Catheter Ablation of Atrial Fibrillation in Patients With Heart Failure

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Atrial fibrillation (AF) and heart failure (HF) both have become major cardiovascular epidemics, adversely affecting quality of life, decreasing longevity, and imparting a large economic burden on the healthcare system. Both share similar risk factors and frequently coexist, leading to increased morbidity and mortality relative to patients with either condition alone. Although evidence-based treatment guidelines for both diseases exist, consensus treatment strategies are less clear when AF and HF co-occur. Given the risks of antiarrhythmic drugs and their incomplete success in maintaining sinus rhythm, catheter ablation has become an increasingly popular alternative to pharmacologic rhythm control in symptomatic patients with AF with normal cardiac function. Although multiple studies have demonstrated the efficacy of catheter ablation in AF, studies examining the use of catheter ablation specifically in patients with HF have recently begun to emerge and provide some guidance in this group of patients. In this review, we examine the effects of catheter ablation of AF in patients with HF on maintenance of sinus rhythm, left ventricular ejection fraction, exercise capacity, quality of life, hospitalization, and mortality rates. Data regarding both HF with reduced ejection fraction and preserved ejection fraction are discussed. **(Am J Cardiol 2019;123:187−195)**

Atrial fibrillation (AF) and heart failure (HF) both have become major cardiovascular epidemics, with estimates projecting that 12.1 million Americans will develop AF and 8 million will develop HF by 2030.[1,2] Both share similar risk factors and frequently coexist, leading to increased morbidity and mortality relative to patients with either condition alone.[3−5] Although evidence-based treatment guidelines for both diseases exist,[6,7] consensus treatment strategies are less clear when AF and HF co-occur. Given the risks of antiarrhythmic drugs and their incomplete success in maintaining sinus rhythm, catheter ablation has become an increasingly popular alternative to pharmacologic rhythm control in symptomatic AF patients with normal cardiac function.[8] Recently, catheter ablation of AF has been demonstrated to improve outcomes in patients with concomitant HF. In this review, we examine the effects of catheter ablation of AF in patients with HF on maintenance of sinus rhythm, left ventricular ejection fraction (LVEF), exercise capacity, quality of life, hospitalization, and mortality rates.

Catheter Ablation for Rhythm Control of AF

The multifactorial causes of AF have led to the development of multiple catheter ablation approaches, with pulmonary vein isolation (PVI) being the most common. Generally, catheters are inserted percutaneously into the right atrium and then the left atrium is accessed through transseptal puncture.[9] Ablation is most often accomplished through radiofrequency (RF) energy or cryothermal energy.

With RF energy ablation, high frequency electrical energy is delivered from the tip of a catheter to the endocardial surface, producing controlled focal tissue ablation. Cryothermal energy uses extreme cold to achieve the same effect as RF energy ablation. The cryoballoon catheter is advanced into the left atrium and inflated in each pulmonary vein. When adequate circumferential contact is achieved, cryoablation is performed. Although multiple studies have demonstrated the efficacy of catheter ablation in AF,[10−12] studies examining the use of catheter ablation specifically in patients with HF have recently begun to emerge and provide some guidance in this group of patients.

Catheter Ablation and Maintenance of Sinus Rhythm

Restoration of sinus rhythm has been shown to improve cardiac function in HF patients.[13] Thus, catheter ablation of AF may improve outcomes in HF due to success in maintaining sinus rhythm and the decrease in AF burden. In a substudy of the AFFIRM trial, restoration and maintenance of sinus rhythm (vs AF recurrence) were associated with a 47% reduction in the risk of death. However, the use of antiarrhythmics drugs increased the risk of death by 49%, essentially offsetting the benefit of the restoration of sinus rhythm.[14] Catheter ablation has been shown to result in a 3 to 4 times greater freedom from AF than antiarrhythmic drug therapy, especially for patients resistant to antiarrhyhmics.[6] Efficacy of catheter ablation in maintaining sinus rhythm has also been demonstrated in HF patients, with an average single-procedure success of 45% and multiple-procedure success of 72% in observational

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Table 1
Summary of studies evaluating freedom from atrial fibrillation after catheter ablation in patients with heart failure

	Sample size	Comparator arm	Method to assess AF recurrence	Average follow-up, months	Single procedure success, %	Multi-procedure success, %
Observational studies						
Chen et al (2004)[15]	377 (94)	Normal EF	ECG, 24-h Holter, loop recorder and device interrogation	14	73	96
Hsu et al (2004)[16]	116 (58)	Normal EF	48-h Holter	12	50	78
Tondo et al (2006)[17]	105 (40)	Normal EF	ECG, 24-h Holter and transtelephonic ECG	14	55	87
Gentlesk et al (2007)[18]	366 (67)	Normal EF	Transtelephonic ECG	20	55	86
Efremidis et al (2008)[19]	13 (13)	NA	ECG and 24-h Holter	9	62	NA
Nademanee et al (2008)[20]	129 (129)	NA	ECG or event monitoring and Holter	27	58	79
Lutomsky et al (2008)[21]	70 (18)	Normal EF	Transtelephonic ECG	6	50	NA
De Potter et al (2010)[22]	72 (36)	Normal EF	ECG and Holter	16	50	64
Choi et al (2010)[23]	30 (15)	Medical management of HF	ECG, 24-h Holter and loop recorder	16	46	73
Cha et al (2011)[24]	368 (111)	Normal EF and diastolic dysfunction	ECG and 24-h Holter	13	NA	76
Anselmino et al (2013)[25]	196 (196)	NA	ECG and 24-h Holter	46	45	62
Calvo et al (2013)[26]	658 (97)	Normal EF	ECG and 48-h Holter	6	70	83
Nedios et al (2014)[27]	138 (69)	Normal EF	7-day Holter and mean heart rates	28	40	65
Kosiuk et al (2014)[28]	73 (73)	NA	7-day Holter	40	37	NA
Lobo et al (2015)[29]	31 (31)	NA	ECG and Holter	20	51	77
Bunch et al (2015)[30]	2403 (267)	Low EF no ablation and low EF no AF	ECG and Holter	60	39	NA
Rillig et al (2015)[31]	80 (80)	NA	ECG and 24-h Holter	72	35	57
Kato et al (2016)[32]	18 (18)	NA	ECG, 24-h Holter, and device interrogation	21	11	61
Yanagisawa et al (2016)[33]	54 (54)	NA	ECG, 24-h Holter, and device interrogation	6	9	35
Ullah et al (2016)[34]	1273 (171)	Normal EF	Holter	43	26	65
Randomized control trials						
Khan et al (2008)[35]	81 (41)	AV nodal ablation and BIV pacing	Loop recorder	6	68	88
MacDonald et al (2011)[36]	41 (22)	Medical rate control	ECG and 24h Holter	6	40	50
Jones et al (2013)[37]	52 (26)	Medical rate control	ECG, 48-h Holter, and device interrogation	12	68	88
Hunter et al (2014)[38]	366 (67)	Medical rate control	ECG and 48-h Holter	12	38	73
Di Biase et al (2016)[39]	203 (102)	Amiodarone	ECG and device interrogation	24	NA	70
Prabhu et al (2017)[40]	63 (33)	Medical rate control	Loop recorder	6	69	NA
Marrouche et al (2018)[41]	363 (179)	Medical rate or rhythm control	Device interrogation	38	NA	63

AF = atrial fibrillation; BIV = biventricular; EF = ejection fraction; HF = heart failure; LVEF = left ventricular ejection fraction.

studies.[15–34] Randomized controlled trials showed similar results with an average single-procedure freedom from recurrent AF of 57% and multiple-procedure freedom from AF of 72%.[35–41]

As shown in Table 1, various monitoring methods were used, in addition to clinical symptoms, to assess recurrence of AF. Additionally, many studies had short follow-up times that may not reflect longer-term freedom from AF.

Although the average follow-up duration was > 2.5 years in the observational studies, the average single-procedure and multiple-procedure success of studies with follow-up data > 2 years were more modest, at 40% and 66%, respectively. Randomized controlled trials had an even shorter follow-up duration with an average of 14 months.

Catheter Ablation for AF and Association With Improvement in LVEF

Most studies examining ablation of AF in HF evaluated change in LVEF after ablation as the outcome of interest (Table 2). Almost all of the initial observational studies demonstrated improvements in LVEF after successful ablation, with an average improvement of approximately 13% in the reduced LVEF ablation group.[15–34]

Among the 9 studies where the comparator arm was comprised of normal EF patients who underwent ablation, the LVEF improved by an average of roughly 12% after ablation in those with reduced LVEF. However, the improvement seen by Chen et al[15] was not statistically significant (p = 0.1). Of note, Lutomsky et al[21] and Calvo et al[26] found no significant change in the EF in the comparator arm after ablation. The rest of the studies did not comment on the change in EF within the control group.[16–18,22,27,34]

Choi et al[23] found an approximate 13% improvement in LVEF after ablation in the study group (37.1 ± 6.1% to 50.6 ± 12.6%, p = 0.001), whereas there was only an insignificant 2% increase in LVEF in the medical management group. Cha et al found a 21% improvement in EF among the study group (median of 35% to 56%, p < 0.001). In the diastolic dysfunction comparator arm, 30% had at least 1 grade improvement in diastolic dysfunction, 62% had no change, and 8% had worsened diastolic dysfunction grade.[24] Bunch et al included 2 comparator arms: a reduced LVEF with AF that did not undergo ablation and a reduced LVEF without AF. LVEF showed greatest improvement at 3-year follow-up after ablation in the study group (27.4 ± 5.9 to 48.4 ± 15.6.), but the change in systolic function at baseline and 5 years was not statistically different among all 3 arms (p = 0.09 and p = 0.17, respectively).[30]

The improvement in LVEF seen in observational studies is largely corroborated by the few randomized controlled trials performed in HF patients with AF thus far. Khan et al[35] found that LVEF improved by 8% at 6 months in the PVI ablation group (27 ± 8% to 35 ± 9%) as compared with a 1% decrease in the AV node ablation with biventricular pacing group (29 ± 7% to 28 ± 6%), which was a statistically significant difference between groups (p < 0.001).

Table 2
Summary of studies evaluating the effect of catheter ablation of atrial fibrillation on ejection fraction in patients with heart failure

	Sample size	Age, years	Comparator arm	Average follow-up, months
Observational studies				
Chen et al (2004)[15]	377 (94)	56	Normal EF	14
Hsu et al (2004)[16]	116 (58)	56	Normal EF	12
Tondo et al (2006)[17]	105 (40)	57	Normal EF	14
Gentlesk et al (2007)[18]	366 (67)	54	Normal EF	20
Efremidis et al (2008)[19]	13 (13)	54	NA	9
Nademanee et al (2008)[20]	129 (129)	67	NA	27
Lutomsky et al (2008)[21]	70 (18)	56	Normal EF	6
De Potter et al (2010)[22]	72 (36)	52	Normal EF	16
Choi et al (2010)[23]	30 (15)	56	Medical management of HF	16
Cha et al (2011)[24]	368 (111)	55	Normal EF and diastolic dysfunction	13
Anselmino et al (2013)[25]	196 (196)	60	NA	46
Calvo et al (2013)[26]	658 (97)	53	Normal EF	6
Nedios et al (2014)[27]	138 (69)	60	Normal EF	28
Kosiuk et al (2014)[28]	73 (73)	59	NA	40
Lobo et al (2015)[29]	31 (31)	60	NA	20
Bunch et al (2015)[30]	2403 (267)	66	Matched low EF, no ablation, low EF no AF	60
Rillig et al (2015)[31]	80 (80)	62	NA	72
Kato et al (2016)[32]	18 (18)	55	NA	21
Yanagisawa et al (2016)[33]	54 (54)	60	NA	6
Ullah et al (2016)[34]	1273 (171)	58	Normal EF	43
Randomized control trials				
Khan et al (2008)[35]	81 (41)	60	AV nodal ablation and BIV pacing	6
MacDonald et al (2011)[36]	41 (22)	62	Medical rate control	6
Jones et al (2013)[37]	52 (26)	63	Medical rate control	12
Hunter et al (2014)[38]	50 (26)	55	Medical rate control	12
Di Biase et al (2016)[39]	203 (102)	62	Amiodarone	24
Prabhu et al (2017)[40]	63 (33)	59	Medical rate control	6
Marrouche et al (2018)[41]	363 (179)	64	Medical rate or rhythm control	38

AF = atrial fibrillation; BIV = biventricular; EF = ejection fraction; HF = heart failure; LVEF = left ventricular ejection fraction.

Four of the randomized control trials compared catheter ablation of AF with medical rate control. Among these studies, there was an approximate 11% improvement in the LVEF at an average of 9 months follow-up. However, the improvement in the ablation group seen by MacDonald et al[36] was not statistically significant relative to the medical treatment group (4.5 ± 11.1% vs 2.8 ± 6.7%, p = 0.6). Jones et al found significant improvements in LVEF in both the ablation group (21.5 ± 8.3% to 32.8 ± 14.3%, p < 0.001) and rate-control group (24.9 ± 7.2% to 30.2 ± 9.4%, p = 0.003). However, the trend toward improvement of LVEF in the ablation arm was not statistically significant compared with rate control (mean difference +5.6%, 95% CI −0.1 to +11.3, p = 0.055).[37] Hunter et al found that LVEF improved by 8% in the ablation group (32 ± 8% to 40 ± 12%) compared with a 3% decrease in the medical group (34 ± 12% to 31 ± 13%) at 6 months (p = 0.015). Although the improvement in LVEF was sustained at 1 year in the ablation group, with an average LVEF of 41%, there were no data for comparison in the medical group at 1 year, as many underwent ablation or device implantation.[38] Prabhu et al[40] found that LVEF improved by 18 ± 13% in the ablation group compared with 4.4 ± 13% in the medical rate control group (p < 0.0001) with a normalized LVEF (defined as LVEF ≥ 50%) in 58% versus 9%, respectively (p = 0.0002).

Di Biase et al[39] found that the ablation group showed a significant improvement in LVEF relative to amiodarone (8.1 ± 4.0% vs 6.2 ± 5.0%, p = 0.02). Marrouche et al[41] showed the median absolute increase in LVEF at 60-month follow-up was 8.0% (interquartile range 2.2 to 19.1) in the ablation group versus 0.2% (−3.0 to 16.1) in the medical therapy group (p = 0.005). The heterogeneity in trial designs makes the results more difficult to generalize, but overall, there was at least a trend toward improvement in LVEF among patients with HF with reduced ejection fraction (HFrEF) who underwent catheter ablation for AF (Figure 1). The proportions of various types of cardiomyopathies included in these studies are summarized in Figure 2.

Exercise Capacity

The New York Heart Association (NYHA) functional class is a well-validated metric for measuring exercise capacity and prognosis in HF.[42] Multiple observational studies have demonstrated significant improvement in NYHA functional class in HF patients with AF who underwent catheter ablation, with an average improvement of approximately 1 functional class. Follow-up ranged from 1 to 6 years post-procedure in these studies.[16,23,25,27-29,31,32,34] Of note, Choi et al[23] found that this increase in NYHA class was not observed in their AF patients with HF receiving medical treatment.

The 6-minute walk test (6MWT) is also often used to assess functional limitations in patients with HF, and has been used as an outcome metric in HF patients with AF who underwent catheter ablation. Tondo et al[17] showed a significant improvement in the 6MWT among those who were in sinus rhythm and increased exercise time from 9 ± 3 to 14 ± 6 minutes a year after ablation (p < 0.001). However, the results from 4 randomized control trials are more heterogeneous. Khan et al[35] found that PVI ablation procedures yielded statistically significant improvements (p < 0.001) in 6 MWT performance (269 ± 54 m to 340 ±

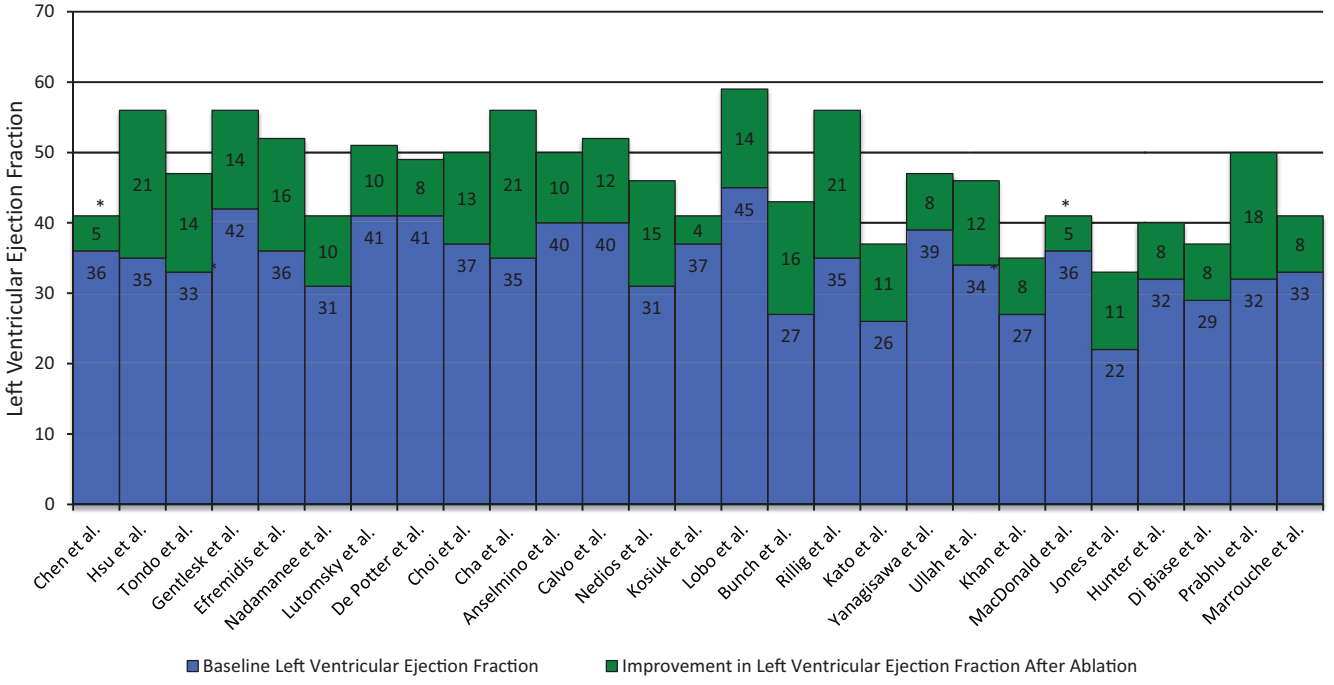

Figure 1. A summary of studies evaluating left ventricular ejection fraction change after ablation for atrial fibrillation. The *blue bars* represent baseline left ventricular ejection fraction and the *green bars* represent improvement in left ventricular ejection fraction after ablation. * p > 0.05. (Color version of figure is available online.)

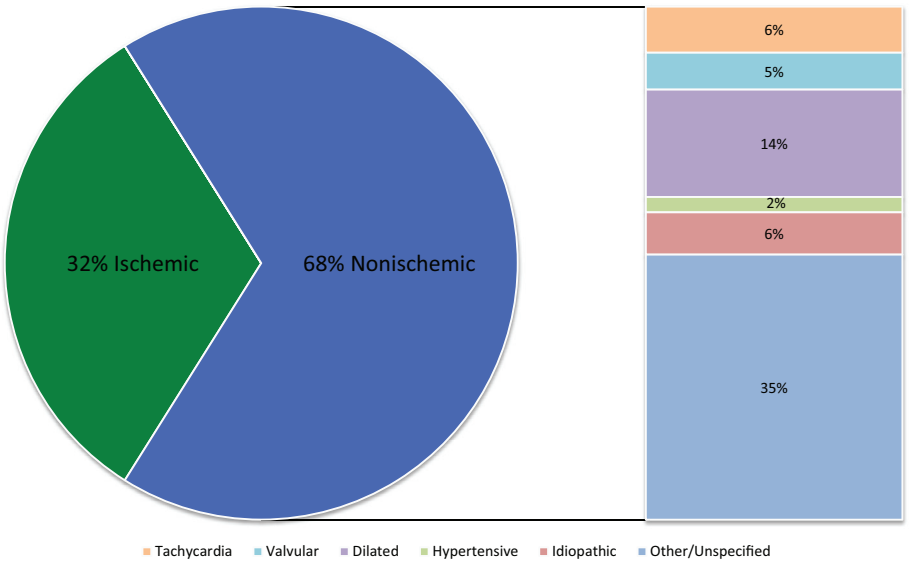

Figure 2. Summary of the various etiologies of heart failure in patients who underwent catheter ablation for atrial fibrillation included in this review. The other or unspecified category included patients with hypertrophic, congenital, inflammatory, metabolic, and neuromuscular cardiomyopathy as well as cardiomyopathy secondary to arrhythmogenic right ventricular dysplasia, myocardial sclerosis, and myocarditis. The rest were otherwise unspecified in the baseline characteristics.

49m) compared with AV node ablation with biventricular pacing (281 ± 44 m to 297 ± 36m). Jones et al[37] found an insignificant increase in the 6MWT distance compared with a decrease in the medical rate control group, and MacDonald et al[36] showed that RF ablation did not significantly improve 6MWT performance compared with medical rate control. Marrouche et al found that the 6MWT distance improved significantly in the ablation group (52.7 ± 10.6) relative to the medical rate or rhythm control group (7.1 ± 13.7) at 12 months ($p = 0.007$). However, this effect was not sustained by 60 months with the ablation group returning to baseline level and medical therapy group decreasing below baseline, which was thought to be due to health deterioration in aging patients.[41] The differences among the results of these studies are likely due to the different comparator arms and variability in AF recurrence rates.

Peak oxygen consumption (VO_2) is another strong prognostic indicator that has been used to evaluate exercise capacity.[43] Jones et al[37] found VO_2 had increased (2.13 [−0.10 to +4.36] ml/kg/min) in the ablation arm compared with a decrease (−0.94 [−2.21 to +0.32] ml/kg/min) in the rate-control arm at 12 months ($p = 0.018$). Hunter et al found similar results, with a VO_2 max of 22.4 ml/kg/min in the ablation group versus 17.7 ml/kg/min in the medical group at 6 months ($p = 0.014$). This improvement was sustained at 1 year, but there are no 1-year data from the medical group to compare results with.[38] In both of these trials, the significant increase in VO_2 was not observed initially at 3 months.

Quality of Life

Quality of life was also evaluated in several studies examining the impact of catheter ablation in AF patients with HF. All of the observational studies that examined quality of life used the Medical Outcomes Survey 36-Item Short-Form Health Survey (SF-36). Scores range from 0 to 100, with a higher score indicative of a better quality of life.[44]

Both Chen et al[15] and Tondo et al[17] found a significant improvement across all areas of the SF-36 ($p < 0.05$), with an average improvement of 42 and 44, respectively. They also showed that the normal LVEF patients in the comparator arm had significant improvement across all areas with an average of 45 in both studies ($p < 0.05$). Hsu et al[16] showed there to be a significant improvement in the physical and mental components after ablation with an average improvement of 24 ± 21 and 21 ± 19, respectively ($p < 0.001$ for both comparisons). Among the normal LVEF patients, the physical component score increased by 18 ± 17 ($p = 0.003$) and the mental component score increased 14 ± 19 ($p = 0.004$). Cha et al[24] found the mean physical component score to be significantly higher in the normal LVEF group (77.3 ± 16.2) and the systolic dysfunction group (77.1 ± 17.5) than in the diastolic dysfunction group (69.3 ± 21.8, p=0.03), although all 3 groups experienced significant improvements from baseline. Mental component scores only improved significantly from baseline to 1 year for patients with systolic dysfunction.

As for the randomized control trials, the predominant questionnaire used was the Minnesota Living with HF Questionnaire (MLHFQ). Scores range from 0 to 105, with lower scores indicative of a better quality of life.[45] Khan et al[35] found that MLHFQ scores significantly improved from baseline to 6 months after the procedure in both the PVI group (89 ± 12 to 60 ± 8) and the AV node ablation with biventricular pacing group (89 ± 11 to 82 ± 14). The

improvement seen in the PVI group was significantly greater ($p < 0.001$). Di Biase et al[39] showed a greater reduction in the MLHFQ score among patients who underwent ablation compared with those who were treated with amiodarone (11 ± 19 vs 6 ± 17; $p = 0.04$).

Jones et al[37] showed that the MLHFQ score did not significantly improve relative to the medical rate control group at 3 months ($p = 0.196$), but significantly at 6 ($p = 0.015$) and 12 months with a median of -15.5 ($p = 0.019$). Hunter et al[38] also found a significant improvement in MLHFQ scores in the ablation group compared with the medical rate control group ($p < 0.001$), but this difference was seen as early as 1 month and sustained at 1 year. There were also significant improvements in the physical functioning ($p = 0.007$), physical role functioning ($p = 0.004$), bodily pain ($p = 0.005$), and vitality components ($p = 0.009$) of the SF-36. However, MacDonald et al[36] did not find a significant difference between ablation and medical rate control in the MLHFQ score or Kansas City Cardiomyopathy Questionnaire. Still, there was a significant improvement in the physical component of the SF-36 score in the ablation group ($+4.0 \pm 9.5$ units vs -1.0 ± 4.4 units, $p = 0.042$).

Hospitalizations and Mortality

Many of the initial studies did not track hospitalizations and mortality in HF patients with AF who underwent catheter ablation. Kato et al showed that hospitalizations for HF significantly decreased after ablation. There were 23 hospitalizations for HF in 13 patients over a median of 33 months between the first diagnosis of AF and the first procedure. During a median follow-up of 30 months after ablation, there were only 9 hospitalizations for HF in 5 patients.[32] Bunch et al found that the ablation group had significantly less HF hospitalizations and death at 5 years relative to patients with AF who did not undergo ablation (13.1% vs 18.9%, $p = 0.03$ and 24.0% vs 44.3%, $p < 0.0001$, respectively). Furthermore, hospitalizations in the ablation group were similar relative to patients without AF (13.1% vs. 13.1%, $p = 1.00$), but with significantly less mortality in the ablation group (24.0% vs 40.5%, $p < 0.0001$).[30]

Hospitalization and mortality findings in observational studies are supported by randomized controlled trial data. The Ablation Versus Amiodarone for Treatment of Persistent Atrial Fibrillation in Patients With Congestive Heart Failure and an Implanted Device (AATAC) study randomized 203 patients with persistent AF and an EF $\leq 40\%$ to either catheter ablation ($n = 102$) or amiodarone ($n = 101$) and found that the catheter ablation group's 31% unplanned hospitalization rate was significantly lower than the 57% among the amiodarone group ($p < 0.001$) over a 2-year follow-up. Additionally, there were significantly fewer deaths in the ablation group (8% vs 18%, $p = 0.037$).[39] Recently, these findings have been corroborated by the Catheter Ablation versus Standard Conventional Therapy in Patients with Left Ventricular Dysfuction and Atrial Fibrillation (CASTLE-AF) trial. This trial randomized 397 patients with symptomatic paroxysmal or persistent AF and an EF $\leq 35\%$ to either RF catheter ablation or conventional drug treatment, including rate or rhythm control. Over a median follow-up period of 38 months, the composite end point of all-cause mortality and unplanned hospitalization for worsening HF was significantly lower in the ablation group relative to the control group (28.5% vs 44.6%, $p = 0.006$). Furthermore, the secondary end points of all-cause mortality (13.4% vs 25%, $p = 0.01$) and HF hospitalizations (20.7% vs 35.9%, $p = 0.004$) were significantly lower in the ablation group.[41]

Catheter Ablation of AF in HF With Preserved Ejection Fraction

Data concerning patients who have HF with preserved ejection fraction (HFpEF) is much more sparse. Cha et al evaluated 368 patients in a prospective cohort study that captured data on 157 patients with diastolic dysfunction (HFpEF), 111 with systolic dysfunction (HFrEF), and 100 controls patients with normal left ventricular function. This study showed no statistically significant difference in 1-year AF recurrence rate between the diastolic dysfunction and control groups, whether on or off antiarrhythmic drugs. However, in extended follow-up out to 5 years, freedom from AF recurrence approached 40% in the diastolic dysfunction group and 65% in the control group, which was statistically significant. Despite this, 30% of HFpEF patients demonstrated at least 1 grade improvement in diastolic dysfunction and significant improvement in the physical component of the SF-36.[24]

Machino-Ohtsuka et al evaluated 74 patients with HFpEF and AF who underwent catheter ablation. There was an average follow-up of 34 months with single- and multiple-procedure drug-free success rates of 27% and 45%, respectively. The success rate increased to 73% with pharmaceutical assistance. Although this study provided evidence in support of the efficacy and safety of ablation in this patient population, there was no comparator arm.[46]

Black-Maier et al enrolled patients with a clinical diagnosis of HF based on the Framingham criteria instead of echocardiographic findings. This retrospective study looked at ablation in 97 HFrEF and 133 HFpEF patients and demonstrated similar effectiveness in both groups. There was no significant difference in procedure times, adverse events, arrhythmia-free recurrence, or functional improvements as assessed by Mayo AF Symptom Inventory and NYHA functional class.[47]

Limitations, Unanswered Questions, and Future Studies

The literature regarding catheter ablation of AF in HF is rapidly expanding and evolving. However, the studies discussed previously need to be interpreted with caution, as there are several limitations. Most of these studies were relatively small, with <100 patients. The majority of these studies had a follow-up time of 16 months or less with limited monitoring of AF after ablation, which could have potentially overestimated success. Additionally, the various studies were mixed in terms of the catheter ablation technique employed; some used PVI alone, whereas others used PVI in tandem with additional ablation. Finally, most of the studies included a majority of nonischemic cardiomyopathy

Table 3
Ongoing randomized control trials evaluating catheter ablation for atrial fibrillation in heart failure patients

	Clinicaltrials.gov identifier	Sample size	Study group	Comparator arm	Primary end point
AMICA	NCT02509754	202	ICD or CRT-D, any AF type, and LVEF ≤35%	Medical rate or rhythm control	LVEF by TTE
AFRC-LVF	NCT02509754	180	Persistent AF and LVEF ≤35%	Medical or interventional rate control	Composite of the improvement of LVEF above 35% and concomitant NYHA class lower than II
RAFT AF	NCT01420393	600	Any type of AF and HF with preserved or reduced EF	Medical or interventional rate control	Composite of all-cause mortality and hospitalization for heart failure
CATCH AF	NCT02686749	220	Symptomatic AF and LVEF 20-45%	Medical rate or rhythm control	First hospitalization for HF, recurrence of AF or DCCV
CABANA	NCT00911508	2204	Any AF type with one risk factor for stroke (including CHF)	Medical rate or rhythm control	Composite end point of total mortality, disabling stroke, serous bleeding or cardiac arrest

AF = atrial fibrillation; BIV = biventricular; EF = ejection fraction; HF = heart failure; LVEF = left ventricular ejection fraction; TTE = transthoracic echocardiogram.

patients and did not have all patients on optimal medical therapy, which limits the generalizability.

For these reasons, it is still unclear if the benefits of ablation apply to all HF patient subgroups, especially ischemic cardiomyopathy and HFpEF patients, which ablation technique is ideal, and how cost-effective ablation is, given that many patients required multiple procedures. More large scale, randomized control trials with longer follow-up are needed to address these questions. Ongoing clinical trials of catheter ablation for AF in a HF population are summarized in Table 3.

In conclusion, the relation between AF and HF is complex, but previous studies suggest a benefit of catheter ablation in HF patients with AF marked by improvements in maintenance of sinus rhythm, LVEF, exercise capacity, quality of life, hospitalization, and mortality rates. Additionally, there are data to support earlier ablation of AF and improved outcomes, but this has not been evaluated specifically in patients with concomitant HF.[48] Given these findings, clinicians may consider a lower threshold to refer patients with AF and HF for catheter ablation. Based on newer guideline recommendations, even for patients in whom AF may not be causing symptoms, ablation may be warranted due to subsequent clinical adverse outcomes.

Disclosures

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