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Evaluation of arrhythmia detection and discrimination efficacy of modern cardioverter defibrillators

PhD Thesis

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PUBLICATIONS RELATED TO THE THESIS

Full papers

I. Gausz FD, Lena KNM, Gedeon PE, Miklos M, Benak A, Bencsik G, Makai A, Kranyak D, Gagyi RB, Pap R, Saghy L, Szili-Torok T, Vamos M. Arrhythmia Detection in Atrioventricular, Single-Lead, Floating Atrial Dipole ICD Systems Compared with Conventional Single- and Dual-Chamber Defibrillators. J Cardiovasc Dev Dis. 2024 Dec 1;11(12):386. doi: 10.3390/jcdd11120386. PMID: 39728276; PMCID: PMC11677019. **(2025 – Impact factor: 2.3, Q1)**

II. Gausz FD, Fodor D, Turani M, Miklos M, Benak A, Kranyak D, Makai A, Bencsik G, Bogyi P, Pap R, et al. Head-to-Head Comparison of Single- Versus Dual-Chamber ICD Discriminators for Tachyarrhythmia Detection: A Single-Manufacturer, Remote Monitoring-Based Bicentric Study. *Journal of Clinical Medicine*. 2025; 14(16):5859. https://doi.org/10.3390/jcm14165859 **(2025 - Impact factor: 2.9, Q1)**

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Congress abstracts

I. Single- versus dual-chamber ICD discriminators for tachyarrhythmia detection: a remote monitoring based, single center study (EHRA Congress 2025, Vienna)

II. Head-to-head comparison of single- versus dual-chamber ICD discriminators for tachyarrhythmia detection: a remote monitoring based, bicentric study (ESC Congress 2025, Madrid)

III. Single- versus dual-chamber ICD discriminators for tachyarrhythmia detection: A remote monitoring based, single-center study (MKT 2025. évi Tudományos Kongresszusa, Balatonfüred)

IV. Arrhythmia detection in atrioventricular, single-lead, floating atrial dipole ICD systems compared to conventional single- and dual chamber defibrillators (MKT 2024. évi Tudományos Kongresszusa, Balatonfüred)

V. Head-to-Head Comparison of Single- Versus Du-al-Chamber ICD Discriminators for Tachyarrhythmia Detection: A Single-Manufacturer, Remote Monitoring-Based Bicentric Study (XV. Aritmia és Pacemaker Kongresszus, Hajdúszoboszló)

1. INTRODUCTION

In the treatment of malignant tachyarrhythmias the role of implantable cardioverter defibrillators (ICDs) is inevitable. Via adequate arrhythmia detection, ICDs are capable to recognize malignant ventricular arrhythmias and terminate them by delivering therapy (in forms of antitachycardia pacing (ATP) and/or shock). However, the identification of tachyarrhythmias is a complex process with the risk of misdetection, which may result in inappropriate therapy delivery. Beside oversensing of cardiac and non-cardiac signals, the main reason of inappropriate therapy delivery is the misidentification of high-frequency supraventricular arrhythmias. To prevent inappropriate therapies, modern cardioverter defibrillators apply discrimination algorithms to differentiate between tachyarrhythmias of supraventricular and ventricular origin: if the detected tachyarrhythmia is classified as supraventricular tachycardia (SVT), therapy delivery will be withheld. Beside tachyarrhythmia discrimination, proper detection of supraventricular arrhythmias has other clinical importance. Modern ICDs are capable to the detect and record atrial tachyarrhythmias (atrial high-rate episodes (AHREs)). Building upon the previous context, the present thesis focuses on two primary topics. First, we aimed to evaluate the atrial arrhythmia detection efficacy of VDD ICD devices, which are distinguished by their special integrated atrial sensing dipole. Our goal was to assess the advantage of this sensing dipole in AHRE detection and its role in tachyarrhythmia discrimination. Second, we analysed the tachyarrhythmia discrimination capabilities of the most widely used device manufacturer in Hungary by conducting a direct, head-to-head comparison between single-chamber and dual-chamber discrimination algorithms. Notably, the clinical relevance of this thesis is grounded in the recognition that selecting the appropriate device type and optimal programming approach can be challenging for physicians, as the underlying scientific evidence is often unclear given a wide variety of ICD models and manufacturer-specific programming options.

1.1. Modern ICD configurations

Based on the number of the implanted leads we distinguish single-chamber (SC) and dual-chamber (DC) ICD devices. VVI ICDs are designed with a right ventricular lead and able to pace and sense in the ventricle. DDD devices utilize both atrial and ventricular leads, enabling pacing and sensing in the atrium and in the ventricle. In addition to conventional VVI and DDD configurations, modern VDD ICD systems are also available (also known as DX ICD). This special device has a ventricular lead equipped with an integrated floating atrial dipole. Although

its pacing function is limited to the ventricle, sensing is not only available in the ventricle, but also in the atrium provided by the floating atrial dipole. Since atrial sensing is available with a single lead implantation in VDD devices, the procedural time and infection risk is decreased compared to conventional DDD ICDs. When an ICD system is supplemented with a left ventricular lead (implanted in the sinus coronarius) aiming cardiac resynchronisation, the device is referred to as a CRT with defibrillator (CRT-D)(Figure 1). Additionally, CRT can be performed using DX systems by incorporating a left ventricular lead alongside the specialized VDD lead (CRT-DX system).

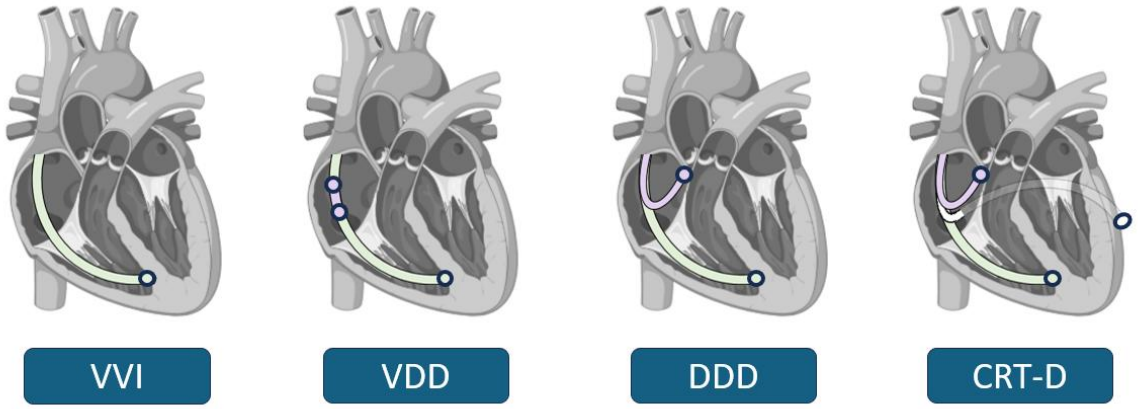

Figure 1. Modern ICD configurations.

1.2. Detection of atrial arrythmias

Proper atrial sensing improves the detection of supraventricular arrhythmias. With AHRE detection, subclinical supraventricular arrhythmias can be identified. As atrial fibrillation is a widespread condition accompanied by increased risk of stroke risk and mortality, its early detection has an undoubtable clinical importance. With early and appropriate detection, optimal medical therapy can be initiated including oral anticoagulant therapy. Furthermore, early steps towards rhythm control therapy (e.g. catheter ablation) can be initiated.

Beside DDD ICDs, VDD systems are also able to provide atrial sensing by the integrated atrial sensing dipole. The sensing dipole evaluates amplified and filtered atrial signals leading to proper and reliable atrial sensing in the long run. Previous studies evaluated the atrial arrhythmia detection capacity of VDD devices compared to VVI and DDD ICD devices. THINGS registry revealed superiority of VDD systems in comparison with VVI ICDs regarding the detection of subclinical atrial fibrillation, as the ability to detect atrial arrhythmias was almost 4 times higher in this group. The SENSE trial provided evidence regarding superiority

of DX systems compared to VVI ICDs in AHRE detection (within a 12 months follow-up period) (13% vs. 5.3%; p=0.026) and revealed non-inferiority of VDD devices in comparison with DDD ICDs (13% vs. 13%; p=1.00). Despite the promising results of these previous studies, the first prospective, multicenter, randomized-controlled trial assessing the subclinical atrial fibrillation detection capacity of VDD ICDs (n=90) compared to VVI ICD devices (n=88) showed only a borderline superiority of DX systems (atrial arrhythmias detected by device, ECG or ECG monitoring HR 2.36; 95% CI 0.73–7.58; p=0.15; atrial arrhythmias detected by device HR 8.39; 95% CI 1.06–66.24; p=0.04).

1.3. Tachycardia discrimination

The two main configurations of tachycardia discrimination algorithms are SC and DC configurations. SC discrimination algorithms analyse exclusively ventricular signals, whereas DC discriminators evaluate both atrial and ventricular activity, enabling comparison of atrial and ventricular frequency and assessment of atrioventricular (AV) synchrony. By their nature, DC algorithms are applicable only to dual-chamber devices (VDD and DDD ICDs). Conversely, SC discrimination is programmable both in SC (VVI ICD) and DC devices (VDD and DDD ICDs). The most recent expert consensus statement on ICD programming (published by HRS/EHRA/APHRS/SOLAECE) recommends the programming of SC vs. DC discrimination algorithms determined by the number of the implanted leads. Notably, the consensus statement emphasizes that the capability to extend discrimination with DC algorithms alone should not be considered an indication for implanting an additional atrial lead, in the absence of other clinical indications for atrial sensing or pacing. This is based on the assumption that, despite the additional information and enhanced discrimination capabilities provided by the atrial lead, the implantation of an extra lead lengthens the implantation procedure and also increases the risk of short-term and long-term complications.

Even though the core principles of tachycardia discrimination are similar in most of the ICD devices, each manufacturer has individual algorithms with manufacturer-specific features. Since the studies forming the basis of this dissertation primarily involved Biotronik (Berlin, Germany) devices, a more detailed presentation of the discrimination algorithms employed by this manufacturer will be described. Single-chamber discrimination of modern Biotronik ICDs involves stability, sudden onset and morphology-based discrimination (MorphMatch algorithm).

The DC discrimination configuration of Biotronik is known as SMART algorithm. This multilevel discrimination system integrates different discrimination algorithms accompanied by frequency analysis of both atrial and ventricular rates. The possible applied algorithms include stability, sudden onset and algorithms that evaluate AV synchrony (AV trend and AV regularity). A so-called multiplicity algorithm is also available, which is useful in the identification of atrial flutter as it can identify atrial arrhythmias with a fixed ratio of A:V frequency (e.g. atrial flutter with 2:1 AV ratio).

The comparative efficacy of SC vs. DC discrimination remains a subject of ongoing debate, due to the limited and controversial data in the literature, which challenges the assumed superiority of DC algorithms. Discrimination algorithms are under constant development and expert opinion suggests, that modern morphology-based SC discrimination algorithms may achieve similar efficacy as DC configurations. However, it is important to note that many previous studies (even the latest meta-analysis) regarding tachyarrhythmia discrimination involved outdated ICDs with old-fashioned discrimination algorithms. Moreover, the available studies usually included devices from different manufacturers. As switching between a specific manufacturer's SC and DC discrimination is possible in DC ICDs during the follow-up, the importance of studies focused on a single manufacturer should be highlighted. The aforementioned reprogramming may be considered when the original discrimination settings failed appropriate arrhythmia detection and resulted in inappropriate therapy delivery.

1.4. The evaluated device spectrum of our work

Modern implantable cardioverter defibrillators encompass a broad range of devices that share common features but also include manufacturer-specific characteristics as described above. In our work, we primarily focused on modern Biotronik devices, as Biotronik is traditionally the most commonly applied manufacturer in Hungary and the sole manufacturer of VDD systems.

2. OBJECTIVES

2.1. We aimed to evaluate the arrhythmia detection and discrimination efficacy of VDD ICDs. To assess the clinical advantages of the floating atrial dipole integrated in these systems, we performed a comparison with conventional single- (VVI) and dual-chamber (DDD) defibrillators focusing on the performance in new-onset atrial arrythmia detection and on the efficacy in malignant tachyarrhythmia detection.

2.2. Our second goal was to evaluate the efficacy of single- versus dual-chamber discrimination algorithms in malignant tachyarrhythmias by performing a direct, head-to-head comparison using remote monitoring-based data.

3. METHODS

3.1. Arrhythmia detection and discrimination efficacy of VDD ICDs

3.1.1. Patient population and baseline characteristics

We retrospectively collected data from consecutive patients undergoing ICD implantation between 2009 and 2023. The devices were implanted with standard indications in the Cardiology Center of the University of Szeged. ICDs from different manufacturers were included and CRT devices were excluded from the analysis. We gathered baseline clinical characteristics like age, gender, ICD indication (i.e., primary or secondary), ischemic etiology, previously diagnosed atrial fibrillation, hypertension, dyslipidaemia, diabetes mellitus previous stroke/transient ischemic attack (TIA), left ventricular ejection fraction (LVEF) and NYHA classification. Data regarding ICD implantation were also collected including bradypacing indication and manufacturer of the implanted device. We analysed baseline ECG and laboratory parameters: QRS width, heart rate, creatinine and hemoglobin values. Moreover, the application of remote monitoring was also assessed. Baseline medical therapy was also collected. The study was approved by the Institutional Review Board (IRB) of the University of Szeged (No. 4870) and it conforms to the ethical guidelines of the Declaration of Helsinki.

3.1.2. Endpoints of interests

We created 3 groups according to the implanted device type: VVI, VDD and DDD ICD groups. The primary outcome was the incidence of the first device detected atrial arrhythmia: regarding this outcome we included patients with paroxysmal or persistent atrial fibrillation (patients with permanent atrial fibrillation were excluded) and collected episodes of new-onset atrial fibrillation (or atrial flutter). Our secondary endpoints were atrial (at 6 months after implantation and at the end of follow-up) and ventricular sensing parameters (at 6 months after implantation), atrial and ventricular pacing percentages (at 6 months after implantation), incidence of appropriate and inappropriate ICD therapy (ATP and/or shock), incidence of hospitalization due to arrhythmic or heart failure events and all-cause mortality. Detailed reasons of arrhythmia-related hospitalizations were evaluated involving acute admissions due

to arrhythmic events, device-related problems and hospital admissions aiming rhythm control of atrial fibrillation or flutter (i.e., electrical cardioversion (ECV), catheter ablation of atrial fibrillation/flutter). Complication rates were also assessed (short-term and long-term complications), including pneumothorax, bleeding, thrombosis, lead- or device-related complications, repeated surgery, and CIED-related infections.

3.2. Tachycardia discrimination efficacy of SC vs. DC discriminators

3.2.1. Patient population and baseline characteristics

Data were collected from to two tertiary referral centers (Cardiology Center, University of Szeged, Szeged, Hungary; Department of Cardiology, Central Hospital of Northern Pest–Military Hospital, Budapest, Hungary). We retrospectively analysed all consecutive patients who underwent an ICD implantation from a single manufacturer (Biotronik) and were remotely followed up via the Home Monitoring® (HM) system. Patients were registered in the HM system between 2009 and 2024.

Baseline clinical characteristics included age at ICD implantation, time from ICD implantation to HM registration, gender, ICD indication (i.e., primary or secondary), chronic coronary syndromes, structural heart diseases, hypertension, previously diagnosed atrial fibrillation or atrial flutter, diabetes mellitus, prior stroke/TIA and LVEF. We also gathered the implanted device types (VVI, VDD, DDD, CRT-D), the applied discrimination algorithms (ie., SC or DC) and indications for antibradycardia pacing. Baseline ECG and laboratory parameters were also assessed: QRS morphology, heart rate, creatinine, estimated glomerular filtration rate (eGFR) and hemoglobin values. Baseline medical therapy was also evaluated, and ICD sensing parameters (at HM registration) and pacing percentages (at one month after HM registration) were collected. Additionally, we registered the baseline detection limits of the different VT zones. The study was approved by the Institutional Review Board (IRB) of the University of Szeged (No. 5514) and it conforms to the ethical guidelines of the Declaration of Helsinki.

3.2.2. Endpoints of interests

Based on the applied discrimination algorithm patients were divided into two groups: SC and DC discrimination group. If the discrimination algorithm was reprogrammed during follow-up – such as a switch between SC and DC configurations – patient data were analysed only until the original settings remained unchanged. The primary outcome was the time to first inappropriate therapy (resulted in ATP and/or shock delivery) completed with separate analysis

of first inappropriate therapies that resulted in ATP delivery alone and therapies that resulted in ATP + shock delivery. Our secondary endpoints were the time to first appropriate ICD therapy and all-cause mortality. We also performed a sensitivity analysis including only a subgroup of SC patients with active morphology discrimination to assess the risk of inappropriate therapy compared to the DC group. A subgroup analysis was also conducted within the DC group, comparing the incidence of inappropriate therapies between patients with VDD vs. DDD devices.

3.3. Statistical analysis

Statistical analysis was performed by using SPSS Statistics (version 27 and 29, IBM, Armonk, NY, USA). Continuous variables are expressed as "mean±standard deviation (SD)" or "median (first quartile (Q1)-third quartile (Q3))" forms and categorical variables as numbers (percentages). Given three groups in the evaluation of VDD ICD efficacy (compared to VVI and DDD ICDs), for the comparison of continuous variables we performed one-way analysis of variance (ANOVA). Notably, in case of non-normal distribution Kruskal-Wallis test was used. Comparing two groups, for the evaluation of continuous variables, we conducted independent samples t-test (or Mann-Whitney U test if the distribution of variables was non-normal). Categorical variables were assessed by Chi-squared test.

We applied time-to-event analysis in both main objectives to evaluate the following parameters accordingly: incidence of the first device-detected atrial arrhythmia, risk of appropriate/inappropriate therapies, all-cause mortality, risk of hospitalization due to arrhythmic causes and risk of hospitalization due to heart failure causes. Time-to-event analysis was performed calculating hazard ratios (HR) along with 95% confidence intervals (CI). Statistical significance was determined as a p-value ≤ 0.05. In most of the cases, time-to-event analysis was completed with a multivariate model. All predictor variables, which were considered potentially impactful regarding the evaluated parameter underwent a univariate analysis. All predictor variables that showed an association of potential statistical relevance ($p \leq 0.1$) in the univariate analysis were subsequently included in the multivariate model. Evaluating the performance of VDD ICD, device type was included in the multivariate models regardless of the significance in the univariate analysis. Similarly, in the head-to-head comparison of SC vs. DC discriminators, the discrimination algorithm was involved in all of the multivariate models independently of its significance in the univariate analysis (and device type was included in the multivariate model of the predefined subgroup analysis accordingly).

4. RESULTS

4.1. Arrhythmia detection and discrimination efficacy of VDD ICDs

4.1.1. Baseline clinical characteristics

256 patients were included with a mean follow-up time of 3.7 years. Mean age was 64 years, 75% were male, and two third of the patients (61%) had ischemic etiology. The distribution of the implanted device types was as follows: 93 VVI, 94 VDD and 69 DDD ICD systems. 28% of the devices were implanted with a primary prophylactic indication.

Majority of baseline clinical characteristics were similar across the VVI, VDD and DDD ICD groups. The prevalence of dyslipidaemia was lower in the DDD group, but the mean LVEF was higher compared to the other groups. Bradycardia indication was more prevalent in DDD group, accompanied by decreased heart rate and broader QRS complexes. As Biotronik is the sole manufacturer of VDD ICD 98% of the VDD ICDs were implanted with a generator from this manufacturer. In the remaining two cases a St. Jude Medical (SJM)/Abbott (Chicago, USA) or a Sorin (New York, USA) generator was connected to the previously implanted VDD leads. In the VVI and DDD groups Biotronik, Boston Scientific (Marlborough, USA), Medtronic (Minneapolis, USA) and SJM generators were applied. Remote monitoring system was most frequently used in the VDD group.

4.1.2. Clinical outcomes

4.1.2.1. Device-detected atrial arrhythmias

The incidence of new-onset device detected atrial arrhythmias was significantly higher in the VDD group compared to the VVI group (adjusted hazard ratio (aHR) 7.087; 95% CI 2.371–21.183; $p<0.001$). The efficacy of atrial arrhythmia detection in VDD ICDs was non-inferior to conventional DDD devices (aHR 1.781; 95% CI 0.737–4.301; $p=0.200$)(Figure 2). The distribution of the detected atrial arrhythmias (e.g. paroxysmal or persistent atrial fibrillation, regular atrial arrhythmias) did not differ among the groups ($p=0.609$).

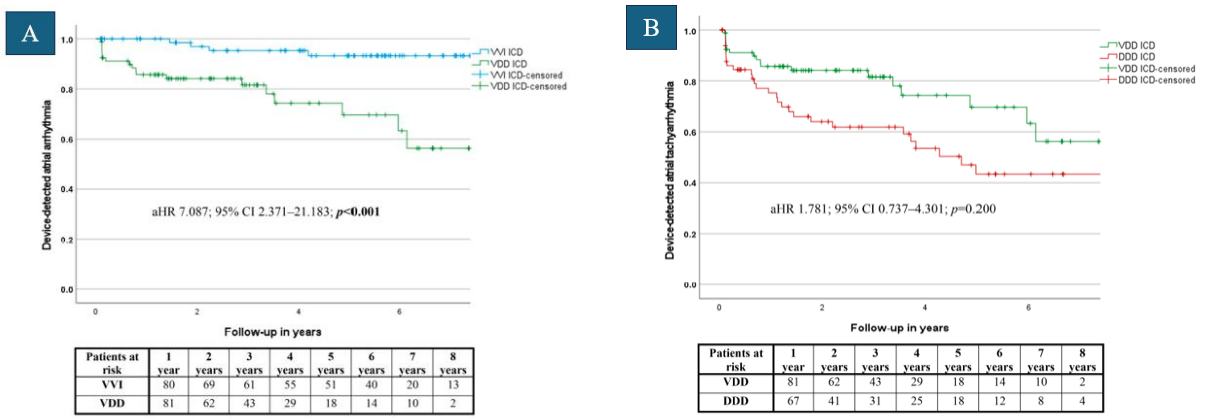

Figure 2. (A) Time to first device-detected atrial arrhythmia – VVI vs. VDD. **(B)** Time to first device detected atrial arrhythmia – VDD vs. DDD.

4.1.2.2. Sensing ang pacing parameters

Atrial sensing was higher in the VDD ICDs compered to DDD devices at both evaluated occasions: 6 months after implantation (5.3 ± 3.7 vs. 3.1 ± 2.1 mV; p<0.001) and at the end of the follow-up (4.2 ± 3.2 vs. 2.7 ± 1.8 mV; p=0.009). Ventricular sensing at 6 months was similar in the three groups (VVI 12.8 ± 4.8 vs. VDD 14.0 ± 6.0 vs. DDD 13.2 ± 5.7 mV; p=0.313). In the DDD group, mean atrial pacing percentage was 23% at 6 months. Ventricular pacing percentage was highest in DDD group (VVI 2.2 ± 7.0 vs. VDD 2.8 ± 14.4 vs. DDD 33.6 ± 41.9%; p<0.001).

4.1.2.3. Complications

Numerically, complications were more frequently observed in the DDD group (20%), while the rates were 13% in the VDD group and 8% in the VVI group (p=0.056). We also performed a subgroup analysis, which detected a significant difference between the complication rates of VVI and DDD devices (p=0.017), but not between the VVI and VDD (p=0.236) or VDD and DDD groups (p=0.195).

4.1.2.4. Tachyarrhythmia discrimination

The risk of appropriate (aHR 0.983; 95% CI 0.641–1.508; p=0.937) and inappropriate ICD therapies (aHR 0.742; 95% CI 0.313–1.757; p=0.497) were similar between VVI and VDD devices. Furthermore, the comparison of VDD and DDD ICDs revealed no difference in the risk appropriate (aHR 0.651; 95% CI 0.371–1.142; p=0.135) and inappropriate ICD therapy delivery (aHR 0.618; 95% CI 0.203–1.878; p=0.396).

4.1.2.5. Arrhythmia and heart failure-related hospitalization

The risk of hospitalization due to arrhythmic causes was elevated in VDD group compared to patients with VVI devices (aHR 1.706; 95%CI 1.043–2.792; p=0.033). Notably, arrhythmia-caused hospitalization was similar in VDD and DDD groups (aHR 0.700; 95% CI 0.365–1.341; p=0.282).

The risk of heart failure-related hospitalization was similar both in VVI vs. VDD (aHR 1.628; 95% CI 0.619–4.279; p=0.323) and VDD vs. DDD (aHR 0.949; 95% CI 0.301–2.991; p=0.928) comparisons.

4.1.2.6. All-cause mortality

All-cause mortality did not differ among the three groups (VVI vs. VDD vs. DDD aHR 0.960; 95% CI 0.711–1.295; p=0.787).

4.2. Tachycardia discrimination efficacy of SC vs. DC discriminators

4.2.1. Baseline clinical characteristics

We included 557 patients with a median follow-up time of 2.4 (1.1–3.6) years. The distribution of the implanted device types was as follows: 76 VVI, 226 VDD, 76 DDD ICD and 179 CRT-D systems. 124 ICDs were programmed to utilize SC discrimination and 433 were assigned to the DC discrimination group. Within the SC group, 47 ICDs (39%) applied active morphology discrimination (i.e. MorphMatch algorithm).

The median age of the patients was 65 (55-72) years. 77% of the patients were male, 49% had chronic coronary syndromes and 39% were previously diagnosed with atrial fibrillation (or flutter). ICDs were implanted with a primary prophylactic indication in 58% of cases.

The median age was higher in the SC group and the prevalence of atrial fibrillation or flutter and hypertension were increased in this group. The history of diabetes mellitus and prior stroke/TIA did not differ among the groups. Primary prophylactic indication was more common in the DC group (61% vs. 46%). The prevalence of bradypacing indication was similar between the groups, however the distribution of underlying conduction disorders varied: atrioventricular (AV) block was more common in the SC group, whereas sick sinus syndrome was more frequently observed in the DC group. Baseline median left ventricular ejection fraction (35%

vs. 30%, p=0.002) was higher in the SC group. Baseline ECG parameters and laboratory values showed no differences among the SC and DC groups.

4.2.2. Sensing/Pacing parameters and VT zone settings

Atrial sensing values were similar among SC and DC discrimination groups at time of HM registration (5.7 [3.4–6.8] mV vs. 4.1 [2.4–6.3] mV; p=0.166). Baseline ventricular sensing values (14.6 [9.4–19.5] mV vs. 16.9 [12.0–20.0] mV; p=0.016) and ventricular pacing percentages were higher in the DC group in comparison with the SC group (0 [0–21]% vs. 1 [0–96]%; p=0.002).

The baseline lower detection limit for the VT1 zone was comparable between the SC and DC groups (340 [330–375] ms vs. 340 [330–360] ms). The lower limit for the VT2 zone was slightly higher in the DC group (320 [290–340] ms vs. 300 [290–320] ms). For the VF zone, the lower detection limit was again similar between groups, at 260 [253–280] ms in the SC group and 260 [250–280] ms in the DC group.

4.2.3. Clinical outcomes

4.2.3.1. Inappropriate therapies

The incidence of inappropriate therapies was 3.2% (0.01% per patient-year) in the SC and 4.4% (0.01% per patient-year) in the DC discrimination group. We revealed also no difference in the risk of inappropriate therapies between the SC and DC discrimination groups on the time-to-event analysis (HR 1.165; 95% CI 0.393–3.448; p=0.783; adjusted HR 1.152; 95% CI 0.387–3.433; p=0.799)(Figure 3). Furthermore, the comparison of inappropriate therapies resulted in ATP delivery alone (HR 1.264; 95% CI 0.365–4.377; p=0.712) and inappropriate therapies resulted in ATP + shock delivery (HR 0.871; 95% CI 0.091–8.372; p=0.905) showed no difference between the SC and DC discrimination groups.

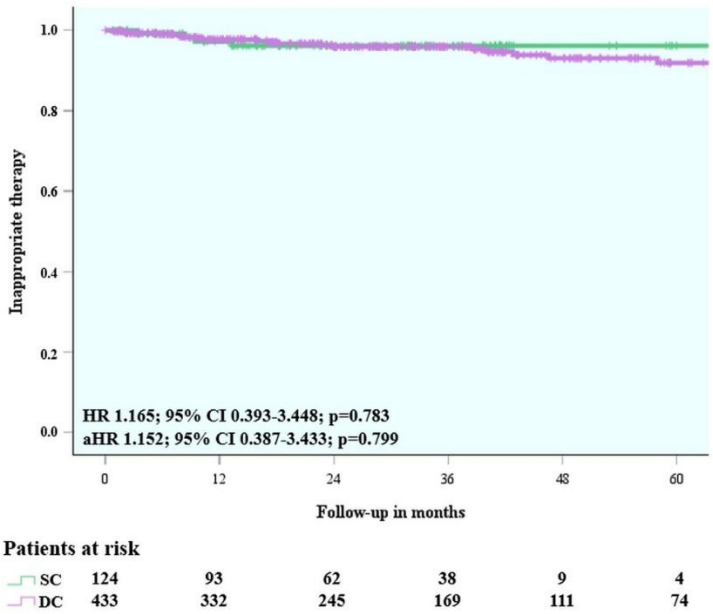

Figure 3. Time to first inappropriate therapy – single-chamber vs. dual-chamber.

Moreover, we detected no difference in the risk of inappropriate therapies in the predefined sensitivity analysis comparing the SC algorithm with activated morphology discrimination to the DC algorithm (HR 1.809; 95% CI 0.241–13.577; p=0.564; adjusted HR 1.571; 95% CI 0.208–11.851; p=0.661). In the predefined subgroup analysis, no difference was observed in the risk of inappropriate therapies between patients with VDD devices and those with DDD devices, both utilizing DC discrimination (HR 0.586; 95% CI 0.230–1.490; p=0.262; adjusted HR 0.597; 95% CI 0.226–1.579; p=0.299).

4.2.3.2. Appropriate therapies

The rate of appropriate therapies was also comparable between the SC and DC discrimination groups (15.3% (0.07% per patient-year) vs. 12.9% (0.04% per patient-year))(HR 0.724; 95% CI 0.428–1.224; p=0.228; adjusted HR 0.699; 95% CI 0.389–1.257; p=0.232).

4.2.3.3. All-cause mortality

All-cause mortality also did not differ among the SC and DC discriminator groups (21.6% (0.09% per patient-year) vs. 26.6% (0.09% per patient-year))(HR 0.930; 95% CI 0.598–1.448; p=0.749; adjusted HR 0.714; 95% CI 0.426–1.197; p=0.201).

5. CONCLUSIONS

1. VDD ICD systems demonstrated superior atrial arrhythmia detection compared to conventional VVI devices and achieved comparable efficacy to conventional DDD devices.

2. To the best of our knowledge, this study was the first to show significantly higher atrial sensing values in DX systems compared to DDD devices.

3. The tachyarrhythmia discrimination performance of VDD devices was comparable to that of traditional VVI and DDD systems.

4. Our results indicate that the primary advantage of VDD systems lies in their enhanced atrial arrhythmia detection, facilitated by the integrated sensing dipole. These devices enable reliable atrial sensing through a single-lead implantation, thereby reducing complication rates relative to DDD systems.

5. Our head-to-head comparison of SC vs. DC discrimination algorithms revealed similar efficacy in malignant tachyarrhythmia detection. To the best of our knowledge, this was the first study to perform a direct comparison of discrimination algorithms in Biotronik devices.

6. Based on our findings, SC discrimination – particularly when morphology-based algorithm is available – constitute a viable and effective alternative even for patients with dual-chamber devices.

7. Based on results, we developed a programming recommendation for tachyarrhythmia discrimination in dual-chamber Biotronik devices.

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I look forward to continuing my scientific work with enthusiasm.