Comparison of Outcomes After Ablation of Atrial Fibrillation in Patients With Heart Failure With Preserved Versus Reduced Ejection Fraction

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Catheter ablation improves outcomes in atrial fibrillation (AF) patients with heart failure (HF) with reduced ejection fraction (HFrEF). We sought to evaluate the efficacy and safety of catheter ablation of AF in HF patients with a preserved ejection fraction (HFpEF). We performed a retrospective study of all patients who underwent de novo radiofrequency catheter ablation enrolled in the UC San Diego AF Ablation Registry. The primary outcome was recurrence of all atrial arrhythmias on or off antiarrhythmic drugs (AAD). Of 547 total patients, 51 (9.3%) had HFpEF, 40 (7.3%) had HFrEF, and 456 (83.4%) were without HF. There was no difference in recurrence of atrial arrhythmias on or off AAD (Adjusted Hazard Ratio [AHR] 1.92 [95% CI 0.97 to 3.83] for HFpEF vs HFrEF and AHR 0.90 [95% CI 0.59 to 1.39] for HFpEF vs no HF) or off AAD (AHR 1.96 [95% CI 0.99 to 3.90] for HFpEF vs HFrEF and AHR 1.14 [95% CI 0.74 to 1.77] for HFpEF vs no HF). There was also no difference in rates of all-cause hospitalizations (AHR 1.80 [95% CI 0.97 to 3.33] for HFpEF vs HFrEF and AHR 2.05 [95% CI 1.30 to 3.23] for HFpEF vs no HF) or rates of all-cause mortality (AHR 0.53 [95% CI 0.05 to 6.11] for HFpEF vs HFrEF and AHR 2.46 [95% CI 0.34 to 17.92] for HFpEF vs no HF). There were no significant differences in AAD use (p = 0.176) or procedural complications between groups (p = 0.980). In conclusion, there were no significant differences in arrhythmia-free survival between patients with HFpEF and HFrEF that underwent catheter ablation of AF. **© 2020 Elsevier Inc. All rights reserved.** **(Am J Cardiol 2020;136:62−70)**

Atrial fibrillation (AF) and heart failure (HF) are very prevalent and frequently co-exist, leading to increased morbidity and mortality relative to patients with either disease alone.[1,2] Given the potential adverse effects of pharmacologic antiarrhythmic therapy, especially in HF patients, and its inconsistent success at maintaining sinus rhythm, catheter ablation (CA) has emerged as a viable alternative for rhythm control of AF. Guidelines have been updated to recommend CA as a preferable alternative for AF in patients with HF with reduced ejection fraction (HFrEF) amidst evidence from several randomized controlled trials.[3−5] The role of CA in HF patients with a preserved ejection fraction (HFpEF) is less clear. The few retrospective and prospective analyses on CA in HFpEF have focused on symptomatic improvement and freedom from recurrent atrial arrhythmias, but data are lacking regarding hospitalization outcomes or mortality following CA.[6] Furthermore, one study did not include patients without HF as a comparator arm[7] and one study did not have any comparator arm.[8] Therefore, the objective of this study is to compare recurrence of AF, procedural complication rates, and all-cause hospitalizations and mortality after CA in AF patients with HFpEF, HFrEF and those without HF, focusing specifically on patients with HFpEF who have been less well-studied.

Methods

This study was an observational, retrospective cohort study using data collected as part of the University of California, San Diego (UCSD) AF Ablation Registry and approved by the UCSD Institutional Review Board. The UCSD AF Ablation Registry was designed as a clinical registry of all patients who underwent left atrial ablation procedures for atrial arrhythmias at UCSD, a single academic center, as captured by a procedural database (Perminova, Inc, San Diego, California) to collect patient, provider, and intraprocedural characteristics. All AF ablation procedures captured by the registry from October 2009 to March 2015 were linked to clinical encounters as recorded by the electronic medical record at UCSD Medical Center (Epic, Verona, Wisconsin). Patients with a previous AF ablation procedure were excluded (n = 296). Data on baseline demographics, medical history, laboratory data, medications, and cardiovascular implantable devices were collected as part of the UCSD AF Ablation Registry. Intraprocedural registry

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Conflicts of Interest: Dr. Hsu reports receiving honoraria from Medtronic, Abbott, Boston Scientific, Biotronik, Janssen Pharmaceuticals, Bristol-Myers Squibb, Altathera Pharmaceuticals, Zoll Medical, and Biosense-Webster, equity in Acutus Medical and Vektor Medical, and research grants from Biotronik and Biosense-Webster. Dr. Ho reports receiving a research grant from Abbott, equity in Vektor Medical and fellowship support from Medtronic, Abbott, Boston Scientific, and Biotronik.

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https://doi.org/10.1016/j.amjcard.2020.09.018

reports were reviewed to determine fluoroscopy and procedure times and ablation lesion sets.

Patients with a clinical diagnosis of HF were stratified into HFpEF versus HFrEF groups by LVEF as determined by transthoracic echocardiography before the index CA procedure. Patients with baseline LVEF ≥ 50% were designated as HFpEF whereas those with an LVEF < 50% were designated as HFrEF. Those without a clinical diagnosis of HF compromised the third group for reference. Clinical outcomes were determined during all follow-up and included in-hospital adverse events, recurrence of atrial arrhythmia at final follow-up on or off antiarrhythmic drugs (AAD) and off AAD, and all-cause hospitalizations and mortality. Arrhythmia recurrence was defined as AF, atrial flutter or atrial tachycardia lasting >30 seconds on 12-lead ECG, ambulatory monitoring, or implantable device, as recommended by contemporary guidelines.[9] Patients who were continued on AAD after the 3-month blanking period were excluded from the analysis assessing recurrence of atrial arrhythmias off AAD.

Adverse events were recorded in the registry and included access site complications (i.e., bleeding, groin hematoma, pseudoaneurysm, and arteriovenous fistula), cardiac perforation or tamponade, stroke or transient ischemic attack, pericarditis, myocardial infarction, atrioesophageal fistula, phrenic nerve paralysis, and pulmonary vein stenosis. As part of the registry, follow-up arrhythmia monitoring was prespecified and was recommended as a 12-lead ECG at each follow-up visit, along with routine ambulatory ECG monitoring (24-hour Holter monitor, extended ambulatory ECG monitoring, or event monitoring) in all patients at 6 months, 1 year and 2 years after ablation and additional ambulatory ECG monitoring to evaluate for arrhythmia recurrence in the presence of suggestive symptoms, which was consistent with consensus guidelines and updated consensus guidelines at the time of the registry.[9,10]

Informed consent was obtained before all ablation procedures. General anesthesia was used in all cases. Intravenous heparin was used to target an activated clotting time of 300 to 400 seconds. A transseptal puncture was performed under direct visualization with intracardiac echocardiography. Pulmonary vein isolation was performed using segmental, circumferential, or both types of ablations at the discretion of the operator. Closed and open irrigated and noncontact and contact force sensing catheters were used at the discretion of the operator. Electroanatomic mapping systems were used in all cases (CARTO, Biosense-Webster Inc, Diamond Bar, California) or Ensite, St Jude Medical, Inc, Minneapolis, Minnesota). Pulmonary vein entrance and exit block were confirmed with use of a circular catheter, and adenosine and isoproterenol were administered at the operator's discretion. Additional lesion sets including cavotricuspid isthmus line, left atrial roof line, mitral isthmus line, coronary sinus ablation, and ablation of complex fractional atrial electrograms were performed at the discretion of the operator.

Continuous variables are presented by group as means ± standard deviation for normally distributed variables and as medians with 25th and 75th percentiles for variables that were not normally distributed. Comparison between all groups was done using the nonparametric Kruskal-Wallis tests. All possible comparisons in groups were performed using the Student *t* test if the data were normally distributed or the Wilcoxon rank sum test if the data were not normally distributed. Categorical variables were reported as count and percentage, with the chi-square or Fisher exact test (expected cell counts<5) used for comparisons.

Recurrence of atrial arrhythmias at final follow up was analyzed using the Kaplan-Meier method with a 3-month blanking period and log-rank significance testing. Unadjusted and adjusted Cox proportional hazards modeling was used to analyze recurrence of atrial arrhythmias with a 3-month blanking period, results are presented as hazard ratios with 95% confidence intervals. Patients who were lost to follow-up were censored at the date of last known follow-up. Covariates included in the adjusted model are presented in Table 1, which were selected based on a clinically plausible association of the categorical predictor variable with recurrence of the primary outcome of recurrent atrial arrhythmias. Missing values were minimal and roughly equivalent between groups for all variables and were thus omitted. Analyses were performed using Stata 11 (StataCorp, LLC, College Station, Texas) statistical software. A $p < 0.05$ was considered statistically significant.

Results

A total of 547 patients underwent de novo radiofrequency CA during the study period with baseline characteristics summarized in Table 1. Of the analyzed cohort, 9% (n = 51) had HFpEF, 7% (n = 40) had HFrEF, and 83% (n = 456) had no HF. Median (Q1, Q3) follow-up duration was 50.9 months (24.5, 62.3) in the HFpEF group, 24.2 months (8.2, 60.4) in the HFrEF group, and 31.3 months (9.2, 57.3) in the no HF group (p = 0.027).

Patients without HF were more likely to have paroxysmal AF relative to HFpEF and HFrEF patients ($p < 0.001$ for both comparisons). HFpEF and HFrEF patients were more likely to have coronary artery disease or an implantable cardioverter defibrillator or cardiac resynchronization therapy defibrillator implanted at baseline relative to those without HF and HFpEF patients were more likely to have chronic obstructive pulmonary disease, obstructive sleep apnea, and end-stage renal disease (see Table 1).

Ablation characteristics are summarized in Table 2. Procedure times were significantly longer in the HFpEF group (277 minutes [229, 331]; p = 0.001) and HFrEF group (266 minutes [226, 300]; p = 0.012) relative to patients without HF (240 minutes [200, 282]). Additionally, fluoroscopy time was longer in the HFrEF group (84 minutes [67, 99]; p = 0.030) relative to patients without HF (73 minutes [58, 90]). The types of additional ablations performed between groups were similar, with the exception that left atrial roof ablations were performed significantly more frequently in patients with HFpEF (36.0%; p = 0.040) and HFrEF (46.2%; p = 0.001) relative to those without HF (22.9%).

There were no statistically significant differences in any procedural complication between groups (Table 2). Recurrence of AF on or off AAD (72% in HFpEF vs 53% in HFrEF vs 63% in no HF at 5 years; log-rank p = 0.205) and off AAD (71% in HFpEF vs 34% in HFrEF vs 49% in no HF at 5 years; log-rank p = 0.053) was statistically similar

Table 1
Baseline characteristics

	HFpEF (n = 51)	HFrEF (n = 40)	No HF (n = 456)	p Value
Follow-up duration (months)	50.9 (24.5,62.3)‡	24.2 (8.2,60.4)‡	31.3 (9.2,57.3)*	0.027
Age (years)	67.6 (56.6,74.7)	68.2 (58.4,73.8)	64.3 (57.6,70.5)	0.096
Men	31 (60.8)‡	32 (80.0)‡	307 (67.3)	0.142
Body mass index (kg/m^2)	29.7 (24.9,34.8)	28.6 (25.6,32.3)	27.8 (25.0,31.0)	0.222
Atrial fibrillation type				<0.001
Paroxysmal	25 (49%)	15 (39%)	331 (74%)*,†	
Persistent	26 (51%)	24 (62%)	117 (26%)*,†	
CHA_2DS_2VASc	3.0 (2.0,4.0)	3.0 (1.0,3.0)	2.0 (1.0,3.0)*,†	<0.001
Co-morbidities				
Hypertension	38 (75%)	27 (69%)	243 (53%)*	0.004
Hyperlipidemia	26 (51%)	19 (49%)	179 (39%)	0.168
Diabetes mellitus	8 (16%)	3 (8%)	44 (10%)	0.351
Chronic obstructive pulmonary disease	7 (14%)‡	0 (0%)‡	13 (3%)*	<0.001
Obstructive sleep apnea	11 (22%)‡	2 (5%‡	51 (11%)*	0.033
Prior cerebral vascular accident	5 (10%)	4 (10%)	38 (8%)	0.876
Coronary artery disease	19 (37%)	15 (39%)	51 (11%)*,†	<0.001
End-stage renal disease	2 (4%)	0 (0%)	1 (0%)*	0.003
Smoker	13 (26%)	6 (15%)	79 (18%)	0.337
Echocardiographic parameters				
Left ventricular ejection fraction (%)	58 (52,65)‡	40 (35,45)‡	64 (60,68)*,†	<0.001
Left atrial diameter (cm)	4.2 (3.9,4.9)	4.6 (4.1,5.0)	4.0 (3.7,4.5)*,†	0.004
Left ventricular end-diastolic volume (cm)	4.9 (4.1,5.3)‡	5.4 (5.0,5.6)‡	4.8 (4.4,5.1)†	<0.001
Mitral valve regurgitation	24 (67%)	19 (63%)	98 (46%)*	0.029
Cardiovascular medications				
Beta-blocker	33 (65%)	22 (55%)	217 (48%)*	0.061
Calcium channel blocker	8 (16%)	13 (33%)	124 (27%)	0.138
Angiotensin converting enzyme inhibitor	21 (41%)	13 (33%)	69 (15%)*,†	<0.001
Aldosterone receptor blocker	11 (22%)	6 (15%)	75 (16%)	0.618
Aldosterone antagonist	3 (6%)	4 (10%)	10 (2%)†	0.012
Digoxin	8 (16%)	6 (15%)	38 (8%)	0.118
Aspirin	20 (39%)	13 (33%)	176 (39%)	0.720
Theinopyridine	3 (6%)	0 (0%)	10 (2%)	0.157
Coumadin	25 (49%)	19 (48%)	181 (40%)	0.337
Apixaban	5 (10%)	2 (5%)	21 (5%)	0.287
Dabigatran	5 (10%)	6 (15%)	57 (13%)	0.751
AAD preablation				
None	13 (26%)	17 (43%)	134 (30%)	0.176
Flecainide	5 (10%)	3 (8%)	95 (21%)	0.024
Propafenone	1 (2%)	3 (8%)	32 (7%)	0.369
Sotalol	17 (33%)	8 (20%)	92 (20%)*	0.099
Dronedarone	2 (4%)	2 (5%)	47 (10%)	0.198
Amiodarone	10 (20%)	6 (15%)	44 (10%)*	0.073
Dofetillide	3 (6%)	1 (3%)	8 (2%)	0.165
Device preablation				
Permanent pacemaker	5 (10%)	1 (3%)	18 (4%)	0.131
Implantable cardioverter defibrillator or cardiac resynchronization therapy	4 (8%)	8 (21%)	4 (0%)*,†	<0.001

Values are presented as median (Q1, Q3) for continuous variables or n (%) for categorical variables
* P<0.05 for HFpEF compared with no HF
† P<0.05 for HFrEF compared with no HF
‡ P<0.05 for HFpEF compared with HFrEF

between groups over all follow-up, with the exception that HFpEF patients had more recurrence off AAD relative to patients without HF (Figure 1). Patients were off AAD after CA in 32 (63%) patients with HFpEF, 20 (50%) with HFrEF, and 255 (56%) with no HF (p = 0.096). Additionally, there were significantly more patients who underwent repeat ablations in the HFpEF group relative to the HFrEF group (51% vs 28%; p = 0.036).

All-cause hospitalizations over all follow-up were significantly more common in the HFpEF group (76%; log-rank p < 0.001) and HFrEF group (67%; log-rank p = 0.039) relative to patients without HF (55% at 5 years) (Figure 2). However, there was no difference in survival between all 3 groups (95% in HFpEF vs 87% in HFrEF vs 96% in no HF at 5 years; log-rank p = 0.604) (Figure 2).

Hazard ratios with multivariable adjustment for potential confounders and respective confidence intervals for recurrence of atrial arrhythmias and all-cause hospitalizations and mortality are summarized in Table 3. Although it did not reach statistical significance, there were trends toward

Table 2
Comparison of ablation characteristics and complications

	HFpEF (n = 51)	HFrEF (n = 40)	No HF (n = 456)	p Value All 3 groups
Total procedure time (minutes)	277 (229,331)	266 (226,300)	240 (200,282)*,†	<0.001
Total fluoroscopy time (minutes)	73 (60,94)	84 (67,99)	73 (58,90)†	0.095
Additional ablation				
Mitral isthmus line	10 (20%)	9 (23%)	62 (14%)	0.163
Left atrial roof line	18 (36%)	18 (46%)	104 (23%)*,†	0.001
Complex fractionated atrial electrogram ablation	3 (6%)	0 (0%)	9 (2%)	0.116
Coronary sinus ablation	10 (20%)	7 (18%)	56 (12%)	0.222
Cavotricuspid isthmus ablation	43 (86%)	33 (85%)	405 (89%)	0.609
Procedural complications				
Access site complication‡	5 (10%)	6 (15%)	57 (13%)	0.748
Cardiac perforation/tamponade	1 (2%)	0 (0%)	2 (0%)	0.327
Stroke/Transient ischemic attack	0 (0%)	0 (0%)	2 (0%)	0.822
Pericarditis	1 (2%)	0 (0%)	2 (0%)	0.327
Other complications§	0 (0%)	0 (0%)	0 (0%)	NA

Values are presented as median (Q1, Q3) for continuous variables or n (%) for categorical variables.
* P<0.05 for HFpEF compared with no HF.
† P<0.05 for HFrEF compared with no HF.
‡ Access site complications included access site bleeding, groin hematoma, groin pseudoaneurysm and groin arteriovenous fistula.
§ Other complications included myocardial infarction, atrioesophageal fistula, phrenic nerve paralysis, and pulmonary vein stenosis.

increased recurrence of atrial arrhythmias on or off AAD in patients with HFpEF relative to those with HFrEF and in rates of all-cause hospitalizations in patients with HFpEF relative to those with HFrEF or no HF. Subgroup analysis grouped by AF type (paroxysmal vs persistent) showed significantly more recurrence of any atrial arrhythmia in HFpEF patients with persistent AF relative to both HFrEF patients and no HF patients both on or off AAD (Figure 3).

Discussion

In this retrospective cohort study, there appears to be no significant differences in safety and efficacy of CA in patients with HFpEF, HFrEF, and those without HF. Patients with HFpEF and HFrEF had longer procedure times compared with those without HF, but complication rates were low and without significant differences across groups. There were no significant differences in recurrence of atrial arrhythmias, regardless of AAD use, between all 3 groups up to 5 years, with the exception that HFrEF patients had less recurrence of atrial arrhythmias on or off AADs relative to those without HF. Furthermore, in a subanalysis looking at paroxysmal and persistent AF, there was significantly more recurrence of atrial arrhythmias on or off AAD in HFpEF patients with persistent AF relative to HFrEF and no HF patients. However, both of these differences may be a consequence of the shorter follow-up in the HFrEF group and not reflective of a true difference. Alternatively, the atrial arrhythmias in the HFrEF population may be primarily driven by the reduced systolic function, which has been shown to improve following CA,[11] and AF may cause more symptoms in patients with HFpEF, resulting in more detected recurrence and repeat ablations.

These findings are significant as options for pharmacologic rhythm control are limited in patients with structural heart disease.[12] Although ablation of AF in HFrEF patients has been shown to effectively maintain sinus rhythm, improve left ventricular ejection fraction, exercise capacity, and quality of life and reduce hospitalization, and mortality rates,[11] it is unclear if these benefits extend to HFpEF patients.

Both systolic and diastolic left ventricular dysfunction result in elevated left ventricular end diastolic pressure which causes increased left atrial filling pressures.[13] This in turn increases atrial wall stress, consequently affecting the renin angiotensin system,[14] calcium handling,[15] profibrotic,[16] and proinflammatory pathways,[17] all of which promote electrical and structural remodeling.[18]

Despite these distinct changes, results from previous studies are mixed. Although Cha et al.[19] showed that patients with diastolic dysfunction were more likely to maintain sinus rhythm at 1 year relative to those with systolic dysfunction, this difference was no longer significant at 5 years. Black-Meier et al. found no difference in freedom from AF after ablation in HFpEF and HFrEF groups. However, they also found no significant difference in recurrence rates between groups and by type of AF in a subanalysis comparing paroxysmal and persistent AF.[7] Vecchio et al.[20] found that freedom from AF following ablation was less in HFpEF patients relative to the general population, but similar to those with HFrEF. In a subgroup analysis by Jayanna et al.[21], recurrence of AF at 3 months and 1 year were similar between HFpEF and HFrEF patients.

None of the previous studies compared hospitalizations and mortality between HFpEF and HFrEF patients who underwent ablation for AF. Although patients without HF had significantly less hospitalizations relative to those with HFpEF, this is expected given the increased morbidity and mortality HF incurs and would likely have also been observed in the HFrEF group had median follow-up duration been equivalent.[22] This is supported by the fact that there were no differences in all-cause hospitalizations when comparing HFpEF to HFrEF. Furthermore, HFpEF patients did not have increased all-cause mortality relative to those

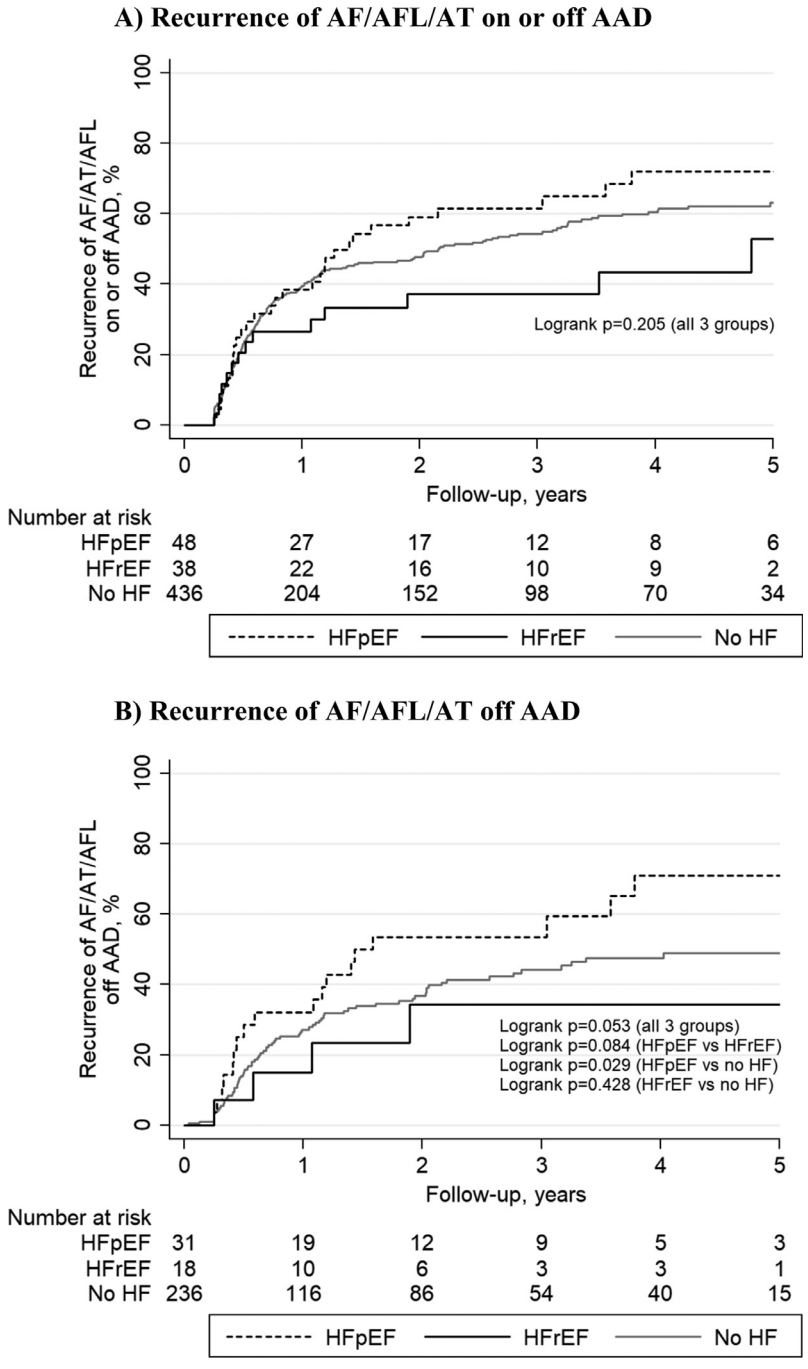

Figure 1. Kaplan-Meier plots of (A) long-term recurrence of atrial arrhythmias on or off antiarrhythmic drugs (excluding a 3-month post-procedural blanking period), and (B) long-term recurrence of atrial arrhythmias off antiarrhythmic drugs. Patients with heart failure with preserved ejection fraction, heart failure with reduced ejection fraction and no heart failure are compared. Abbreviations: AAD = antiarrhythmic drug; AF = atrial fibrillation; HF = heart failure; HFpEF = heart failure with preserved ejection fraction; HFrEF = heart failure with reduced ejection fraction.

with HFrEF and no HF. This is significant, as before ablation, patients with AF and HFpEF suffer from greater morbidity and mortality relative to those with AF and HFrEF or no HF, which is likely a result of the increased dependence on left atrial function in HFpEF.[23–27]

There are some limitations to interpreting the data presented in this study. First, the generalizability may be limited given that this study involved a single-center and is a retrospective study. Second, given the numerically small number of HF patients, a lack in significant difference between groups may reflect a type II error and not a lack of a true difference. Third, there is no consensus definition for the clinical classification of HFpEF or for the precise ejection fraction cutoff to distinguish HFpEF from HFrEF.[28–30] Although patients with an ejection fraction of 40% to 50% represent an intermediate group, they were included in the HFrEF group, as in previous studies, since they are often treated with goal-directed medical therapy similar to that

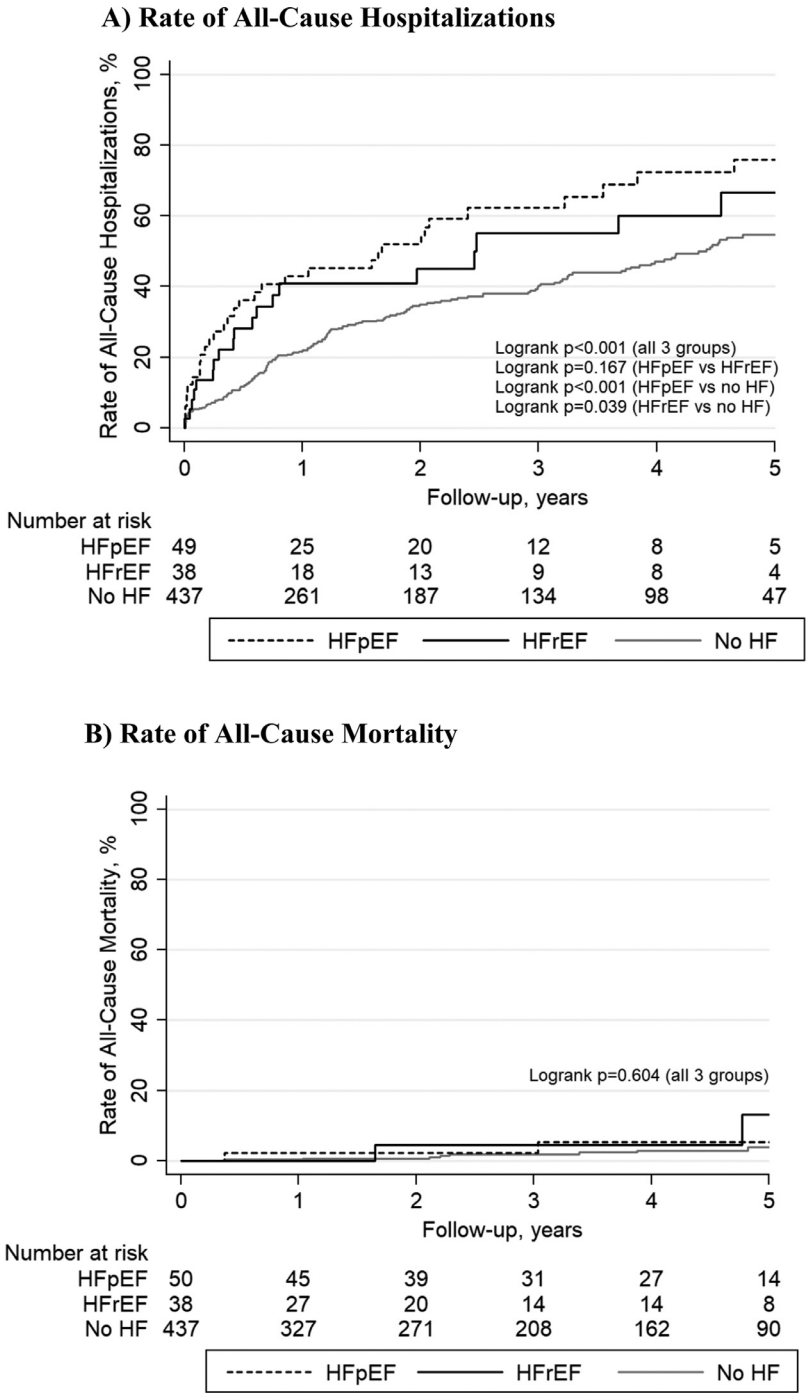

Figure 2. Kaplan-Meier plots of (A) long-term rate of all-cause hospitalizations and (B) long-term rate of all-cause mortality. Patients with heart failure with preserved ejection fraction, heart failure with reduced ejection fraction and no heart failure are compared. Abbreviations: HF = heart failure; HFpEF = heart failure with preserved ejection fraction; HFrEF = heart failure with reduced ejection fraction.

used in patients with HFrEF.[30] Fourth, groups differed in terms of co-morbidities, with HFpEF patients having more chronic obstructive pulmonary disease, obstructive sleep apnea, and end-stage renal disease. This may significantly affect rates of all-cause hospitalization. Fifth, there was no standardized duration of monitoring for AF recurrence as it was left to the discretion of the clinician. However, at the minimum, guideline based recommendations were followed in all cases.[9] Patients with HF may be more symptomatic when they are not in sinus rhythm, potentially resulting in less detection of asymptomatic AF in patients without HF. Sixth, the analysis looking at recurrence of atrial arrhythmias off AAD is at risk of selection bias given that the patients chosen to be taken off AAD may have been inherently different (such as having a lower AF burden before ablation or less subjective symptoms of AF).

Table 3
Adjusted hazard ratios and confidence intervals

	Adjusted HR	p Value
Recurrence of AF/AFL/AT on or off AAD		
HFpEF vs HFrEF	1.92 (95% CI 0.97−3.83)	0.063
HFpEF vs no HF	0.90 (95% CI 0.59−1.39)	0.642
HFrEF vs no HF	0.47 (95% CI 0.26−0.85)	0.013
Recurrence of AF/AFL/AT off AAD		
HFpEF vs HFrEF	2.52 (95% CI 0.73−8.77)	0.145
HFpEF vs no HF	1.00 (95% CI 0.51−1.96)	0.993
HFrEF vs no HF	0.40 (95% CI 0.13−1.24)	0.112
Rate of all-cause hospitalizations		
HFpEF vs HFrEF	1.80 (95% CI 0.97−3.33)	0.061
HFpEF vs no HF	2.05 (95% CI 1.30−3.23)	0.002
HFrEF vs no HF	1.14 (95% CI 0.66−1.94)	0.638
Rate of all-cause mortality		
HFpEF vs HFrEF	0.53 (95% CI 0.05−6.11)	0.612
HFpEF vs no HF	2.46 (95% CI 0.34−17.92)	0.374
HFrEF vs no HF	4.63 (95% CI 0.63−34.26)	0.133

Abbreviations: AF = atrial fibrillation; AFL = atrial flutter; AT = atrial tachycardia; CI = confidence interval; HFpEF=heart failure with preserved ejection fraction; HFrEF=heart failure with reduced ejection fraction; HR = hazard ratio

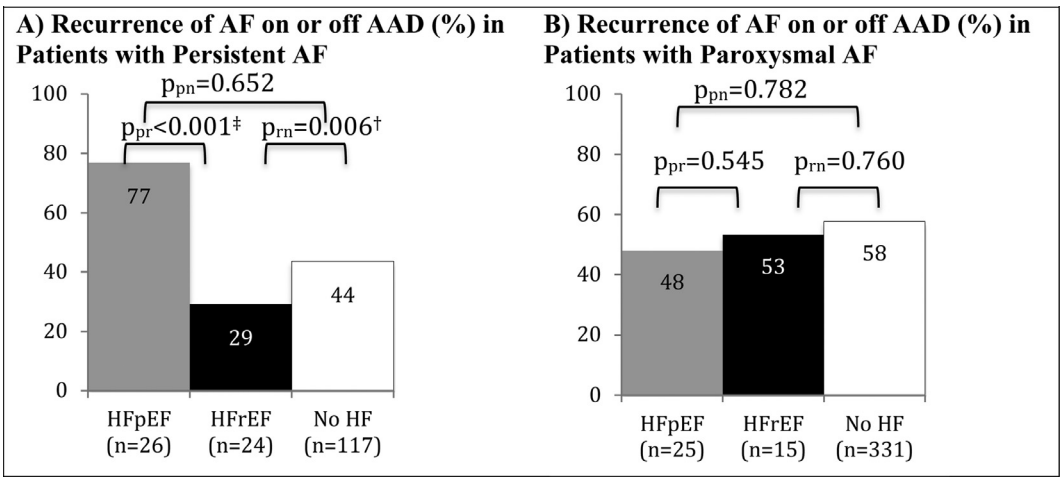

Figure 3. Freedom from atrial arrhythmias by atrial fibrillation subtype over all follow-up. Patients with heart failure with preserved ejection fraction, heart failure with reduced ejection fraction and no heart failure are compared. (A) Freedom from atrial arrhythmias on or off antiarrhythmic drugs in patients with persistent atrial fibrillation and (B) freedom from atrial arrhythmias on or off antiarrhythmic drugs in patients with paroxysmal atrial fibrillation. p-values that are presented have been adjusted with a multivariable regression models using the covariates listed in Table 1. Abbreviations: AAD = antiarrhythmic drug; AF = atrial fibrillation; AFL = atrial flutter; AT = atrial tachycardia; HF = heart failure; HFpEF = heart failure with preserved ejection fraction; HFrEF = heart failure with reduced ejection fraction. *P<0.05 for HFpEF compared with no HF. †P<0.05 for HFrEF compared with no HF. ‡P<0.05 for HFpEF compared with HFrEF.

In conclusion, CA of AF appears safe and effective in patients with HF, regardless of the presence of systolic or diastolic left ventricular dysfunction. There were no significant differences in recurrence of atrial arrhythmias and rates of procedural complications, all-cause hospitalizations, and mortality between patients with HFpEF and HFrEF.

Authors contribution

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