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Atrioventricular and ventricular-to-ventricular programming in patients with cardiac resynchronization therapy: results from ALTITUDE

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Abstract

Purpose—Cardiac resynchronization therapy (CRT) improves outcomes in patients with heart failure, yet response rates are variable. We sought to determine whether physician-specified CRT programming was associated with improved outcomes.

Methods—Using data from the ALTITUDE remote follow-up cohort, we examined sensed atrioventricular (AV) and ventricular-to-ventricular (VV) programming and their associated outcomes in patients with *de novo* CRT from 2009–2010. Outcomes included arrhythmia burden, left ventricular (LV) pacing, and all-cause mortality at 4 years.

Results—We identified 5709 patients with *de novo* CRT devices; at the time of implant, 34 % ($n=1959$) had entirely nominal settings programmed, 40 % ($n=2294$) had only AV timing adjusted, 11 % ($n=604$) had only VV timing adjusted, and 15 % ($n=852$) had both AV and VV adjusted from nominal programming. Suboptimal LV pacing (<95 %) during follow-up was similar across groups; however, the proportion with atrial fibrillation (AF) burden >5% was lowest in the AV-only adjusted group (17.9 %) and highest in the nominal (27.7 %) and VV-only adjusted (28.3 %)

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groups. Adjusted all-cause mortality was significantly higher among patients with non-nominal AV delay >120 vs. <120 ms (adjusted heart rate (HR) 1.28, $p=0.008$) but similar when using the 180-ms cutoff (adjusted HR 1.13 for >180 vs. 180 ms, $p=0.4$).

Conclusions—Nominal settings for *de novo* CRT implants are frequently altered, most commonly the AV delay. There is wide variability in reprogramming. Patients with nominal or AV-only adjustments appear to have favorable pacing and arrhythmia outcomes. Sensed AV delays less than 120 ms are associated with improved survival.

Keywords

Cardiac resynchronization therapy; Optimization; Programing; Outcomes

1 Introduction

Cardiac resynchronization therapy (CRT) improves symptoms and survival in patients with refractory heart failure and conduction delay [1]. However, there is extensive variability in clinical response rates following CRT, with up to one third of patients deriving little or no clinical benefit [2]. Many studies have attempted to identify clinical predictors of response, including baseline electrocardiographic morphology, QRS duration, heart failure etiology, New York Heart Association class, and advanced echocardiographic parameters [3]. Additional studies have assessed the efficacy of electrocardiographic algorithms, echocardiography, or invasive assessments to determine ideal settings [4, 5]. Preliminary data suggested significant benefit to patient-specific optimization of atrioventricular (AV) timing and ventricular-to-ventricular (VV) timing [5, 6], yet subsequent clinical trials of an electrogram-based algorithm and echocardiography to determine optimal AV activation did not demonstrate clinical superiority for the endpoint of left ventricular end-systolic volume [7]. Therefore, providers are largely left to their own judgment as to the ideal programming for AV and VV delays in CRT patients.

While “nominal” values for AV timing and VV timing are preset by the manufacturer, operators may adjust or tailor these intervals at the time of implant to suit each specific patient. However, it is unknown how often this is done. Furthermore, it remains unclear if poor response can be partially explained by a “one-size-fits-all” approach to timing settings. Accordingly, we conducted a retrospective analysis of patients who underwent *de novo* CRT-D device and were enrolled in the ALTITUDE clinical science program. The objective of the study was to assess the use of physician-adjusted timing settings (versus nominal) in patients undergoing CRT, and their association with clinical outcomes. We hypothesized that physician-adjusted settings would be associated with improved biventricular pacing percentage and improved survival.

2 Methods

The design and methods of the ALTITUDE research program have been described previously [8]. Briefly, beginning in 2006, the ALTITUDE study has been updated with data from the LATITUDE US remote monitoring system (Boston Scientific, Natick, MA) for clinical research purposes. Uploaded LATITUDE data include device parameters, clinical

diagnostics, and episodes. Participation in the ALTITUDE initiative is elective and governed by a data use agreement allowing for the use of such de-identified data for research purposes in accordance with Health Insurance Portability and Accountability Act regulations. Less than 10 % of LATITUDE centers decline to contribute data to ALTITUDE [8].

The goal of the present analysis was to analyze non-nominal programming of CRT devices. Therefore, for the purpose of this study, the dataset was limited to *de novo* implants of a single model device (Boston Scientific Cognis N118 & N119), during a single implant period (2009–2010). Patients without functional biventricular pacing leads, those without programming settings available at implant, or without LATITUDE transmission within 6 months of implant were excluded. Finally, patients programmed to bradycardia modes other than DDD or DDDR were excluded.

We subsequently characterized CRT programming at implant (or within 10 days) and stratified patients by changes from nominal: (1) no change (all nominal settings), (2) sensed AV-only adjusted (hereafter “AVonly”), (3) VV-only adjusted, and (4) both sensed AV and VV adjusted. Since most CRT patients are atrially sensed, we utilized sensed AV delays (vs. paced AV delays) for the primary analyses. Notably, automatic algorithms such as Smart-AV are implemented at the level of the programmer, and therefore, only the resulting AV delays are included here. Baseline characteristics and other device programming parameters for these patients were compared. Distributions of programmed timing intervals were assessed relative to nominal values (180 ms for paced and 120 ms for sensed AV timing; 0 ms for VV timing). Additionally, analyses of sensed AV timing were conducted with binary stratification at (a) <120 vs. >120ms (excluding patients set to the nominal value, 120 ms) and (b) 180 vs. >180 ms.

As an assessment of baseline rhythm characteristics, device parameters and arrhythmias were measured within the first 6 months after implant (among patients with a LATITUDE transmission during that period). These included heart rate variability (HRV) parameters, patient activity, left ventricular (LV) pacing percentage, atrial fibrillation (AF) burden, and ventricular tachyarrhythmia therapies, each as measured by the device.

Follow-up was censored at last LATITUDE transmission. Arrhythmia outcomes at follow-up were shock or anti-tachycardia pacing for ventricular tachyarrhythmias and changes in LATITUDE parameters. Changes in these parameters were calculated between the initial 6-month post-implant period and subsequent follow-up and included changes in patient activity, burden of AF, percent LV pacing, and HRV parameters (footprint, standard deviation of the average NN intervals [SDANN], and mean heart rate). Clinical outcome was measured as all-cause mortality and identified by cross-reference with the US Social Security Death Index (with surveillance out to 12 months after last follow-up).

2.1 Statistical methods

Pairwise comparisons of data across groups were tested using a *t* test for continuous variables, or a Wilcoxon rank-sum test for variables with extremely skewed distributions, or a chi-square test for categorical variables.

Landmark analyses were conducted, including all patients who survived at least 90 days post-implant. For these patients, day 0 was set at 90 days post-implant, and Kaplan-Meier curves of survival by group were plotted out to four subsequent years. For multivariable adjustment, a Cox proportional hazard model of time to death was used and adjusted for age, gender, defibrillation threshold (DFT) testing at implant, number of treatment zones, brady programming of DDD, LRL, VF detection rate, AF burden, LV pacing, and shock therapy.

2.2 Sensitivity analyses

To identify the durability of programming modifications at implant, we assessed the frequency of subsequent programming changes during follow-up. Additional, identical landmark analyses for the mortality were also repeated only for patients with HRV data, with the additional variables SDANN, footprint, and mean heart rate adjusted for in the Cox model.

The study complies with the Declaration of Helsinki, and informed consent was waived under the common rule. All analyses were performed using SAS version 9.3.

3 Results

3.1 Baseline characteristics

After exclusions (Fig. 1), the final analysis population included 5709 patients. Among these patients, 34 % ($n=1959$) had entirely nominal settings programmed, 40 % ($n=2294$) had only AV timing adjusted, 11 % ($n=604$) had only VV timing adjusted, and 15 % ($n=852$) had both AV and VV adjusted from nominal programming at the time of implant. Baseline characteristics of these groups are shown in Table 1. Age, gender, and defibrillation threshold testing were roughly similar across programming strategies. Patients with AV adjustment were less frequently programmed with rate-responsive bradycardia pacing modes (60 % DDD vs. 40 % DDDR), whereas pacing mode was more balanced among patients with nominal AV and VV timing, and in patients with any VV adjustment. Programming of ventricular tachyarrhythmia detection and therapy was similar across CRT programming groups.

3.2 Distribution of AV and VV intervals

Distributions of AV and VV times, over the entire cohort, are shown in Fig. 2a, b. Nearly 80 % of patients had VV programmed to the nominal value (0 ms), whereas the nominal sensed AV delay was used in 30%. There appeared to be more heterogeneity in programming of AV timing versus VV timing, including use of long AV delays. Programming changes during follow-up occurred in approximately one third of patients in each baseline group (nominal, AV-only, VV-only, and both adjusted; Supplemental Material).

3.3 Heart rhythm and pacing outcomes within 6-months of implant

Baseline rhythm characteristics within 6 months of implant are shown in Table 2. Overall, patient activity was low (6–7 %), although it was higher in the AV adjusted group. HRV was similar across all four groups as demonstrated by multiple indices. During this initial period, AF burden >5 % was 11–12 % in patients with any AV adjustment, and 22–23 % in patients with all nominal or VV-only adjusted settings. Patients were atrially paced a

minority of the time, across groups. Suboptimal LV pacing (<95 %) was highest in the nominal (17.6 %) and AV-only adjusted (17.7 %) groups. Overall, 6–7 % experienced a shock within 6 months of implant.

3.4 LATITUDE parameters during follow-up

Overall, mean follow-up was 2.5 ± 1.1 years across CRT programming strata. Patients in the AV-only adjusted group had increased activity (7.5 vs. 6.9–7.3 % for other groups) and increased measures of HRV compared with other programming groups (Table 3). Burden of AF remained lowest in patients with AV-only adjusted, but the increase in AF burden was similar across groups. Proportion of patients with <95 % LV pacing was lowest in the nominal and AV-only adjusted groups (approximately 17%), compared with VV-only adjusted (19.2 %) and both adjusted (18.5 %). For both anti-tachycardia pacing and shocks, patients with both AV and VV adjusted had the highest rates (32.7 % with ATP, 16.7 % with shocks).

3.5 Mortality

Unadjusted mortality was 18.6 % for patients with nominal settings at baseline, 19.1 % among those with AV-only adjustment, 20.7 % in patients with VV-only adjustment had the worst survival, and 19.2 % in patients with both AV and VV adjusted (P=NS for each pairwise comparison vs. nominal). Results of the Cox proportional hazards adjustment for all-cause mortality are shown in Fig. 3. After adjustment, risk of mortality was similar between patients programmed nominally and those with AV-only adjustment (adjusted heart rate (HR) 1.05 for AV-only vs. nominal; 95 % confidence interval (CI) 0.91–1.22). There was slightly higher mortality in patients with VV-only adjustment (adjusted HR 1.09 vs. nominal, 95 % CI 0.88–1.34) and in those with both AV and VV adjustment (adjusted HR 1.08 vs. nominal, 95% CI 0.89–1.30); however, none of the differences were statistically significant. Results of multivariable models for all-cause mortality adjusted for HRV yielded results similar to the primary analysis (Supplemental Material).

3.6 Short versus long AV delays

Survival results according to short and long AV delay programming are shown in Figs. 4 and 5. When stratifying by AV adjustment (<120 ms [1046/3146, 33 %] vs. >120 ms [2100/3146, 67 %]; 180 ms [4674/4953, 94 %] vs. >180 ms [279/4953, 6 %]), unadjusted mortality consistently favored patients with short AV timing (15.6 % for <120 ms vs. 21 % for >120 ms, $p=0.0003$; 16.2 % for 180 ms vs. 21.8 % for >180 ms, $p<0.0001$). In adjusted analyses, mortality remained significantly lower for patients with AV delay <120 ms (adjusted HR 1.28 vs. >120 ms, 95 % CI 1.06–1.53, $p=0.0083$) but was similar for patients with AV delay 180 ms (adjusted HR 1.13 vs. >180 ms, 95 % CI 0.86–1.49, $p=0.4$).

3.7 Sensitivity analysis

In sensitivity analyses, findings were consistent when using paced AV delay settings, instead of sensed AV delay (see Supplemental Material). However, among patients with non-nominal paced AV delay (180ms), there did not appear to be a survival advantage of short, paced AV delays (<120 or <180 ms).

4 Discussion

We examined *de novo* CRT programming in more than 5700 patients enrolled in remote monitoring. Based upon these analyses, there are three primary findings. First, AV and VV intervals are often adjusted, and these changes are highly variable. Second, nominal programming and AV adjustment only are associated with improved biventricular pacing percentage and lower atrial arrhythmia burden. Despite differences in pacing and arrhythmia outcomes, survival was not significantly different according to AV and VV adjustment. Finally, and perhaps most importantly, there may be a survival advantage to short, sensed AV delay programming (<120 ms), and this strategy deserves a prospective, randomized trial.

The optimal programming of AV and VV timing for patients with CRT is not known. Optimization using either advanced imaging or invasive hemodynamics has improved response rates and outcomes in some studies [5, 6]. However, complex electrocardiographic algorithms to set the AV delay, such as Smart-AV and QuickOpt, have failed to “optimize” response rates in randomized controlled trials [7, 9]. The conflicting data have led many to conclude that a highly individualized approach is warranted, and there are data to support improved outcomes for patients managed in an “optimization” clinic [10]. Yet such clinics are not universally available nor are they uniformly implemented. Therefore, most implanting physicians must attempt to identify the ideal settings on their own, often at the time of implant. However, additional, device-based algorithms with continuous optimization, such as AdaptiveCRT, may help still prove helpful in reducing non-responder rates [11, 12]. In the absence of additional, randomized data, shorter AV delays may be preferable in empiric CRT programming.

Overall, more than 70 % of the CRT population had some alteration from nominal values at implant, and one third of the remaining patients had modifications during follow-up. Modification of the nominal sensed AV delay was most common, with or without VV adjustment (VV-only modification accounted for a minority of patients). The use of long AV delays was common in these patients with new CRT, and patients in whom only the AV delay was modified from base-line appeared to have favorable arrhythmia outcomes.

When not selecting the nominal value (120 ms), providers used a variety of settings above and below 120 ms. Recent data from the MADIT-CRT trial suggest that short AV delays (<120 ms) are associated with improved clinical outcomes, including reductions in heart failure and death [13]. In ALTITUDE, AV adjustment was associated with improved arrhythmia outcomes including lower AF burden and greater biventricular pacing percentage. Furthermore, among patients who were programmed non-nominal, a short AV delay (<120 ms) was associated with significantly lower all-cause mortality. In contrast to the closely controlled environment of the MADIT-CRT randomized clinical trial, these data are from a nationwide, observational cohort and yield consistent findings. While some have suggested that the association between short AV delays and improved survival is due to the selection of healthier patients with shorter AV delays [14], the consistency of this finding across different clinical settings and different populations lends further support to the hypothesis that shorter AV delays may lead to improved CRT treatment effects. However,

additional study of the impact of AV programming on clinical outcomes in prospective clinical trials is warranted prior to broadly implementing this strategy in clinical practice.

In programming of VV timing, the predominant use of 0 ms LV offset contradicts studies demonstrating -40 ms may improve outcomes in many patients [1, 15]. However, a minority of patients, either initially or at follow-up, had VV timing adjustment and it appears that patients who did tended to have worse clinical outcomes. While this may represent more aggressive care for patients with worse underlying disease or suboptimal lead position, it may also reflect deleterious consequences of poor VV timing and another opportunity to improve response rates.

Lastly, the use of programming strategies to suppress AF remains of great interest. Our data demonstrate higher rates of significant AF in patients programmed nominally or with VV-only adjustment vs. those with any AV adjustment. This difference persisted during follow-up. Since we excluded patients programmed to VVI, all of the patients in our cohort had the opportunity for AV timing adjustment, and this may contribute to lower rates of AF. The recent results of the MINERVA study demonstrated the potential for device programming interventions to alter AF progression [16], and such interventions could be of great benefit to the high-risk population of patients with heart failure and AF being treated with CRT. However, we cannot exclude the possibility that this effect is due to baseline arrhythmias (e.g., high AF burden) influencing subsequent programming.

5 Limitations

This study utilized a national database of patients enrolled in remote follow-up from centers consenting to participate in voluntary de-identified data-sharing scientific program. Thus, it is limited in the data elements captured and may represent a selected cohort that is not generalizable to CRT patients followed without remote monitoring. Furthermore, arrhythmia episodes are device-identified, without physician adjudication. Given the observational nature of our study, in order to account for potential confounding, we utilized multivariable adjustment. The adjustment methods included the use of heart rate variability, a factor strongly associated with all-cause survival; however, it is possible that residual confounding exists.

6 Conclusions

Nominal device programming settings are frequently modified in patients undergoing *de novo* implant of CRT devices. Though programmed timing is highly variable, AV adjustment is the most common and appears to be associated with improved survival.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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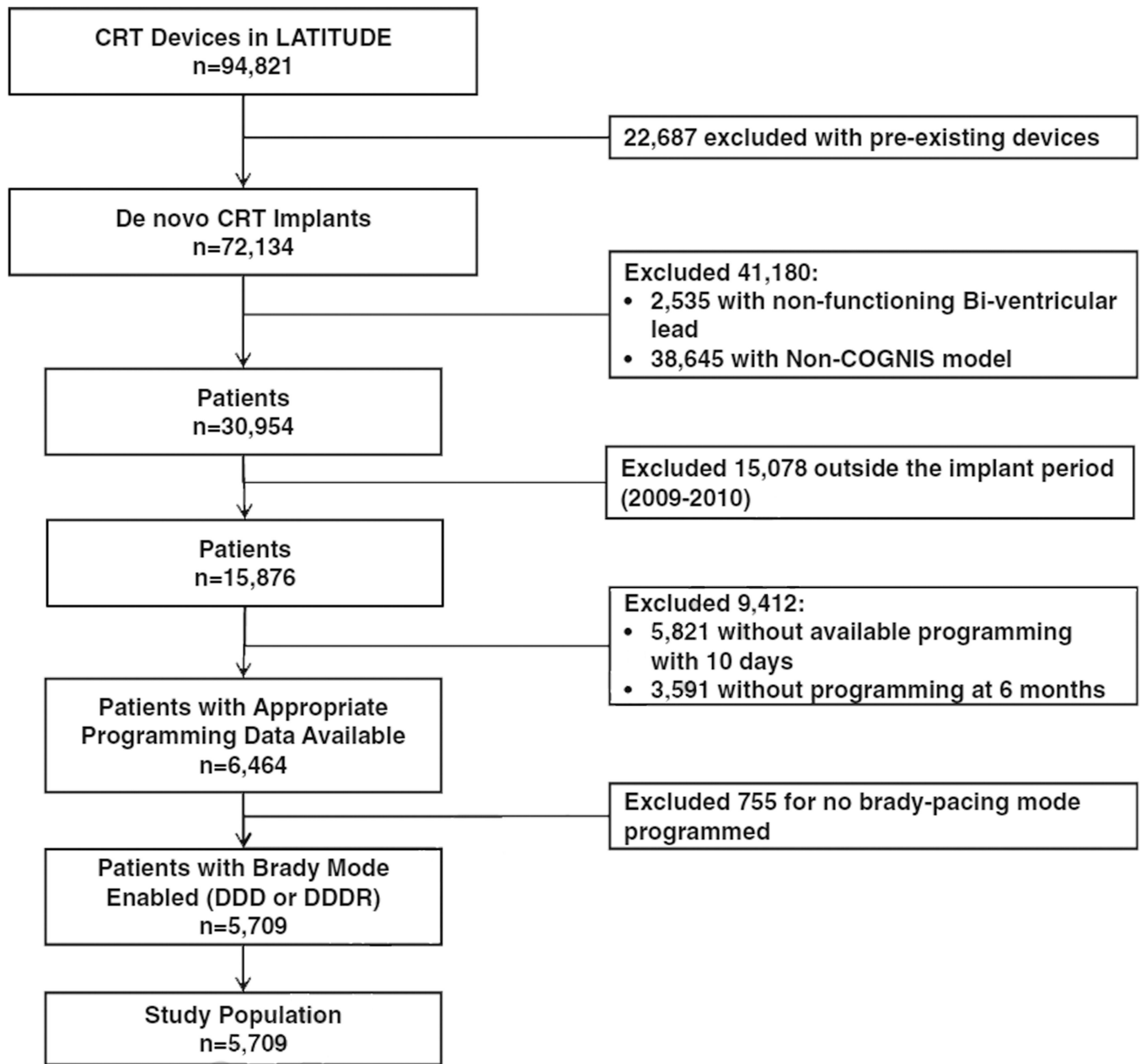


Fig. 1. Selection of analysis population, by exclusion criteria. AV atrioventricular timing, VV ventricular-to-ventricular timing

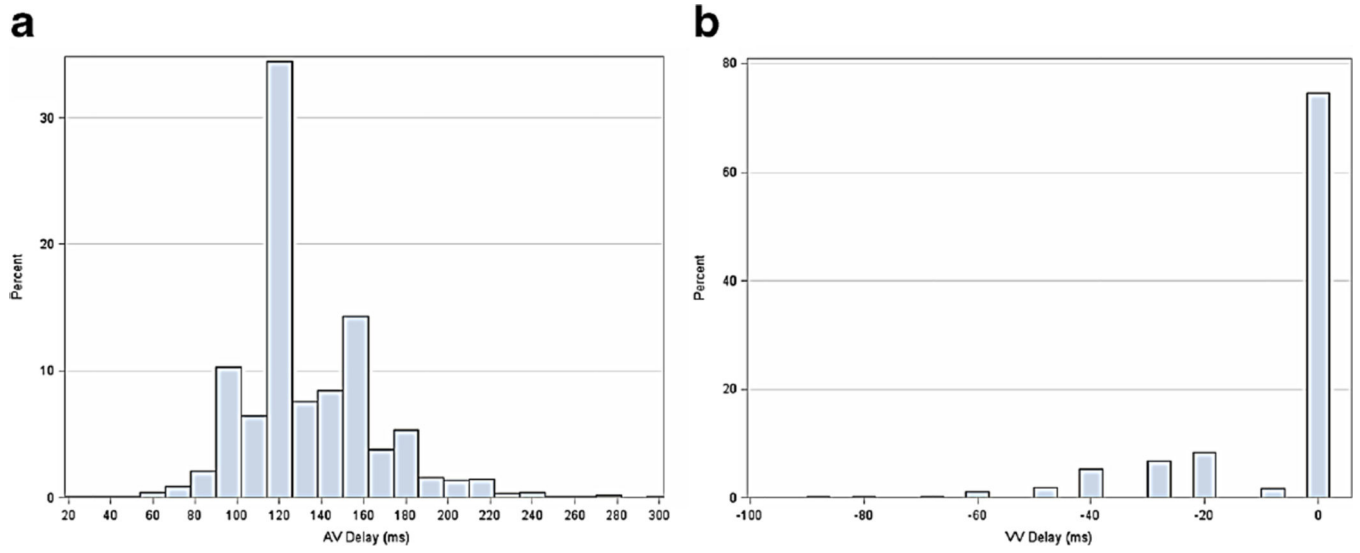


Fig. 2.
a, b Distribution of programming parameters within 10 days of implant, across the entire analysis population. AV atrioventricular timing, VV ventricular-to-ventricular timing

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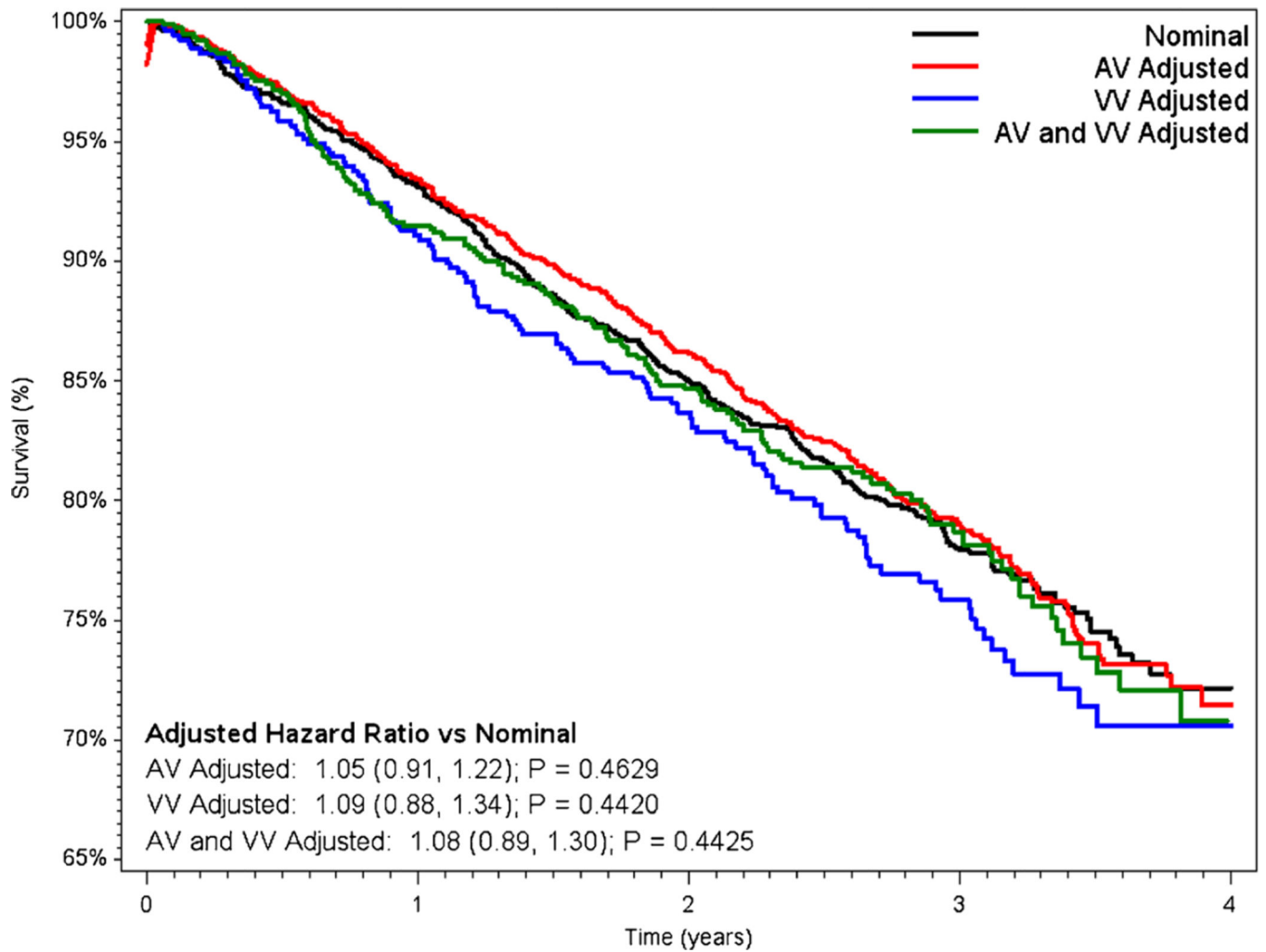


Fig. 3.

Unadjusted Kaplan-Meier survival curves, stratified by baseline programming. Hazard ratios adjusted for age, gender, DFT at implant, number of treatment zones, brady programming of DDD, LRL, VF detection rate, AF burden, LV pacing, and shock therapy. *AV* atrioventricular timing, *VV* ventricular-to-ventricular timing, *DFT* defibrillation threshold, *LRL* lower rate limit, *VF* ventricular fibrillation, *AF* atrial fibrillation, *LV* left ventricular

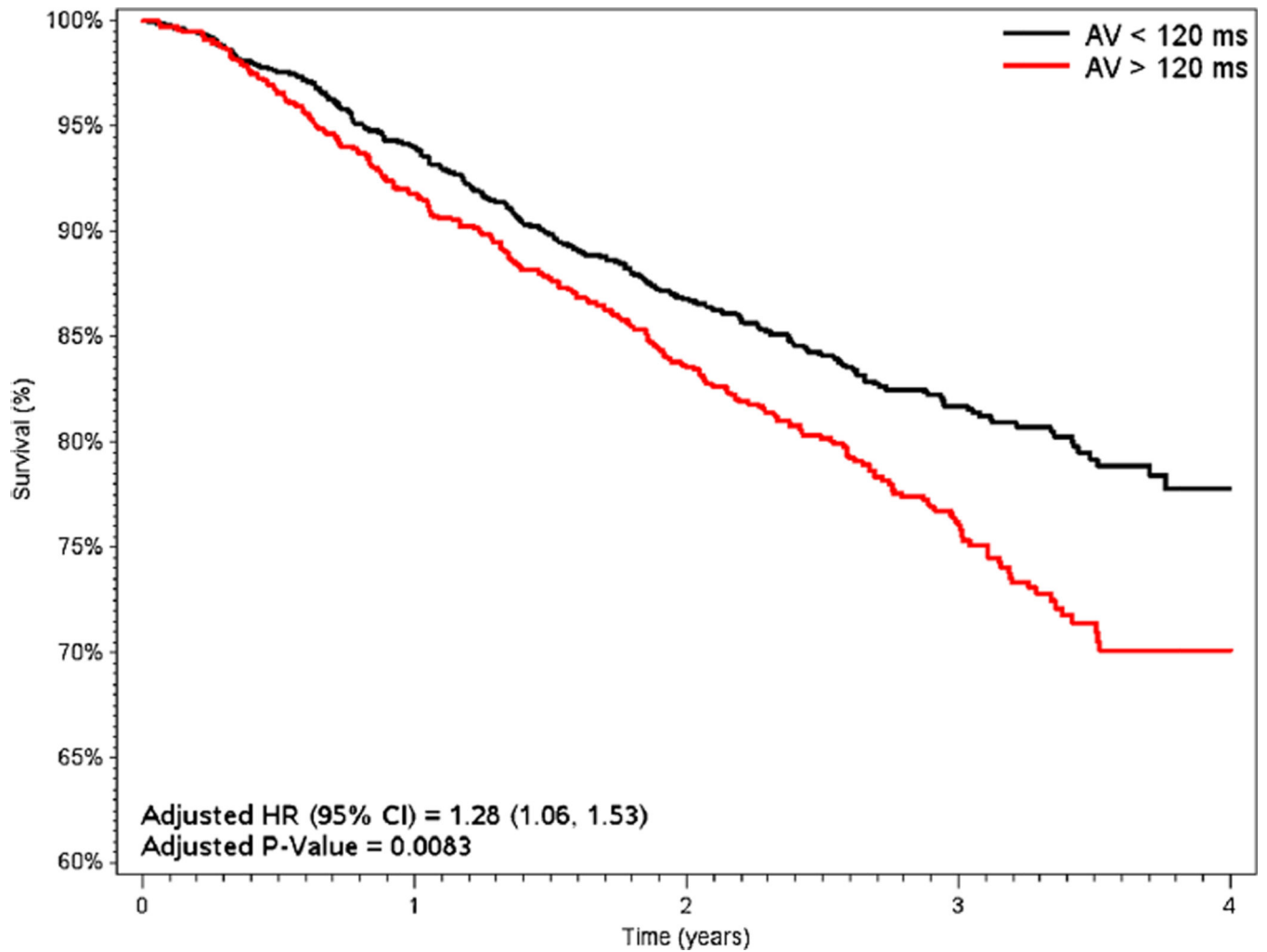


Fig. 4.

Unadjusted Kaplan-Meier survival curves, dichotomized by baseline sensed AV programming (nominal=120 ms). Hazard ratios adjusted for age, gender, DFT at implant, number of treatment zones, brady programming of DDD, LRL, VF detection rate, AF burden, LV pacing, and shock therapy. *AV* atrioventricular timing, *VV* ventricular-to-ventricular timing, *DFT* defibrillation threshold, *LRL* lower rate limit, *VF* ventricular fibrillation, *AF* atrial fibrillation, *LV* left ventricular

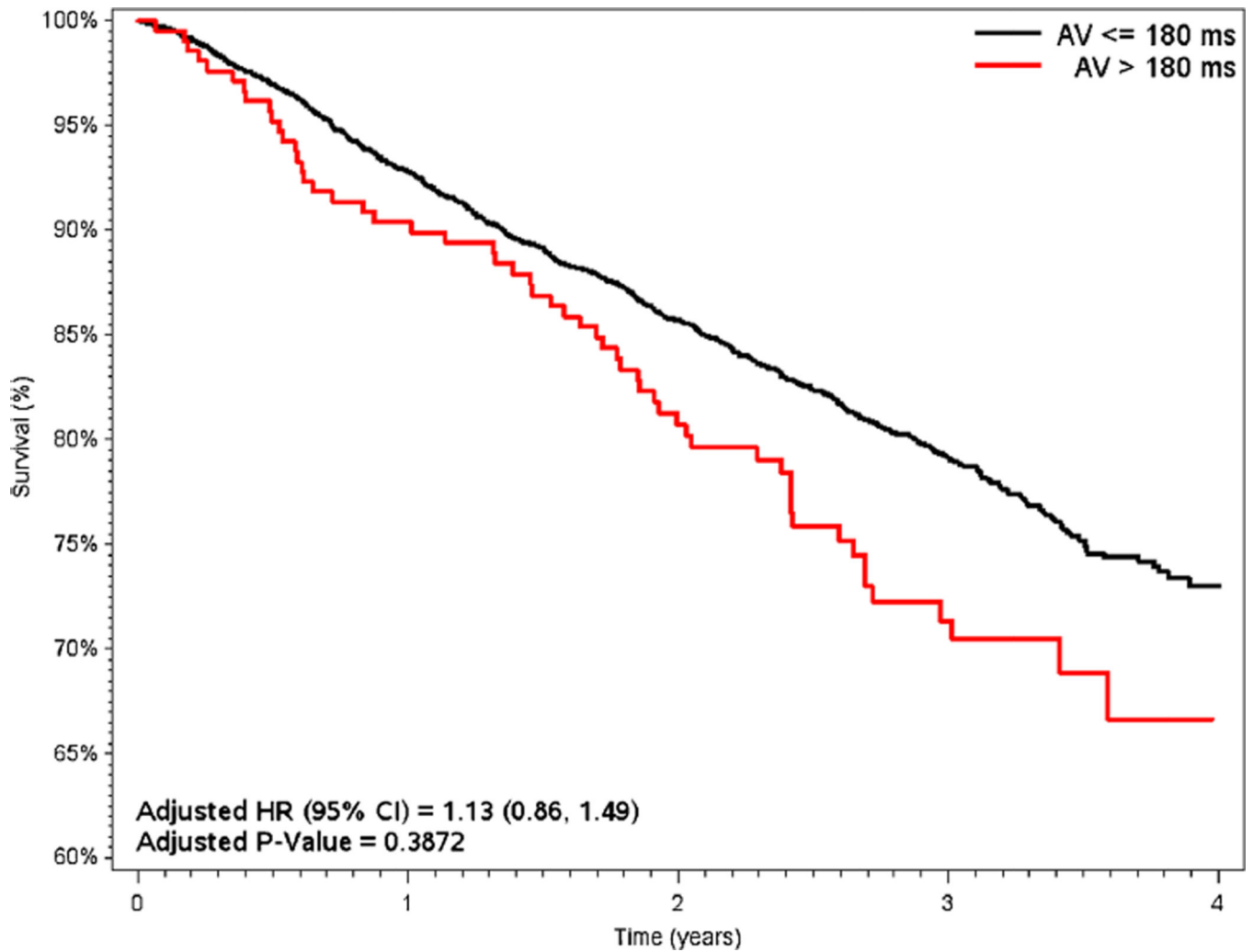


Fig. 5. Unadjusted Kaplan-Meier survival curves, dichotomized by baseline sensed AV programming at 180 ms (nominal=120 ms). Hazard ratios adjusted for age, gender, DFT at implant, number of treatment zones, brady programming of DDD, LRL, VF detection rate, AF burden, LV pacing, and shock therapy. *AV* atrioventricular timing, *VV* ventricular-to-ventricular timing, *DFT* defibrillation threshold, *LRL* lower rate limit, *VF* ventricular fibrillation, *AF* atrial fibrillation, *LV* left ventricular

Table 1

Baseline characteristics, stratified by programming at implant

	Nominal (n=1559)	AV adjusted (n=2294)	p value (vs. nominal)	VV adjusted (n=604)	p value (vs. nominal)	AV and VV adjusted (n=852)	p value (vs. nominal)
Age	69.8 (11.3)	68.8 (11.1)	0.007	69.8 (11.8)	0.997	68.8 (11.5)	0.030
Male	73.7 %	69.9 %	0.006	73.8 %	0.964	71.0 %	0.133
DFT at implant	77.6 %	83.8 %	<0.0001	80.3 %	0.166	81.9 %	0.011
Last shock energy (J)	19.97 (6.31)	19.43 (6.35)	0.011	19.97 (5.98)	0.956	19.45 (5.55)	0.069
Bradycardia programming							
DDD	52.5 %	59.8 %	<0.0001	48.2 %	0.065	59.0 %	0.001
DDDR	47.5 %	40.2 %	<0.0001	51.8 %	0.065	41.0 %	0.001
LRL	61.5 (7.3)	59.9 (7.5)	<0.0001	60.2 (9.4)	0.000	58.7 (8.9)	<0.0001
Tachyarrhythmia programming							
1 therapy zone	16.5 %	15.9 %	0.580	8.9 %	<0.0001	11.4 %	0.0004
2 therapy zones	69.7 %	71.2 %	0.269	75.3 %	0.007	75.7 %	0.001
3 therapy zones	13.8 %	12.9 %	0.377	15.7 %	0.232	12.9 %	0.534
VT detection rate	175 (15)	176 (14)	0.224	176 (14)	0.564	175 (14)	0.290
VF detection rate	207 (16)	207 (16)	0.379	209 (15)	0.009	207 (16)	0.736
ATP therapy "on" in VT zone/s	94.3 %	95.2 %	0.227	95.9 %	0.134	96.1 %	0.051

Numbers are % or mean (standard deviation)

AV atrioventricular timing, VV ventricular-to-ventricular timing, DFT defibrillation threshold testing, LRL lower rate limit

Table 2
Baseline rhythm characteristics (within 6 months of implant), stratified by programming at implant

	Nominal (n=1559)	AV adjusted (n=2294)	p value (vs. nominal)	VV adjusted (n=604)	p value (vs. nominal)	AV and VV adjusted (n=852)	p value (vs. nominal)
Patient activity (%)	6.7 (4.0)	7.3 (4.3)	<0.0001	6.5 (4.0)	0.2	6.9 (4.0)	0.3
HRV SDANN	70.1 (20.4)	70.6 (18.9)	0.6	70.1 (20.3)	1	70.7 (20.3)	0.6
HRV footprint	28.2 (9)	28.3 (8.7)	0.9	27.5 (9.5)	0.3	28.3 (9.2)	0.9
HRV mean HR	77.2 (8.2)	77.2 (8.3)	0.9	77.4 (9.3)	0.7	76.6 (8.8)	0.2
AF burden >5 %	21.7 %	11.7 %	<0.0001	22.0 %	0.9	11.0 %	<0.0001
Atrial pacing (%)	32 (36)	27 (33)	0.01	27 (35)	0.0001	27 (35)	0.005
LV pacing <95 %	17.6 %	17.7 %	0.9	15.9 %	0.3	14.9 %	0.08
Any shock within 6 months of implant	6.1 %	6.9 %	0.3	7.6 %	0.2	7.4 %	0.2
ATP therapy	12.9 %	16.7 %	0.0005	16.2 %	0.04	18.2 %	0.0002

Numbers are % or mean (standard deviation)

AV atrioventricular timing, VV ventricular-to-ventricular timing, ATP anti-tachycardia pacing, AF atrial fibrillation, LV left ventricular, HRV heart rate variability, SDANN standard deviation of the average NN intervals, HR heart rate

Table 3

Unadjusted outcomes through last follow-up

	Nominal (n=1559)	AV adjusted (n=2294)	p value (vs. nominal)	VV adjusted (n=604)	p value (vs. nominal)	AV and VV adjusted (n=852)	p value (vs. nominal)
Follow-up, days	956 (328)	983 (322)	0.009	944 (344)	0.5	952 (330)	0.8
PCT activity	7 (4.2)	7.5 (4.6)	0.0005	6.9 (4.3)	0.8	7.3 (4.2)	0.2
Change from baseline	0.00 (1.4)	-0.03 (1.6)	0.5	-0.09 (1.5)	0.2	0.03 (1.5)	0.8
HRV SDANN	73.6 (20.7)	72.9 (18.8)	0.5	73 (21.4)	0.7	73.5 (22.4)	0.9
Change from baseline	0.83 (9.8)	0.92 (10.2)	0.9	0.21 (9.7)	0.5	0.71 (10.2)	0.9
HRV footprint	29 (8.9)	28.8 (9)	0.8	29.1 (10.5)	0.9	28.9 (9.6)	0.9
Change from baseline	0.24 (3.8)	0.14 (3.9)	0.7	0.63 (0.9)	0.3	-0.13 (4.5)	0.2
HRV mean HR	77 (8)	77.1 (8.2)	0.8	77.2 (10.2)	0.8	76.5 (9.5)	0.4
Change from baseline	-0.45 (3.4)	-0.47 (3.7)	0.9	-0.28 (4.4)	0.6	-0.08 (4.9)	0.2
AF burden >5 %	27.7 %	17.9 %	<0.0001	28.3 %	0.8	18.9 %	<0.0001
Change from baseline	4.00 % (21.0 %)	4.00 % (18.0 %)	0.8	3.00 % (19.0 %)	0.9	4.00 % (17.0 %)	0.6
Atrial pacing (%)	33 (37)	31 (35)	0.6	29 (36)	0.001	32 (37)	0.8
Change from baseline	1.00 (32)	4.00 (29)	0.03	2.00 (32)	0.9	5.00 (32)	0.06
LV pacing <95 %	17.3 %	17.8 %	0.6	19.2 %	0.3	18.5 %	0.4
Change from baseline	0.00 % (13.0 %)	-1.00 % (14.0 %)	0.8	-1.00 % (12.0 %)	0.046	-2.00 % (15.0 %)	0.09
ATP therapy	27.6 %	29.5 %	0.2	31.0 %	0.1	32.7 %	0.006
Shock during follow-up	13.1 %	13.4 %	0.8	12.9 %	0.9	16.7 %	0.01
Death	18.6 %	19.1 %	0.7	20.7 %	0.3	19.2 %	0.7

Numbers are % or mean (standard deviation)

AV atrioventricular timing, VV ventricular-to-ventricular timing, ATP anti-tachycardia pacing, AF atrial fibrillation, LV left ventricular, HRV heart rate variability, SDANN standard deviation of the average NN intervals, HR heart rate