Cardiac Resynchronization Therapy Reduces Left Atrial Volume and the Risk of Atrial Tachyarrhythmias in MADIT-CRT (Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy)

Andrew Brenyo, MD,* Mark S. Link, MD,† Alon Barsheshet, MD,* Arthur J. Moss, MD,* Wojciech Zareba, MD, PhD,* Paul J. Wang, MD,‡ Scott McNitt, MS,* David Huang, MD,* Elyse Foster, MD,§ Mark Estes III, MD,† Scott D. Solomon, MD,¶ Ilan Goldenberg, MD*

Rochester, New York; Boston, Massachusetts; and Palo Alto and San Francisco, California

Objectives
We hypothesized that reductions in left atrial volume (LAV) with a cardiac resynchronization therapy–defibrillator (CRT-D) would translate into a subsequent reduction in the risk of atrial tachyarrhythmias (AT).

Background
There is limited information regarding the effect of CRT-D on the risk of AT.

Methods
Percent reduction in LAV at 1 year following CRT-D implantation (pre-specified as low [lowest quartile: <=20% reduction in LAV] and high [>=20% reduction in LAV] response to CRT-D) were related to the risk of subsequent AT (comprising atrial fibrillation, atrial flutter, atrial tachycardia, and supraventricular tachyarrhythmias) among patients enrolled in MADIT-CRT (Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy).

Results
The cumulative probability of AT 2.5 years after assessment of echocardiographic response was lowest among high LAV responders to CRT-D (3%) and significantly higher among both low LAV responders to CRT-D (9%) and implantable cardioverter-defibrillator–only patients (7%; p = 0.03 for the difference among the 3 groups). Consistently, multivariate analysis showed that high LAV responders to CRT-D experienced a significant 53% (p = 0.01) reduction in the risk of subsequent AT as compared with implantable cardioverter-defibrillator–only patients, whereas low LAV responders did not derive a significant risk reduction with CRT-D therapy (hazard ratio [HR]: 1.05 [95% confidence interval (CI): 0.54 to 2.00]; p = 0.89). Patients who developed in-trial AT experienced significant increases in the risk for both the combined endpoint of heart failure or death (HR: 2.28 [95% CI: 1.45 to 3.59]; p < 0.001) and the separate occurrence of all-cause mortality (HR: 1.89 [95% CI: 1.08 to 3.62]; p = 0.01).

Conclusions
In the MADIT-CRT study, favorable reverse remodeling of the left atrium with CRT-D therapy was associated with a significant reduction in risk of subsequent AT. (Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy [MADIT-CRT]; NCT00180271) (J Am Coll Cardiol 2011;58:1682–9) © 2011 by the American College of Cardiology Foundation...
Cardiac resynchronization therapy (CRT) has emerged as an important therapeutic modality for patients with severe drug-refractory HF (5,6) and more recently for patients with mildly symptomatic (NYHA functional class I/II) HF (7). Recent studies have suggested that CRT is associated with favorable reverse remodeling effects on the left atrium (LA), in addition to its well-established effects on the left ventricle (LV), thereby possibly reducing the risk for the development of AT and AF in patients with HF (9,10). Despite this, data on the effect of CRT on the resolution of chronic and prevention of new atrial arrhythmias are conflicting (11–15), possibly because the majority of prior studies had a nonrandomized or retrospective design and comprised relatively small sample sizes. Furthermore, previous studies were carried out among patients with advanced HF symptoms (NYHA functional class III/IV); however, currently there are no data regarding the effect of CRT on the risk of AT among patients with mild HF symptoms.

Accordingly, the present study was carried out in a population of patients with mild HF symptoms enrolled in MADIT-CRT (Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy) and was designed to evaluate: 1) the effect of cardiac resynchronization therapy-defibrillator (CRT-D) on the risk of the development of AT during the trial; 2) the association between LA remodeling with CRT-D and the risk for development of AT; and 3) the association between the development of AT following device implantation and the risk of subsequent HF events and death.

Methods

MADIT-CRT study. The design and results of the MADIT-CRT study have been reported previously (7). Briefly, 1,820 patients who had ischemic or nonischemic cardiomyopathy, ejection fraction ≤0.30, and abnormal intraventricular conduction with QRS ≥130 ms were randomized to receive CRT-D or implantable cardioverter-defibrillator (ICD) therapy in a 3:2 ratio were enrolled at 110 centers in the United States, Canada, and Europe. The presence of AF at enrollment was an exclusion criterion. However, patients with a history of prior AT were not excluded. The MADIT-CRT study was conducted from December 22, 2004, through June 22, 2009. After the study was stopped on the recommendation of the safety monitoring board, complete data collection and adjudication of clinical and arrhythmic endpoints were continued throughout 2009. Thus, the present study provides extended follow-up data for all MADIT-CRT participants through December 31, 2009.

Echocardiographic methods. Echocardiograms were obtained according to a study-specific protocol at baseline, which was before device implantation (n = 1,809), and at 1 year (n = 626 in the ICD group; n = 752 in the CRT-D group). Paired echocardiograms from baseline and after 12 months with the device turned on were available for 1,372 patients who comprised the present study population.

Echocardiographic parameters were measured in a core laboratory according to established American Society of Echocardiography protocols (16). LV and LA volumes were measured by the Simpson method of discs in the apical 4- and 2-chamber views and averaged.

Device programming and interrogation. Commercially available transvenous devices (Boston Scientific, Natick, Massachusetts) were used in the trial. Standard techniques were used to implant the CRT-D and ICD devices. Device testing and programming were performed as reported previously (17). Devices were programmed to monitor + therapy; sensitivity was programmed according to physician discretion. The configuration used a ventricular tachycardia zone set at 170 beats/min and a ventricular fibrillation zone set at 230 beats/min. The ICDs were interrogated quarterly; after the occurrence of device therapy, the discs were sent to the core laboratory for arrhythmia categorization and adjudication of detected arrhythmias.

Definitions and outcome measures. ATRIAL TACHYARRHYTHMIA. The diagnosis of AT was determined by an adjudication committee that evaluated documented arrhythmias from device electrograms. Arrhythmic events were categorized as AT if they included the occurrence of AF, atrial tachycardia, or other supraventricular tachyarrhythmias. A detailed definition used for adjudication of each type of AT is provided in the Online Appendix. Follow-up time for AT monitoring was the individual time in which each study patient had a CRT-D/ICD device implanted and activated (average 2.9 years).

ECHOCARDIOGRAPHIC RESPONSE. The LA remodeling effect of CRT-D was defined as percent reduction in LA volume (LAV) between enrollment and 1-year echocardiogram (calculated as the difference between the 1-year volume and baseline volume, divided by baseline volume). CRT-D patients were categorized into 2 groups based on their echocardiographic response: high LAV responders (defined as ≥20% reduction in LAV at 1 year post-implantation [=lower-quartile response in the CRT-D group]) and low LAV responders (defined as <20% reduction in LAV at 1 year post-implantation [<lower-quartile response in the CRT-D group]). In a secondary analysis, LAV was replaced with LA diameter (categorized similarly.
at the upper quartile (≥4.5% reduction in LA diameter)) to assess whether the latter echocardiographic parameter provided incremental prognostic information to the former method of LA assessment.

The LV remodeling effect of CRT-D was defined as percent reduction in LV end-systolic volume (LVESV) between enrollment and 1-year echocardiogram (calculated as the difference between 1-year and baseline LVESV, divided by baseline LVESV). Similar to the definition of LAV response, LVESV responders to CRT-D were categorized into 2 groups: high LVESV responders (defined as ≥25% reduction in LVESV at 1 year post-implantation [≥lower-quartile response in the CRT-D group]) and low LVESV responders (defined as <25% reduction in LVESV at 1 year post-implantation [<lower-quartile response in the CRT-D group]). It should be noted that possibly because of different enrollment criteria, echocardiographic response to CRT was more pronounced in the MADIT-CRT study compared with that in previous studies among patients with more advanced HF. Thus, the definition of nonresponse used in previous studies (<15% reduction in LVESV at 6 months post-implantation, comprising approximately one-third of CRT-treated patients) included only a minority (<10%) of those who received a CRT-D device in the MADIT-CRT study. Accordingly, we dichotomized LVESV response at the first quartile (i.e., 25%) in the primary analysis and used the definition of 15% as a secondary analysis.

Endpoints. The primary endpoint of the present study was defined as the first occurrence of AT. The consistency of the results for the primary endpoint was also assessed for a secondary endpoint that included the first occurrence of AF only (i.e., excluding other AT). To account for the censoring of death in these endpoints, all analyses were repeated for a composite endpoint that included all-cause mortality. The CRT-D versus ICD-only benefit for reduction in the risk of AT was assessed: 1) from enrollment (i.e., with follow-up beginning at enrollment in the trial); and 2) following assessment of echocardiographic response to CRT-D at 1 year (i.e., “landmark” analysis, with follow-up beginning following the 1-year echocardiogram). The effects of the development of time-dependent AT on the risk of subsequent HF or death and all-cause mortality were also assessed as secondary endpoints.

Statistical analysis. Baseline characteristics were compared: 1) between patients who did and did not develop post-enrollment AT; and 2) among CRT-D high responders, low responders, and ICD-only patients. Comparisons among groups were assessed using the: 1) chi-square test for categorical variables; and 2) Wilcoxon rank sum and Kruskal-Wallis (nonparametric) tests for 2- and 3-group testing of continuous variables, respectively. The Pearson correlation was used to assess the relation between changes in LAV and LVESV at 1 year. The cumulative probabilities of a first AT and the combined endpoint of AT or death from enrollment (by treatment arm; CRT-D and ICD only) and subsequent to the 1-year echocardiogram (by LAV response to CRT-D and ICD only) were assessed according to the method of Kaplan and Meier, with comparison of cumulative events by the log-rank test. Multivariate analysis for the primary and secondary endpoints was carried out using Cox proportional hazards regression modeling. Pre-specified covariates in the multivariate models included treatment arm, age >65 years, sex, history of prior treatment for atrial arrhythmia, baseline LAV (per 1-ml/m² increment), baseline LVESV (per 1-ml/m² increment), ischemic etiology of LV dysfunction, QRS ≥150 ms, left bundle branch block, serum creatinine >1.4 mg/dl, and blood urea nitrogen ≥25 mg/dl. In the models that evaluated the effect of echocardiographic response to CRT-D therapy, effect was assessed as a 3-level categorical variable (including high LAV responders to CRT-D, low LAV responders to CRT-D, and ICD-only patients), and further adjustment was made for percent change in LVESV at 1 year (assessed both as a binary variable [dichotomized at the lower-quartile response to CRT-D of 25% or at 15%] and as a continuous measure).

The cumulative probabilities of HF or death and the separate occurrence of all-cause mortality after the 1-year echocardiogram, by the development of AT during the first year of the trial, were assessed according to the Kaplan-Meier method, with comparison of cumulative events by the log-rank test. Cox proportional hazards regression modeling was used to evaluate the effect of development of in-trial AT (assessed as a time-dependent covariate) and of changes in LAV and LVESV (included in the same model as either continuous or binary measures) on the risk of HF or death and on the separate occurrence of all-cause mortality, after the 1-year echocardiographic assessment. Additional covariates in the multivariate models for the endpoint of HF or death and all-cause mortality included treatment arm, age >65 years, sex, history of prior treatment for atrial arrhythmia, ischemic etiology of LV dysfunction, QRS ≥150 ms, left bundle branch block, serum creatinine >1.4 mg/dl, and blood urea nitrogen ≥25 mg/dl. Models did not include tests for multiple comparisons.

The statistical software used for the analyses was SAS version 9.2 (SAS Institute, Cary, North Carolina). Two-sided p < 0.05 was used for declaring statistical significance.

Results

Atrial arrhythmias. During follow-up, 139 patients experienced AT, of which 66 (47%) were identified as AF, 31 (22%) as atrial tachycardia, and 42 (30%) as other supraventricular tachyarrhythmias. Patients with and without AT events exhibited similar characteristics at enrollment, with the exception of a significantly higher frequency of prior AT and somewhat higher baseline LAV among patients who developed in-trial AT (Table 1). Medication usage, includ-
Effects of CRT-D on LA reverse remodeling. At 1-year follow-up echocardiography, the mean percent reduction in LAV was 3-fold higher in patients treated with CRT-D compared with that in ICD-only patients (Fig. 1A). Among patients treated with CRT-D therapy, the median reduction in LAV was 29% (interquartile range: 20% to 36%), whereas the median reduction in LAV was only 10% (interquartile range: 5% to 14%) among ICD-treated patients. Low responders to CRT-D were defined as having a lower-quartile LAV response (<20%), whereas high responders experienced ≥20% reductions in LAV with CRT-D therapy. Notably, in the ICD-only group, the majority of patients (91%) had <20% reduction in LAV at 1 year. Thus, the mean reduction in LAV among ICD-only patients was similar to that observed among low responders to CRT-D (Fig. 1B). The baseline clinical characteristics of low and high responders to CRT-D and ICD-only patients (Online Table 1) were similar, with the exception of a higher frequency of a history of AT prior to enrollment among low responders to CRT-D.

Effects of CRT-D on risk of AT. When assessed from enrollment, CRT-D and ICD-only patients showed similar 3-year cumulative probabilities of AT (7% vs. 9%, respectively; p = 0.63) and of AT or death (15% vs. 15%, respectively; p = 0.39). However, the cumulative probabilities of these endpoints were shown to be related to LAV response to CRT-D. Thus, at 2.5 years after assessment of echocardiographic response, the cumulative probability of

| Table 1 Baseline Characteristics by the Development of AT During Follow-Up |
|---------------------------|---------------------|---------------------|---------------------|
| CRT-D treatment arm       | AT (n = 139)        | AT (n = 1,681)      | p Value             |
| Age at enrollment, yrs    | 64.5 ± 10.7         | 63.1 ± 10.7         | 0.21                |
| Female                    | 25                  | 20                  | 0.18                |
| Diabetes mellitus         | 30                  | 33                  | 0.47                |
| Hypertension              | 63                  | 66                  | 0.49                |
| History of atrial arrhythmia | 11              | 18                  | 0.03                |
| Currently smoking         | 12                  | 13                  | 0.85                |
| Previously smoked         | 53                  | 60                  | 0.17                |
| NYHA functional class II  | 86                  | 85                  | 0.55                |
| Ischemic cardiomyopathy   | 56                  | 53                  | 0.75                |
| BUN, mg/dl                | 22 ± 9              | 22 ± 9              | 0.36                |
| BUN >25 mg/dl             | 24                  | 26                  | 0.60                |
| Creatinine, mg/dl         | 1.2 ± 0.4           | 1.2 ± 0.3           | 0.68                |
| Creatinine >1.4 mg/dl     | 22                  | 19                  | 0.56                |
|QRS, ms                    | 158 ± 20            | 156 ± 17            | 0.26                |
|QRS <150 ms                | 35                  | 40                  | 0.29                |
|LBBB                       | 71                  | 68                  | 0.45                |
|RBBB                       | 12                  | 16                  | 0.22                |
|IVCD                       | 17                  | 16                  | 0.72                |

Echocardiography

| LVEF, %                    | 24 ± 5               | 23 ± 6               | 0.45                |
| LVEDV, ml/m²               | 123 ± 29             | 121 ± 28             | 0.14                |
|LVESV, ml/m²               | 88 ± 23              | 87 ± 23              | 0.44                |
|LAV, ml/m²                 | 46 ± 10              | 49 ± 11              | 0.07                |

Medications

| Beta-blocker              | 93                   | 91                   | 0.36                |
|ACEI/ARB                   | 77                   | 77                   | 0.98                |
|Aldosterone receptor antagonist | 32              | 32                   | 0.87                |
|Class III antiarrhythmic   | 7                    | 9                    | 0.28                |

Values are % or mean ± SD. ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; AT = atrial tachyarrhythmia; BUN = blood urea nitrogen; CRT-D = cardiac resynchronization therapy-defibrillator; IVCD = intraventricular conduction delay; LAV = left atrial volume; LBBB = left bundle branch block; LVEDV = left ventricular end-diastolic volume; LVEF = left ventricular ejection fraction; LVESV = left ventricular end-systolic volume; NYHA = New York Heart Association; RBBB = right bundle branch block.
AT was lowest among high LAV responders to CRT-D (3%) and significantly higher among both low LAV responders to CRT-D (9%) and ICD-only patients (7%) (p < 0.03 for the difference among the 3 groups) (Fig. 3A). Similarly, the respective 2.5-year rates of AT or death in the 3 groups were 6%, 18%, and 14% (p < 0.001 for the comparison among the 3 groups) (Fig. 3B).

Consistent with these findings, multivariate analysis showed that CRT-D therapy was not associated with a significant reduction in the risk of AT and of AT or death from enrollment (Table 2). However, risk reduction associated with the device was shown to be related to percent reduction in LAV. Thus, high LAV responders experienced a significant 53% (p < 0.01) reduction in the risk of AT and a 49% (p = 0.002) reduction in the risk of AT or death as compared with ICD-only patients (Table 2), whereas low LAV responders did not derive a significant reduction in the risk of AT and AT or death from the device compared with ICD-only patients (Table 2). Furthermore, the significant reduction in the risk of AT among high LAV responders was also evident when this subgroup was compared with the low LAV response subgroup (Table 2). Notably, the reduction in the risk of AT associated with LAV response to CRT-D was maintained after further adjustment for percent change in LVESV. In contrast, LVESV response to CRT-D, categorized either at the lower quartile (≥25%) (Table 2) or at >15% (Online Tables 2A and 2B), did not make an independent contribution to the occurrence of AT when included with LAV response in the same model.

Consistent with the findings regarding the effect of LAV response to CRT-D on the risk of AT, high LAV responders also showed a similar magnitude of risk reduction when the endpoint was restricted to the first occurrence of AF and AF or death (Table 2). In a secondary analysis, we replaced LAV with LA diameter for assessment of the association between atrial reverse remodeling and the risk of AT/AF. The results of this analysis (Online Tables 3A and 3B) showed a consistent relationship between LA response to CRT-D (assessed as percent reduction in LA diameter) and the risk for subsequent AT/AF. However, this association was somewhat weaker compared with the association observed with LAV, suggesting that the latter parameter may be a better predictor of AT risk in the study population.

**Effect of the development of post-enrollment AT on the subsequent risk of HF and death.** Kaplan-Meier survival analysis showed that the cumulative probability of HF or death after the 1-year echocardiographic assessment was significantly higher among patients who developed AT during the first year of the study as compared with those who did not (Fig. 4A). Similarly, the cumulative probability of all-cause mortality was significantly higher among patients who developed in-trial AT (Fig. 4B). Consistent with these findings, multivariate analysis showed that the development of time-dependent AT was associated with a signif-
LBBB, serum creatinine adjustment for change in LAV and LVESV in the same model. Percent change in LVESV at 1 year (categorized at 25% in the primary analysis and at 15% or as a continuous measure in secondary analyses). §Analysis was carried out among CRT-D patients and included a multivariate model that included the 1,372 patients with a 1-year echocardiogram, with follow-up beginning after the 1-year echocardiographic assessment; all findings were further adjusted for the risk of new AF or time to first AF episode compared with CRT was not associated with a significant reduction in the risk of AT/AF in patients with NYHA class III/IV HF symptoms and showed that the burden of AF was reduced during the first 3 months after CRT implant. This reduction in chronic AF was also accompanied by a significant 50% reduction in the occurrence of new-onset AF. Lellouche et al. (8) subsequently reported, in a retrospective, single-center cohort, that the total recurrence rate and the mean duration of AF episodes at 6 months after CRT implant were significantly reduced in those who responded clinically to CRT (improved NYHA functional class and no HF admissions) compared with nonresponders, with a lower incidence of persistent AF. Similar to the present study, Lellouche et al. (8) showed a significant decrease in LAV among CRT responders, suggesting a potential pathophysiologic mechanism for the observed reduction in the AF incidence and burden.

The association between reduction in LAV with CRT and its effect on AT/AF has been previously examined in a number of small nonrandomized trials. In a nonrandomized cohort of 97 patients with severe HF and no prior AF history, Fung et al. (10) showed that improvement of LA function with CRT at 3 months of follow-up was associated with a reduction in the risk for new-onset AF, regardless of the occurrence of LV remodeling. Leclercq et al. (15) studied a consecutive cohort of 173 patients with NYHA functional class III/IV HF symptoms and showed that patients who did not experience AT had smaller LAV at baseline and follow-up echocardiography, although the differences were not statistically significant. In a small nonrandomized cohort of 74 patients with HF and persistent or permanent AF receiving longstanding CRT, Kies et al. (9) showed a nonsignificant trend toward return to

### Discussion

The present study has several important implications regarding the therapeutic effects of CRT in patients with mildly symptomatic HF with LV dysfunction. We have shown that: 1) CRT-D therapy was associated with pronounced reverse remodeling effects on the LA; 2) patients who derived a favorable LA response to CRT-D therapy experienced a subsequent reduction in the risk of AT, including a 50% reduction in the risk of AF; and 3) the development of AT following device implantation was associated with a significant increase in the risk of subsequent HF and death. Prior studies have yielded inconsistent results regarding the effect of CRT on the incidence of AT/AF in patients with advanced HF symptoms. In the CARE-HF (Cardiac Resynchronization in Heart Failure) trial (14), treatment with CRT was not associated with a significant reduction in the risk of new AF or time to first AF episode compared with best medical therapy in patients with NYHA class III/IV HF. In contrast, Hugl et al. (18), in a small study of
normal sinus rhythm or reduction in AF burden in patients with LAV reductions.

In contrast to the inconsistent results of prior studies regarding the effects of CRT on the risk for AT/AF among patients with advanced HF symptoms, the present study in the MADIT-CRT population showed a significant and independent association between the degree of reverse LA remodeling associated with CRT-D therapy and the risk for subsequent AT. In this regard, it is important to note differences between the current study and prior reports: 1) patients enrolled in the MADIT-CRT study had milder HF symptoms than those in prior studies; thus, it is possible that in a lower-risk population, the favorable effects of CRT-D on LAV are more likely to translate into a reduction in the risk of AT than among patients with more advanced heart disease; 2) in the present study, we used a “landmark” analysis, which facilitated assessment of the effect of CRT-D on the LA at 1 year post-implantation on the risk for subsequent AT, whereas most prior studies assessed the risk of AT immediately following implantation; and 3) most prior data on the effect of CRT-D on the risk of AT had been derived from small cohort studies, resulting in inconsistent results, whereas the present findings were derived from a larger randomized clinical trial in which both echocardiographic parameters and arrhythmias were adjudicated in core laboratories.

The pronounced effect of CRT-D therapy on reverse LA remodeling in the present study is likely to be secondary to the effect of the device on reverse LV remodeling because these parameters were shown to be highly correlated (Fig. 2). However, the effect of LAV reduction on the risk of AT and of HF or death persisted after further adjustment for changes in LV volumes (Tables 2 and 3, respectively), suggesting that reverse remodeling of the LA is an independent predictor of outcome in CRT-D recipients. Prior studies have shown that reverse LV remodeling with CRT-D is associated with improved systolic and diastolic function, resulting in decreased LV end-diastolic volume pressure (19,20). Thus, these effects are likely to translate into corresponding reductions in LAV and LA pressures. The fact that CRT-D therapy was only effective in reducing AT episodes after the follow-up echocardiographic assessment of LAV, and not from enrollment, suggests that the favorable effects of CRT-D on the structure and function of the LA at 1 year translate into a subsequent reduction in the clinical risk of AT/AF.

**Study limitations.** Data regarding the occurrence of AT were derived from adjudicated device interrogations. Thus, lower-rate AT episodes (i.e., below the ventricular tachycardia zone, which was mostly set to ≥170 beats/min) were not identified or included in the present analysis. However, the overall consistent device settings in the 2 treatment groups provided support for our findings regarding the benefit of CRT-D in the reduction of AT (mostly in the range of ≥170 beats/min) in the MADIT-CRT population.

It should also be noted that the rate of new-onset AT in MADIT-CRT was somewhat lower (8%) than that in prior CRT studies that enrolled patients with more advanced HF symptoms (in which the reported frequency of new-onset AT was between 10% and 30%) (8,14,15,18). Thus, the present findings regarding reduction in the risk of new-onset AT/AF among responders to CRT-D therapy pertain only to patients with asymptomatic or mildly symptomatic LV dysfunction. As noted previously, current data regarding the effect of CRT-D therapy on the risk of AT/AF among patients with more advanced HF symptoms who receive CRT are conflicting.

We did not include adjustments for multiple comparisons in the multivariate models. Thus, the significance level of our findings should be interpreted with caution, given the multiple significance tests performed.
Conclusions

The present study is the first to explore the effect of CRT on the risk of AT/AF in patients with asymptomatic or mildly symptomatic HF with LV dysfunction. We have shown that CRT exerts pronounced reverse remodeling effects on the LA, which may be secondary to the known effects of the device on the LV. Importantly, our findings suggest that favorable reverse remodeling of the LA with CRT-D therapy may translate into a reduction in risk for subsequent AT/AF among patients with LV dysfunction and mild HF symptoms.

Reprint requests and correspondence: Dr. Ilan Goldenberg, Heart Research Follow-up Program, Box 653, University of Rochester Medical Center, Rochester, New York 14642. E-mail: ilan.goldenberg@heart.rochester.edu.

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Key Words: atrial tachyarrhythmias • cardiac resynchronization therapy • heart failure.

APPENDIX

For supplementary Tables 1 to 4, please see the online version of this article.