Experiences with a New VDD Defibrillation Lead for Dual-Chamber Defibrillators: Implant and Discharge Data

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Summary

To minimize inappropriate shock delivery during defibrillator therapy, implantable cardioverter-defibrillators (ICDs) should sense both atrial and ventricular intracardiac signals. So far, an increase in postoperative complications due to the implantation of a separate atrial lead has been a drawback of dual-chamber ICDs. To address this problem, a VDD defibrillation lead with two free-floating atrial ring electrodes has been developed. This VDD defibrillation lead (Kainox VDD) was implanted in ten patients, along with Deikos A+ dual-chamber ICDs. Ventricular fibrillation could be converted in all patients with a satisfactory safety margin. The ventricular pacing thresholds during the operation and at discharge were 0.7 ± 0.4 V and 1.1 ± 0.5 V (at 0.4 ms), respectively; the ventricular impedances were 594 ± 131 W and 479 ± 103 W, respectively; and the R-wave amplitudes were 13.1 ± 3.7 mV and 12.7 ± 3.9 mV, respectively. The atrial ring electrodes allowed the measurement of P-wave amplitudes of 4.9 ± 1.6 mV intraoperatively, and of 4.9 ± 2.0 mV at discharge. In one patient, atrial fibrillation occurred for the first time postoperatively. The ICD correctly sensed the arrhythmia and withheld therapy due to activation of the SMART algorithm. In conclusion, implantation of the new VDD lead is feasible, and excellent electrical parameters and low conversion energies can be achieved in the ventricle as well as in the atrium. The defibrillation system presented here has the advantage that patients receive the benefits of a dual-chamber ICD with the implantation of only one lead.

Key Words

Implantable cardioverter defibrillator (ICD), VDD defibrillation lead, single-lead electrode, defibrillation

Introduction

Implanting a cardioverter-defibrillator (ICD) is an effective therapy for the treatment of ventricular tachyarrhythmias [1]. Single-chamber devices with a ventricular defibrillation lead that detect ventricular tachyarrhythmias by registering faster heart rates can deliver false positive therapies in the presence of atrial tachycardias. Expanded detection criteria, such as stability and tachycardia onset, must therefore be activated in single-chamber ICDs. While this clearly improves the differentiation between supraventricular and ventricular tachycardias, the expanded detection criteria are still not entirely reliable [2]. Dual-chamber ICDs involve to an additional atrial lead and sense atrial signals continuously. In combination with special discrimination algorithms such as the SMART algorithm, dual-chamber ICDs are able to differentiate more accurately between atrial and ventricular tachycardias [3]. The drawback of dual-chamber ICDs is that they are associated with more frequent complications than single-chamber systems, primarily atrial lead dislocations [4]. An alternative to having two separate leads is sensing the atrial and ventricular signals with a special single defibrillation lead. In pacemaker therapy, this concept has been technically realized with a free-floating VDD lead in combination with a VDD pacemaker. In patients with higher-degree AV blocks, these systems sense the

atrial signal as reliably as do dual-chamber pacemakers [5]. Analogously, a VDD defibrillation lead has been developed that possesses two free-floating atrial ring electrodes [6]. This communication presents first experiences with the novel VDD defibrillation lead gathered during implantation and hospital discharge.

Materials and Methods

Patients

Implantation of a Kainox VDD defibrillation lead (Biotronik, Germany) was attempted in 11 patients (63 ± 13 years, ten male and one female) of three clinics. The implanted leads were connected to a dual-chamber Deikos A+ ICD (Biotronik). Indications for ICD implantation were ventricular fibrillation in four patients and persistent ventricular tachycardia in seven patients. The underlying cardiac disease was coronary heart disease in nine patients and dilated cardiomyopathy in two. The mean left-ventricular ejection fraction was 32 ± 12 %.

VDD Defibrillation Lead

The Kainox VDD lead is a pentapolar defibrillation lead with not only a bipolar ventricular sensing and pacing electrode and a ventricular shock electrode, but also a bipolar atrial ring electrode (Figure 1). The latter is intended for atrial sensing and, if necessary, atrial pacing, without the need to implant another atrial lead. There are two versions, which differ in the distance between the tip electrode and the atrial bipole (either 15 or 17 cm). The conductors for the individual lead poles are run through a multi-lumen silicone tube. The lead has a length of 75 cm and a maximum diameter of 10.5 F.

Dual-chamber ICD

The atrial channel of the Deikos A+ is four times more sensitive than those of conventional dual-chamber ICDs, and is tuned to the atrial signals sensed by the VDD defibrillation lead. The atrial sensitivity can be programmed to values between 0.25 mV and 3.0 mV. The SMART detection algorithm is used to discriminate between atrial and ventricular tachycardias.

Implantation

It was recommended that VDD defibrillation leads with a 17-cm distance to the lead tip be used for men with a body height exceeding 175 cm, and that defibrillation leads with a 15-cm distance be used for smaller men and women. After puncturing the subclavian vein, the lead was placed in the apex or the base of the right ventricle. Care was taken to place the atrial rings at the height of the mid- to upper atrium. During the intraoperative measurements with the external measuring device TMS 1000 (Biotronik, Germany), we attempted to attain ventricular pacing thresholds of < 1.0 V at a 0.4 ms pulse width and R-wave amplitudes > 10 mV. The P-wave signal should be at least 1.0 mV. After connecting the leads to the dual-chamber ICDs, the electrical parameters were measured once more. Subsequently, the effective termination of ventricular fibrillation was tested. Usually, the test was performed twice at energies of 20 J and less, thus leaving a safety margin of at least 10 J. The postoperative examinations were carried out upon discharge from the hospital, usually 2 to 6 days after the implantation.

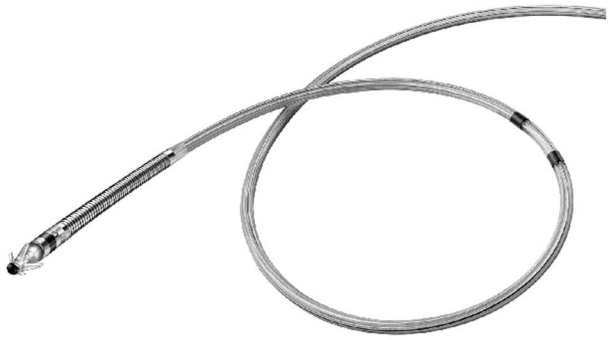

Figure 1. A photo of the endocardial ICD electrode Kainox VDD (Biotronik, Germany).

Results

The 17-cm lead was implanted in eight patients, and the 15-cm lead in three patients. The VDD defibrillation lead could be implanted in 10 of the 11 patients (Figure 2). Implantation was not possible in one patient because of an unstable position of the lead tip, necessitating the use of a screw-in lead. There were no intraoperative complications. The electrical parameters for the ventricle are shown in Table 1, and those for the atrial rings in Table 2. A higher P-wave signal could be registered after connecting the lead to the ICD than was possible with the PSA measuring device. During conversion testing, 20 inductions were performed. Ventricular fibrillation could be induced in all cases. It was terminated with 6 J in one patient, with 12 J in six, with 15 J in ten, and with 20 J in three patients. The shock impedance was 80 ± 20 Ω. During testing, the

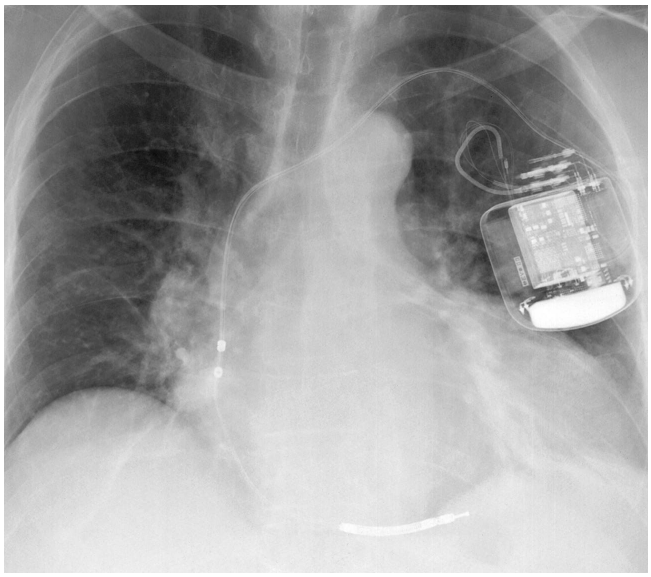

Figure 2. An X-ray image of an implanted Kainox VDD electrode connected to a Deikos A+ ICD (Biotronik, Germany).

ICD always sensed the P wave correctly (Figure 3). The electrical measurement values were unchanged at hospital discharge with respect to the intraoperative measurements (Tables 1 and 2). At the interrogation, the ICD memory of one patient indicated the occurrence of atrial fibrillation for the first time. The ICD detected the atrial fibrillation correctly and, since the SMART algorithm was activated, it correctly withheld therapy (Figure 4).

Ventricle	Implantation TMS 1000	Implantation Deikos	Discharge Deikos
Pacing threshold (V) at 0.4 ms pulse width	0.8 ± 0.3	0.7 ± 0.4	1.1 ± 0.5
Impedance (Ω)	601 ± 84	594 ± 131	479 ± 103
R-wave amplitude (mV)	15.8 ± 7.7	13.1 ± 3.7	12.7 ± 3.9

Table 1. Electrical measurements for the ventricular defibrillation lead (mean value ± standard deviation).

Atrium	Implantation TMS 1000	Implantation Deikos	Discharge Deikos
Pacing threshold (V) at 0.4 ms pulse width	2.1 ± 1.1	3.0 ± 2.4	2.6 ± 0.3
Impedance (Ω)	253 ± 46	258 ± 27	259 ± 27
P-wave amplitude (mV)	1.4 ± 0.6	4.9 ± 1.6	4.9 ± 2.0

Table 2. Elektrophysiological parameters measured in the atrial dipole lead (mean value ± standard deviation).

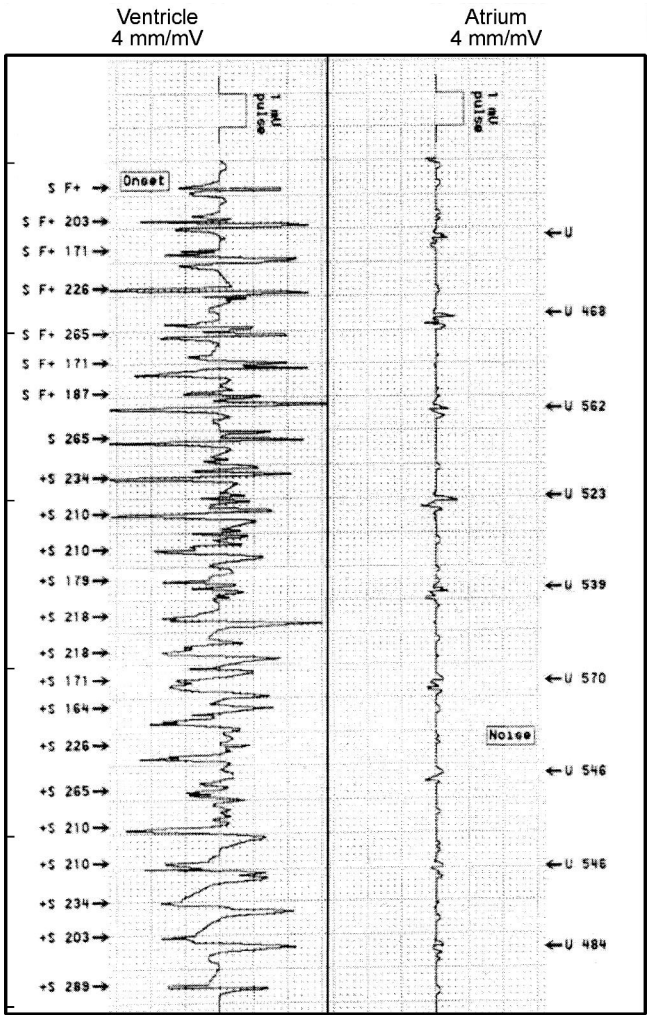

Figure 3. Detection of the atrial and ventricular signals during ventricular fibrillation measured by a VDD electrode and a Deikos A+ ICD.

Discussion

The reported experiences show that the new lead allows stable positioning of the ventricular defibrillation electrode as well as a reliable detection of the atrial signal. Due to the more sensitive atrial sensing by the ICD, high P-wave amplitudes were recorded, which also guaranteed the detection of newly occurring atrial fibrillation. Thus, it was possible to activate dual-chamber discrimination algorithms. As a prototype, the new VDD defibrillation lead had only been tested intraoperatively [6]. Based on those results, the lead was produced with its current specifications. In contrast to conventional pacemaker VDD leads, one lead version has a distance of 17 cm between lead tip

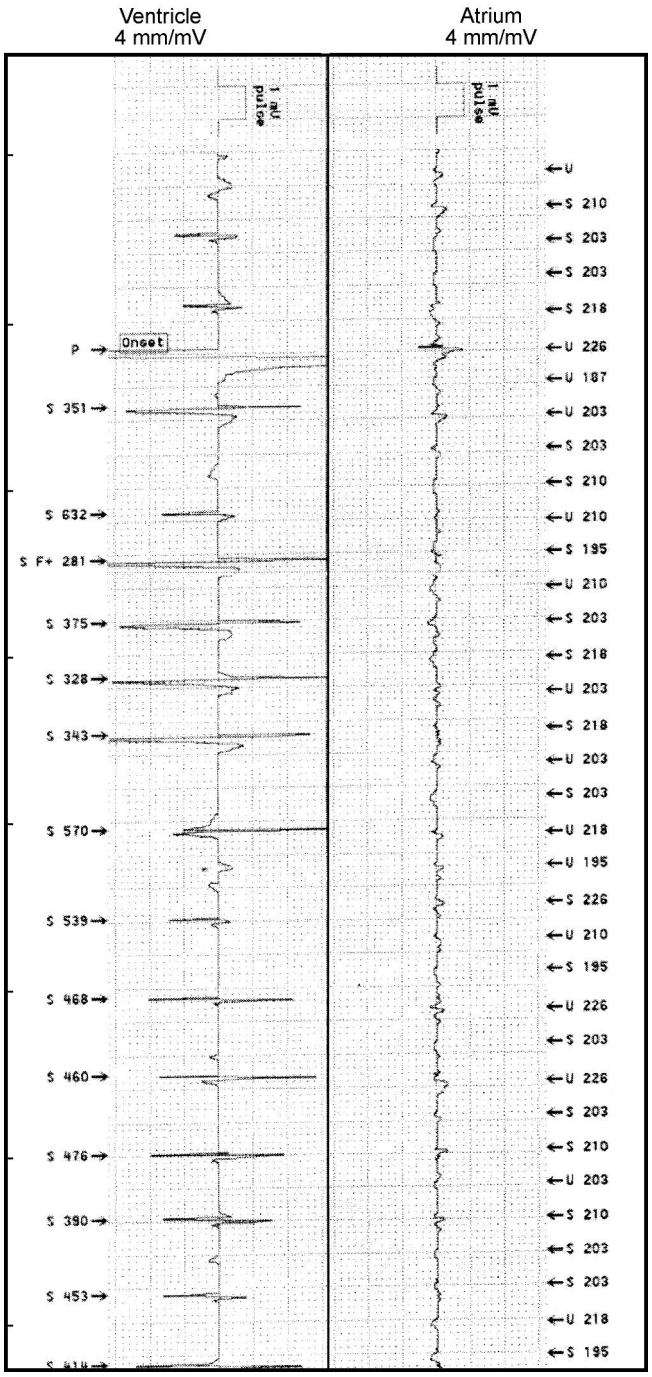

Figure 4. Detection of the atrial and ventricular signals during atrial fibrillation measured by a VDD electrode and a Deikos A+ ICD.

and atrial ring electrodes. In the patients studied, this enabled a more stable contact with the lateral atrial wall. Furthermore, the ability to pace the atrium was demonstrated for most patients.

Compared with conventional VDD pacemaker systems, higher P-wave amplitudes could be recorded. This was the result of implementing a high-amplification atrial input amplifier in the ICD. Furthermore, in contrast to VDD pacemakers, no postoperative decrease in P-wave amplitude was found. The presented defibrillation system has the advantage that patients receive the benefits of a dual-chamber ICD with the implantation of only one lead, at least in regard to expanded detection of atrial signals. Such a system would be useful in 14 – 42 % of the patients with an indication for an ICD [7].

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