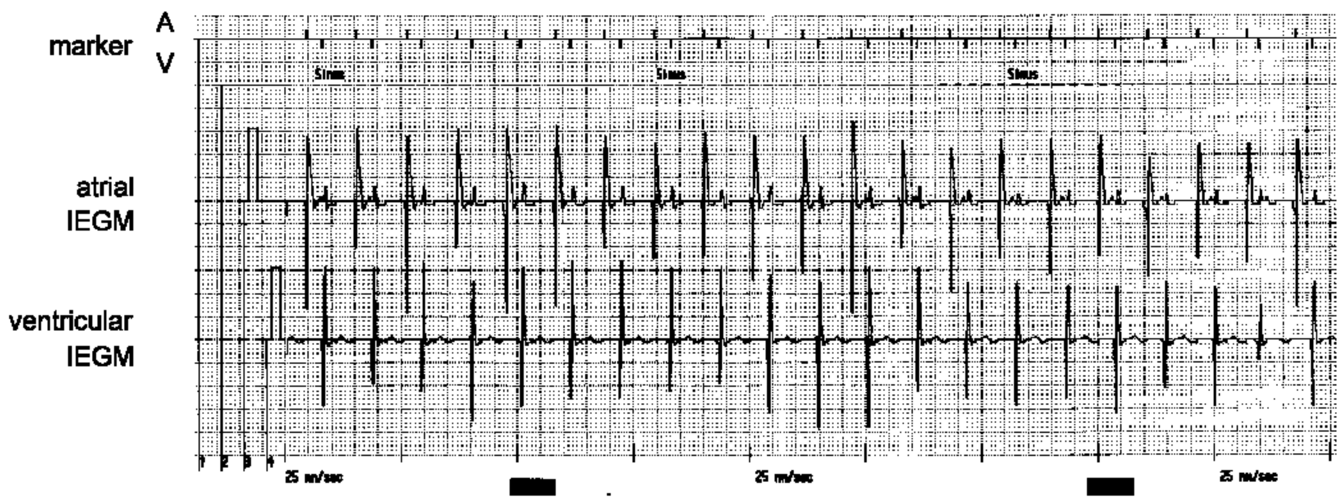

Figure 2. Discrimination of a 150/min sinus tachycardia by a dual-chamber ICD using the SMART algorithm.

ICD implantation

ICDs were implanted under local anesthesia in all patients. DFT and device testing was performed under short-acting intravenous general anasthesia. Minimal implantation criteria required two consecutive successful conversions of ventricular fibrillation using 20 Joules or less.

All implantations were performed using tripolar Kainox RV shock electrode (BIOTRONIK) without any additional leads. Regarding atrial sensing and pacing, in 13 patients active fixation J-shaped leads (Retrox JBP, BIOTRONIK) and in 9 patients passive fixation leads Synox or Polyrox JBP (BIOTRONIK) have been used. Active fixation lead has been used mostly in cases after coronary bypass surgery and if the passive lead had no stable position in the right appendage.

Results

Functional status of heart failure

Due to sick sinus syndrome or I to III degree

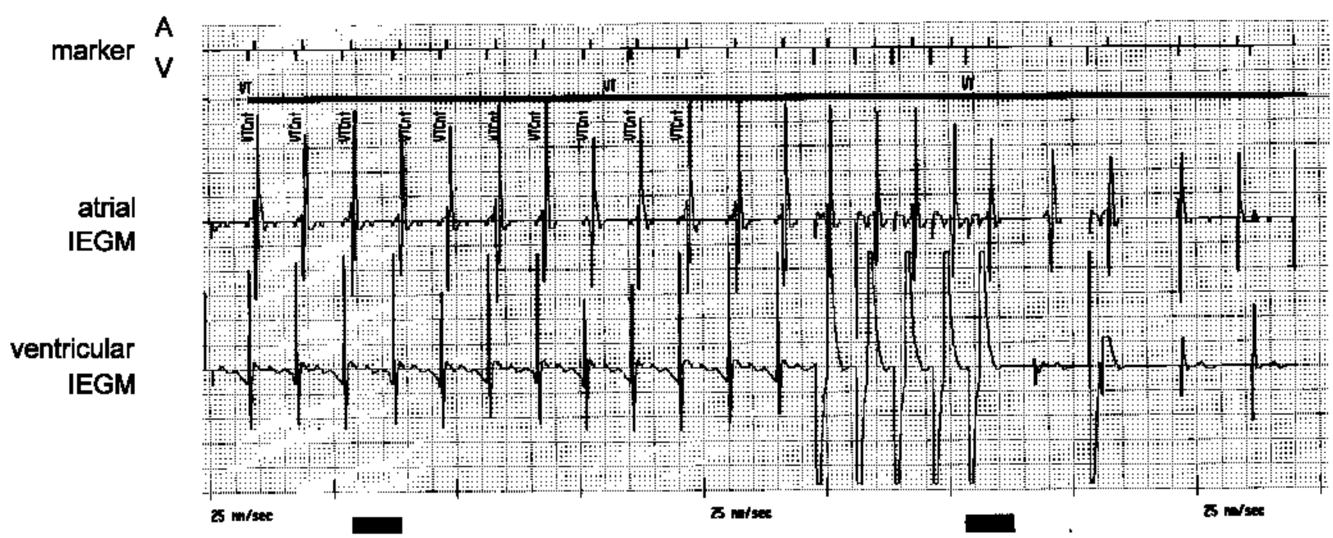

Figure 3. Detection and therapy of a spontaneous 1:1 VA conduction VT (150/min) by a dual-chamber ICD.

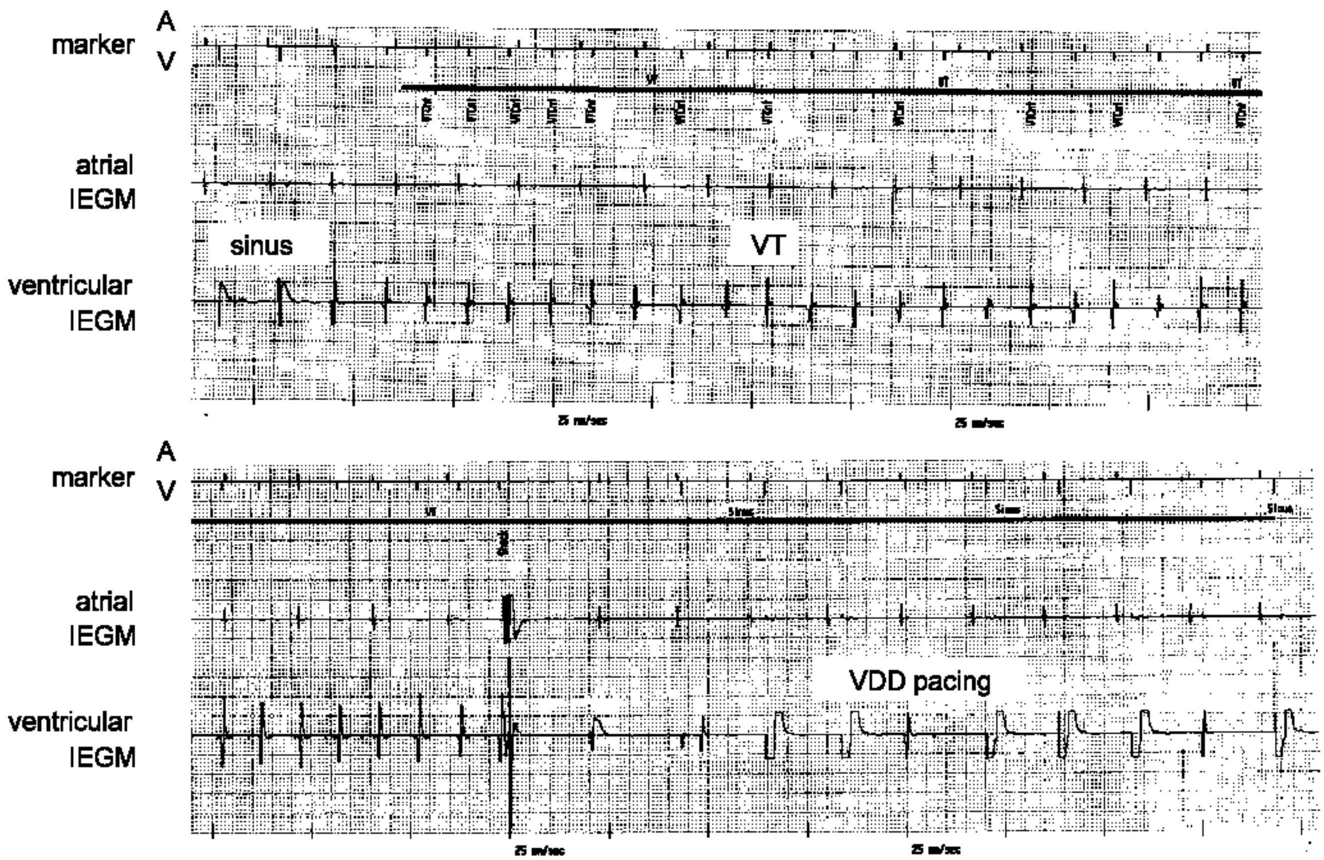

Figure 4. Detection and therapy of a spontaneous VT with VA dissociation by a dual-chamber ICD.

AV-block or intraventricular conduction block, 18 patients, 82%, needed DDD or VDD bradycardia support or AV-delay optimization.

During follow-up, the NYHA classification was assesed again: at the time of the last outpatient clinic visit, 12 patients were in NYHA class II, and 8 patients in NYHA class III, and 2 patients in NYHA class IV. 11 patients were found to improve in NYHA class due to the individual echocardiographic AV-delay optimization after ICD implantation. Doppler-mitral inflow, aortic outflow velocity were used to determine the optimal AV-delay. The programming was controlled by Quality-of-Life-questionnaires regarding the cardiovascular symptoms (chest pain, dyspnea, physical capacity, dizziness, palpitations) or self perceived health (well-being, mood and sleep disturbances).

There was only 1 patient who had a lesser degree of functional status of heart failure after implant. No patients were lost during the study.

Spontaneous arrhythmias

Mean implantation time was 72.4 ± 12.0 min. Postoperative atrial electrode dislodgement was observed twice. Over the follow-up period (7.1 ± 3.6 months), 26 episodes of spontaneously occurring VF and 298 episodes of VT were noted. These were terminated by cardioversion-defibrillation in 90 cases and by antitachycardia stimulation (ATS) in 234 instances. ATS was effective in 88% and cardioversion in 100%. Analysis of IEGM records revealed VA dissociation in 82% of the spontaneously occurring VTs, partial retrograde conduction in 14% and 1:1 VA conduction in 4.0%. Inappropriate shocks were delivered only twice using SMART™ discrimination algorithm because of atrial fibrillation. Effective AV discrimination deduced from Holter records and stored SMART success IEGM have been observed in 45 cases (36 sinus tachycardia, 5 atrial fibrillation and 1 atrial flutter). 2 patients were lost during the study.

In Figure 4, stored dual-chamber intracardiac electro-

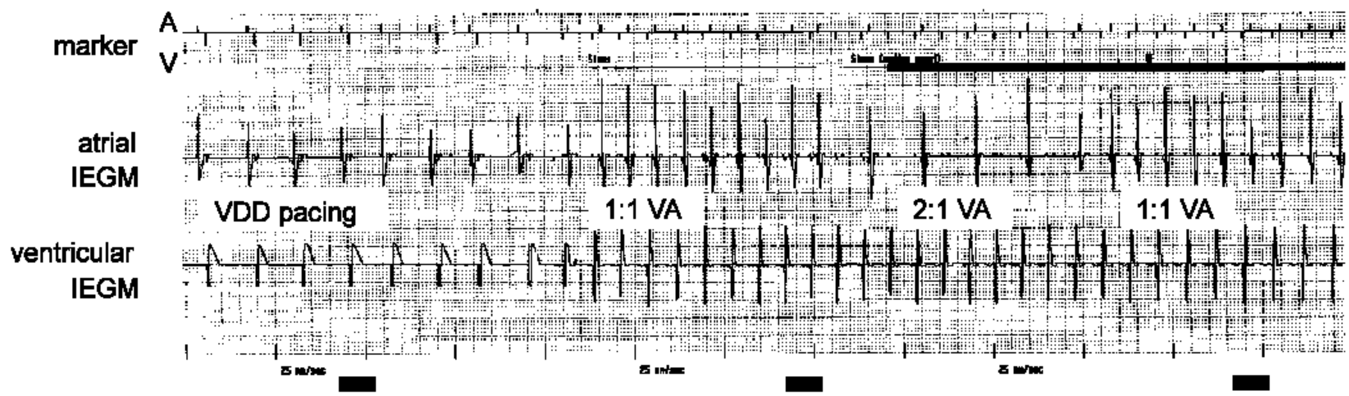

Figure 5. Detection of the onset of a 180/min VT with alternating 1:1 and 2:1 VA conduction.

grams of one patient are shown with marker channels for a spontaneous ventricular tachycardia. After the onset of VT, ventriculoatrial dissociation could be observed on the stored IEGMs. VT was detected and terminated by 6-J cardioversion. After the termination of the ventricular tachyarrhythmia, AV-sequential pacing was performed

Figure 5 shows the stored dual-chamber intracardiac-electrograms with marker channels for a spontaneous ventricular tachycardia of another patient. After the onset of VT, 1:1 atrial and 2:1 ventriculoatrial conduction could be observed on the stored IEGMs. VT was detected and terminated by cardioversion.

Discussion

According to our clinical experience, dual-chamber ICDs provide optimal AV pacing, sensing and discrimination and further improve the efficacy of ICD therapy. The case of a 1:1 ratio of atrial and ventricular rate is still a problem. With any passive discrimination algorithm, a success rate of 100% will never be achieved. Thus, using an active discrimination algorithm with stimulation in the ventricle might bridge this gap.

Dual-chamber ICD therapy could have several advantages over single chamber ICDs, namely the positive hemodynamic effects of AV pacing, possibility of AV discrimination, AV diagnostic capabilities, decreasing inappropriate therapy and prevention of atrial and eventual ventricular tachyarrhthmias. According to Epstein et al, approximately 11% of ICD patients require concomitant pacing for sinoatrial or atrioventricular conduction disturbances [5]. Drug induced sinus bradycardia is a common finding in ICD patients requiring additional pharmacologic therapy, and even these patients may benefit from dual-chamber pacing. But the true incidence of the need for additional pacing in ICD patients is still unknown.

It has been emphasized that the preservation of atrioventricular synchronization may have a positive effect on morbidity and possibly even mortality of patients with depressed left-ventricular function. Using dual-chamber defibrillators, AV-sequential pacing can be carried out, having positive haemodynamic effects in patients with bradycardia and congestive or hypertrophyc cardiomiopathy [3,4,6,8]. Patients with dilated cardiomyopathy [6,8], severe mitral regurgitation [9], and prolonged atrioventricular conduction, and patients with hypertrophic obstructive cardiomyopathy may significantly benefit from DDD pacing with an individual-short atrioventricular interval.

Dual-chamber pacing may also prevent supraventricular tachyarrhythmias particularly atrial fibrillation, resulting in inappropriate ICD shocks. Data from prospective and retrospective studies have suggested that atrial pacing was associated with less atrial fibrillation and thromboembolic events than VVI pacing. [1,2]. In addition, pacing at rates slightly higher than the spontaneous rhythm may suppress initiation of VT and VF by decreasing of premature beats and short-long-short periodes that trigger arrhythmia. This has been demonstrated in VVI pacing. Dual-chamber pacing may be even more effective for a variety of arrhythmias. However, future studies comparing conventional ICDs and dual-chamber ICDs will be necessary to prove these questions.

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