# Positive impact of pulmonary vein isolation on biventricular pacing in nonresponders to cardiac resynchronization therapy

Thomas Fink, MD,* Enida Rexha, MD,* Michael Schlüter, PhD,† Christine Lemes, MD,* Tilman Maurer, MD,* Christian-Hendrik Heeger, MD,* Bruno Reissmann, MD,* Laura Rottner, MD,* Tobias Tönnis, MD,* Amaar Ujeyl, MD,* Matthias Krüger, MD,* Nathaniel Portz, MD,* Peter Wohlmuth, PhD,† Shibu Mathew, MD,* Feifan Ouyang, MD,* Andreas Rillig, MD,* Karl-Heinz Kuck, MD, FHRS,* Andreas Metzner, MD*

*From the *Department of Cardiology, Asklepios Klinik St. Georg, Hamburg, Germany, and †Asklepios Proresearch, Hamburg, Germany.*

**BACKGROUND** Cardiac resynchronization therapy (CRT) is less effective in patients with atrial fibrillation (AF) because of impaired ventricular CRT capture.

**OBJECTIVE** We investigated the effects of catheter ablation in patients with AF and previous nonresponse to CRT.

**METHODS** Consecutive patients with AF and CRT nonresponse who underwent catheter ablation for AF were analyzed. *CRT nonresponse* was defined as one of the following: (1) reduced biventricular capture <95% due to rapidly conducted AF, (2) <1 point improvement in New York Heart Association (NYHA) class after CRT implantation, or (3) insufficient increase in left ventricular ejection fraction (LVEF; ≤5%) after CRT implantation.

**RESULTS** Thirty-eight patients (8 women [21%]; mean age 68 ± 10 years; LVEF 30% ± 7%, biventricular capture 88.0% [25th, 75th percentile 75.3%, 98.5%]) underwent catheter ablation. One major and 1 minor complication occurred (1 lethal atrioesophageal fistula and 1 hemodynamically nonrelevant pericardial effusion). The Kaplan-Meier estimates for arrhythmia-free survival after single and multiple ablation procedures were 29% (95% confidence interval 16%–51%) and 67% (95% confidence interval 53%–86%) after 24 months. After a median follow-up of 817 days (25th, 75th percentile 179, 1741 days), biventricular capture and LVEF were significantly higher (median [25th, 75th percentile] 99% [96%, 99%], difference 8% [0.2%, 3.75%], $P < .0001$; mean 32.1% ± 9.1%, difference 2.2% ± 7.1%, $P = .0225$) and patients had a significantly lower functional NYHA class (28 of 37 patients with improvement of at least 1 point; $P < .0001$).

**CONCLUSION** Catheter ablation of AF significantly improves CRT response in patients with heart failure and concomitant AF in terms of increased biventricular capture and LVEF and improved functional NYHA class.

**KEYWORDS** Atrial fibrillation; Cardiac resynchronization therapy; Catheter ablation; Heart failure; Pulmonary vein isolation

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## Introduction

Cardiac resynchronization therapy (CRT) has evolved as a standard treatment in patients with heart failure and stable sinus rhythm, impaired systolic left ventricular (LV) function, and left bundle branch block and is recommended in the current guidelines.[1,2] There are only limited data on CRT in patients with heart failure and concomitant atrial fibrillation (AF), since in most trials for CRT evaluation, the occurrence of AF was an exclusion criterion.[3–7] CRT response is lower in patients with atrial arrhythmias than in patients with stable sinus rhythm because of impaired CRT pacing delivery in irregular atrioventricular (AV) electrical conduction resulting in fusion and pseudofusion beats.[8–10] As a consequence, current guidelines recommend CRT in patients with heart failure and AF only in the case of sufficient biventricular capture or expected restoration of sinus rhythm.[1,2] Nevertheless, a current European survey showed that 26% of patients with CRT devices suffer from persistent AF.[11]

The optimal treatment strategy for patients with CRT devices and AF is not known yet. Potential treatment options

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include rate control, antiarrhythmic drug (AAD) therapy, and AV node ablation to preserve a high level of biventricular pacing in patients with CRT devices. While several trials investigated the effect of AV node ablation, to our knowledge there are no data on rhythm control therapies such as catheter ablation for AF. In this study, we investigated the effects of catheter ablation in patients with AF and previous nonresponse to CRT.

## Methods

### Inclusion criteria and study population

Consecutive patients with documented AF and CRT nonresponse who underwent catheter ablation for AF between January 2010 and August 2017 were included in this retrospective analysis. The study was approved by the local ethics committee (file number WF-18/16). *CRT nonresponse* was defined as fulfillment of at least one of the following criteria (in the absence of any cause other than underlying AF):

1. recurrent proof of biventricular capture <95% due to rapidly conducted AF or
2. missing improvement in New York Heart Association (NYHA) class (<1 point after CRT device implantation) or
3. missing increase in LV ejection fraction (LVEF) of ≥5%

Procedural success and periprocedural adverse events, rhythm outcome, and the effect of catheter ablation on the percentage of biventricular capture, clinical improvement, or improvement in LVEF as documented by echocardiography were assessed. All patients included in the analysis gave written informed consent to the procedure and patient information was anonymized for analysis.

### Catheter ablation

Patients underwent transthoracic echocardiography and transesophageal echocardiography before ablation to exclude intracardiac thrombi and to assess LV and right heart function, left atrial (LA) diameter, and valve status. Oral anticoagulation with vitamin K antagonists was continued during the ablation procedure targeting a therapeutic international normalized ratio of 2–3. Novel oral anticoagulants were discontinued 24 hours before the ablation procedure. Procedures were performed under deep sedation with propofol, midazolam, and sufentanil.

Ablation was performed with either radiofrequency with a 3-dimensional mapping system (CARTO, Biosense Webster, Diamond Bar, CA) or the second generation cryoballoon (CB) (freeze cycle duration was set at 180–240 seconds). The degree of fibrosis was estimated according to the grade of fibrotic atrial cardiomyopathy[12] and to the extent of atrial fibrosis[13] as described previously. Transseptal puncture was performed using a modified Brockenbrough technique and transseptal sheaths (SL 1, St. Jude Medical, Minneapolis, MN) followed by selective pulmonary vein (PV) angiographies. After LA access, intravenous heparin was administered targeting an activated clotting time of >300 seconds. Ablation was performed using a 3.5-mm tip irrigated radiofrequency current catheter (ThermoCool NaviStar, Biosense Webster) with online verification of PV signals with a spiral mapping catheter. All patients underwent wide area circumferential PV isolation (PVI). Further ablation strategies (ablation of complex fractionated atrial electrograms, linear lesions, or block of the cavotricuspid isthmus) were conducted at the discretion of the operator. In case of CB ablation only a single transseptal puncture was perfomed under fluoroscopic guidance using a modified Brockenbrough technique and an 8,5 F transseptal sheath (SL 1, St. Jude Medical, Inc, St Paul, MN). The transseptal sheath was exchanged over a guidewire for a 15 F steerable sheath (Flexcath advance, Medtronic Inc). Then a freeze cycle with a duration of 240 seconds was applied until documentation of PVI. In all cases the second generation CB was used.

**Table 1** Patients' baseline data (N = 38)

| Variable | Value |
|---|---|
| Age (y) | 67.8 ± 9.8 |
| Female sex | 8 (21.1) |
| Type of AF | |
| Paroxysmal | 10 (26.3) |
| Persistent | 26 (68.4) |
| Long-standing persistent | 2 (5.3) |
| Mean ventricular rate before ablation (beats/min) | 90.7 ± 22.1 |
| AF before CRT implantation | 25 (65.8) |
| iCMP | 20 (52.6) |
| dCMP | 17 (44.7) |
| hCMP | 1 (2.6) |
| LVEF (%) | 30.4 ± 7.2 |
| LA diameter (mm) | 52.0 ± 6.6 |
| Time span from CRT implantation to AF ablation (d) | 874 ± 648 |
| Biventricular capture (%) | 88.0 (75.3, 98.5) |
| $CHA_2DS_2$-VASc score | 2 (1, 2) |
| 0–1 | 1 (2.6) |
| 2–3 | 18 (47.4) |
| >3 | 19 (50.0) |
| Baseline NYHA class | |
| I | 0 (0) |
| II | 3 (7.9) |
| III | 32 (84.2) |
| IV | 3 (7.9) |
| MitraClip after CRT implantation | 6 (15.8) |

| Baseline medication | CRT implantation* | First ablation |
|---|---|---|
| ACE/AT2 inhibitor | 28/29 (96.6) | 37 (97.4) |
| β-Blocker | 29/29 (100) | 37 (97.4) |
| Aldosterone antagonist | 22/29 (75.9) | 27 (71.1) |
| Loop diuretics | 38 (100) | 38 (100) |
| Class III AAD therapy | 13/29 (44.8) | 27 (71.1) |

Values are presented as mean ± SD, as median (25th, 75th percentile), or as n (%).

AAD = antiarrhythmic drug; ACE = Angiotensin-converting-enzyme inhibitor; AT2 = Angiotensin 2; AF = atrial fibrillation; CRT = cardiac resynchronisation therapy; dCMP = dilative cardiomyopathy; hCMP = hypertrophic cardiomyopathy; iCMP = ischemic cardiomyopathy; LA = left atrial; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association.
*Data available for 29 patients.

### Postprocedural care

All patients underwent transthoracic echocardiography to rule out pericardial effusion. Low-molecular-weight heparin was administered if the international normalized ratio was <2.0. Novel oral anticoagulants were reinitiated 6 hours postablation. Anticoagulation was continued in all patients for 3 months and thereafter on the basis of the individual $CHADS_2$/$CHA_2DS_2$-VASc score. AAD therapy was continued for at least 3 months after the ablation procedure. All patients were treated with proton pump inhibitors twice daily for 6 weeks.

### Repeat procedures

In repeat procedures, PVs were reisolated in case of electrical reconduction. Additional ablation was performed at the discretion of the operator. In case of atrial tachycardia (AT) as a mode of recurrence, the underlying AT mechanism was analyzed using standard pacing maneuvers and activation mapping and treated specifically according to its mechanism.

### Clinical follow-up

Follow-up was performed after 3, 6, and 12 months postprocedure and thereafter in 6-month intervals, including clinical examination, 12-lead electrocardiography, 24-hour Holter electrocardiography, and echocardiography, to estimate functional NYHA class, LVEF, and CRT device interrogation. Follow-up parameters were analyzed for differences before the first ablation procedure and at the time point of last clinical follow-up. Recurrence of atrial arrhythmias was analyzed respecting a blanking period of 90 days after the initial ablation procedure. Patients who underwent AV node ablation were excluded from the follow-up analysis of NYHA class, LVEF, and biventricular capture.

### Statistics

Continuous data were summarized as mean ± SD or as median (25th, 75th percentile), as appropriate. Categorical data were presented as number (percentage). Linear and ordinal mixed models were used to compare bipace, NYHA, and LVEF data between preintervention and the last follow-up of patients. The follow-up duration was taken into account, and bipace data were logit transformed beforehand. Freedom of atrial arrhythmias was estimated using the Kaplan-Meier method. $P$ values were 2-sided, and a $P$ value of <0.05 was considered significant. All calculations were performed using the statistical analysis software R (R Core Team, 2018).

## Results

### Patient characteristics

A total of 38 patients were analyzed. The mean LA diameter was 52.0 ± 6.6 mm, and the mean LVEF was 30.4% ± 7.3%. The median ratio of biventricular stimulation before ablation was 88.0% (25th, 75th percentile 75.3%, 98.5%). Twenty-four

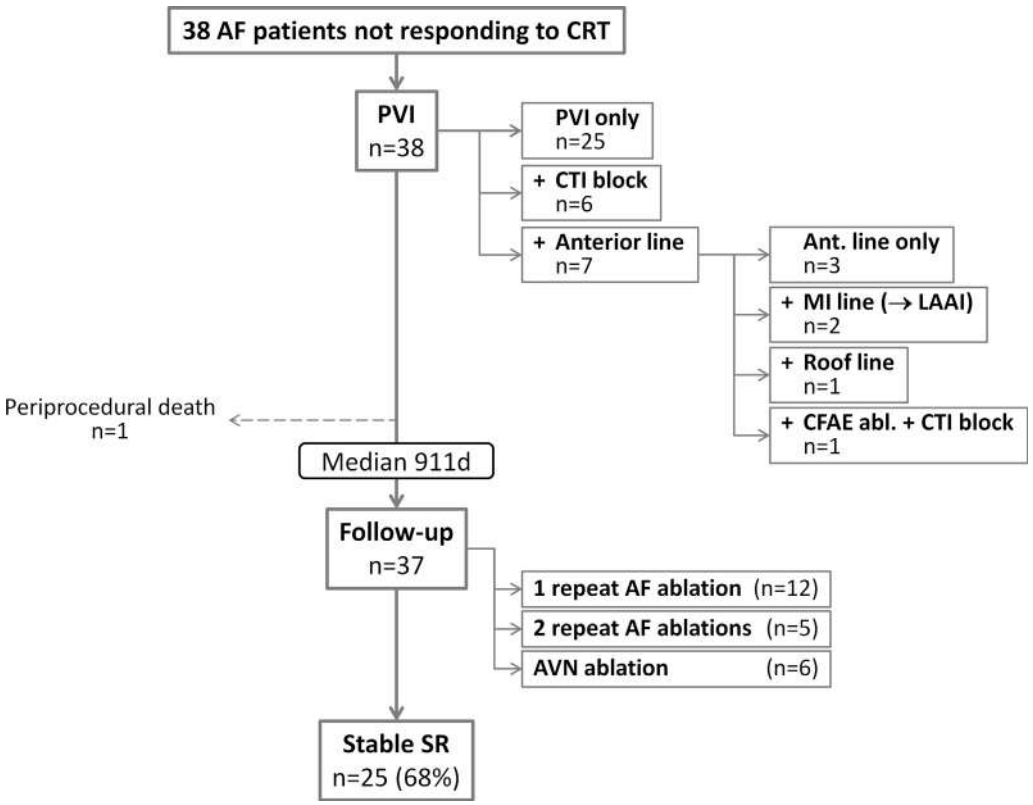


**Figure 1** Study overview. AF = atrial fibrillation; Ant. line = anterior line; AVN = atrioventricular node; CFAE = complex fractionated atrial electrogram; CRT = cardiac resynchronization therapy; CTI = cavotricuspid isthmus; LAAI = left atrial appendage isolation; MI = mitral isthmus; PVI = pulmonary vein isolation; SR = sinus rhythm.

patients (63.2%) were categorized as CRT nonresponders because of insufficient biventricular capture before the first ablation procedure, 4 patients (10.5%) because of missing clinical response as estimated by NYHA classification, and 10 patients (26.3%) because of lack of improvement in LV function as estimated by echocardiographic parameters. Table 1 summarizes patients' baseline data.

### Results of catheter ablation

All patients underwent successful PVI (36 radiofrequency ablation procedures and 2 CB ablation procedures) (Figure 1). The amount of atrial fibrosis was classified as a fibrotic atrial cardiomyopathy grade >2 in 25 of 37 patients with available 3-dimensional mapping (67.6%) with an amount of LA scarring >10% in 22 of 37 patients (59.5%). There was 1 major procedural complication in the form of an atrioesophageal fistula diagnosed 28 days postablation. The patient suffered from a febrile infection and underwent transesophageal echocardiography to exclude endocarditis, which caused air embolism and bleeding from the atrioesophageal fistula. The patient died 2 days later after excessive bleeding from the fistula. In addition, 1 minor complication occurred in the form of a hemodynamically nonrelevant pericardial effusion.

### Clinical follow-up and repeat ablation procedures

Thirty-seven patients underwent clinical follow-up (excluding the patient with atrioesophageal fistula) with a median follow-up duration of 817 days (25th, 75th percentile 179, 1741 days) (Table 2). One patient died 53 days after ablation because of a noncardiac reason. The Kaplan-Meier estimates for arrhythmia-free survival after single and multiple ablation procedures were 29% (95% confidence interval 16%–51%) (Figure 2) and 67% (95% confidence interval 53%–86%) (Figure 3) after 24 months. The mode of recurrence was AF in 19 of 26 patients (73.1%) and AT in 7 of 26 patients (26.9%).

Seventeen patients underwent 22 repeat ablation procedures. LA-to-PV reconduction was documented in 16 of 17 patients (94%) during at least 1 repeat procedure. All PVs were successfully reisolated. More extensive strategies were applied in 9 of 17 patients (53.0%). Four of these 9 patients had perimitral flutter and underwent LA anterior line ablation. Figure 4 presents detailed results of the repeat ablation procedures.

Six patients (15.8%) underwent AV node ablation after a median of 99 days (25th, 75th percentile 98, 99 days) (3 patients without repeat ablation attempt, 2 patients after 1 repeat ablation, and 1 patient after 2 repeat ablation procedures). At the end of follow-up, 25 patients (67.6%) were in sinus rhythm, with 12 patients (32.4%) in sinus rhythm without AAD.

### Effects on biventricular capture and CRT response

At last clinical follow-up, biventricular capture and LVEF were significantly higher than those before the first ablation procedure (median [25th, 75th percentile] 99% [96%, 99%]; difference 7.5% [0.2%, 3.75%], $P < .0001$; mean 32.1% ± 9.1%, difference 2.2% ± 7.1%, $P = .0225$) and NYHA class was significantly lower ($P < .0001$) (Table 3) in patients without AV node ablation. The amount of biventricular capture was 99% in all 6 patients who underwent AV node ablation.

**Table 2** Procedural data and follow-up

| Variable | Value |
|---|---|
| Procedure data (n = 38) | |
| Procedure duration (min) | 128.5 ± 35.9 |
| Fluoroscopy duration (min) | 17.5 ± 7.3 |
| Fluoroscopy dosage (cGy•cm$^2$) | 3225.9 ± 3191.8 |
| Volume contrast medium (mL) | 87.6 ± 32.1 |
| FACM grade*[12] | |
| 0–1 | 11 (29.7) |
| 2 | 12 (32.4) |
| 3 | 13 (35.1) |
| Amount of scarring*[13] | |
| 0%–10% | 15 (40.5) |
| >10%–50% | 11 (29.7) |
| >50% | 11 (29.7) |
| Major complications | 1 (2.6) |
| Lethal atrioesophageal fistula | 1 (2.6) |
| Minor complications | 1 (2.6) |
| Pericardial effusion, conservative treatment | 1 (2.6) |
| Follow-up data (n = 37)† | |
| Follow-up duration (d) | 817 (179, 1741) |
| Arrhythmia recurrence after 1 procedure | 26 (70.3) |
| AF | 19 (73.1) |
| AT | 7 (26.9) |
| Repeat ablation procedures during follow-up | |
| No. of patients undergoing repeat ablation procedures‡ | 17 (45.9) |
| No. of patients undergoing 1 repeat ablation‡ | 12 (31.6) |
| No. of patients undergoing 2 repeat ablation procedures‡ | 5 (13.2) |
| Mean number of ablation procedures‡ | 1.6 ± 0.8 |
| No. of patients undergoing AV node ablation | 6 (16.2) |
| Rhythm at the end of follow-up | |
| Sinus rhythm | 25 (67.6) |
| AF | 9 (24.3) [5 with AV node ablation] |
| AT | 3 (8.1) [1 with AV node ablation] |
| Death, noncardiac reason | 1 (2.7) |

Values are presented as mean ± SD or as n (%).

AF = atrial fibrillation; AT = atrial tachycardia; AV = atrioventricular; FACM = fibrotic atrial cardiomyopathy.

*Excluding AV node ablation procedures.

†1 patient died during follow-up because of noncardiac reasons.

‡3-dimensional mapping available only in 37 patients during index or repeat ablation procedures.

## Discussion

### Major findings

To our knowledge, we report for the first time the results of catheter ablation of AF as a rhythm control strategy in

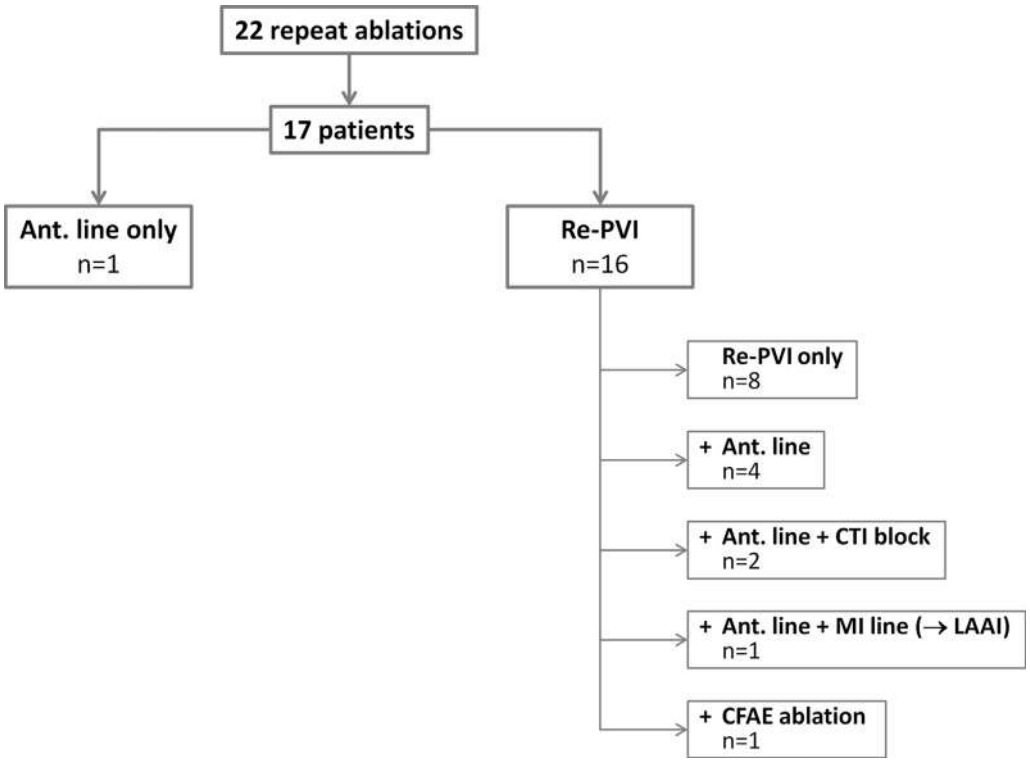


**Figure 2** Freedom from recurrence of atrial arrhythmias after the first ablation procedure. The Kaplan-Meier estimate after a single ablation procedure was 33.4% (95% confidence interval 20.0%–55.6%) after 24 months. Two patients underwent atrioventricular node ablation and 1 patient underwent repeat ablation and atrioventricular node ablation during the blanking period.

patients with heart failure and CRT devices. Our main findings are as follows: (1) Stable sinus rhythm after a single ablation procedure was restored in only one-third of patients and the rate increased substantially after multiple ablation procedures. (2) Catheter ablation resulted in a significant improvement in biventricular capture, LVEF, and functional NYHA class in patients with CRT devices. (3) PVI was the main ablation strategy during the index procedure, and electrical PV reconnection was the main finding in repeat procedures.

## CRT in patients with AF

A subgroup analysis of patients with AF in the Multisite Stimulation in Cardiomyopathies (MUSTIC) trial, which was the first randomized study to compare right ventricular pacing and CRT in heart failure, demonstrated comparable results for patients with AF and patients with sinus rhythm if rate control was sufficiently achieved[14]; the remaining patients had no benefit from CRT as compared to pure right ventricular pacing. The Resynchronization–Defibrillation for Ambulatory Heart Failure Trial (RAFT) was the only large randomized CRT trial that included patients with AF and showed similar effects of CRT for patients with AF or atrial flutter as compared with patients with sinus rhythm, but the inclusion criterion was optimal rate control for patients with AF with a heart rate of <60 beats/min during rest and <90 beats/min during exercise.[6] Effective CRT capture in AF therefore depends on optimal rate control. In addition, AF reduces the effectiveness of CRT therapy in patients with heart failure because of ineffective biventricular capture.[8–10] If rate control cannot be achieved or AF leads to a decreased amount of biventricular capture, effort should therefore be made to restore CRT efficacy.

## Current status of catheter ablation for AF in heart failure and patients with CRT devices

Although AF is a common finding in patients with heart failure, data on the optimal AF therapy in this patient group is still limited.[1,2] Rhythm control of AF in patients with heart failure is challenging because of the limited range of possible AAD therapy.[15,16] In addition, LV dysfunction itself was a major risk factor for AF recurrence after rhythm control attempts in the Atrial Fibrillation Follow- Up Investigation of Rhythm Management trial.[17,18] Initial studies on catheter ablation of AF showed promising results regarding improvement in heart failure symptoms and functional parameters.[19,20] Nevertheless, these studies lacked in larger patient cohorts and did not result in a clear recommendation of the current ACC/AHA/HFSA/ESC guidelines to pursue rhythm control in heart failure.[1,2,15,16] The multicenter randomized Ablation vs Amiodarone for Treatment of Atrial Fibrillation in Patients With Congestive Heart Failure and an Implanted ICD/CRTD (AATAC) trial showed superior results of catheter ablation for AF as compared to therapy with amiodarone in patients with heart failure and reduced mortality and rehospitalizations.[21] The Catheter Ablation

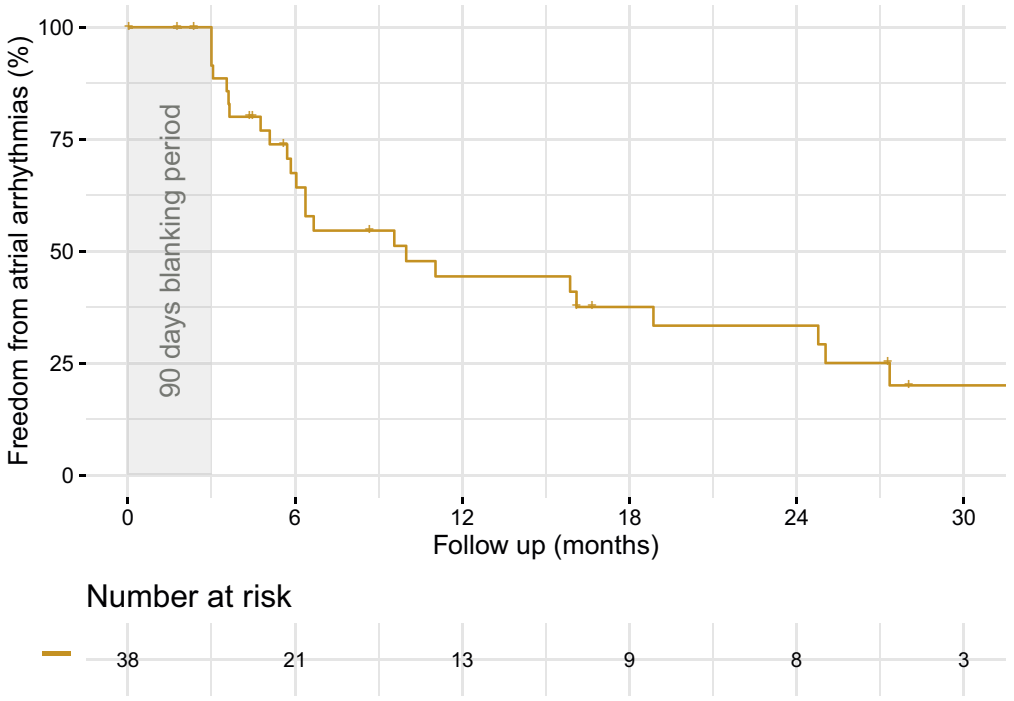


**Figure 3** Freedom from recurrence of atrial arrhythmias after multiple procedures. The Kaplan-Meier estimate after multiple ablation procedures was 71.8% (95% confidence interval 57.5%–89.7%) after 24 months. Two patients underwent atrioventricular node ablation and 1 patient underwent repeat ablation and AV node ablation during the blanking period.

versus Standard Conventional Therapy in Patients with Left Ventricular Dysfunction and Atrial Fibrillation (CASTLE-AF) trial showed analogous findings with regard to improved rhythm control and reduced mortality after catheter ablation as compared to standard treatment comprising medical rhythm control or medical rate control.[22] Patients with CRT devices were included in these 2 studies, but detailed outcome was not reported yet.

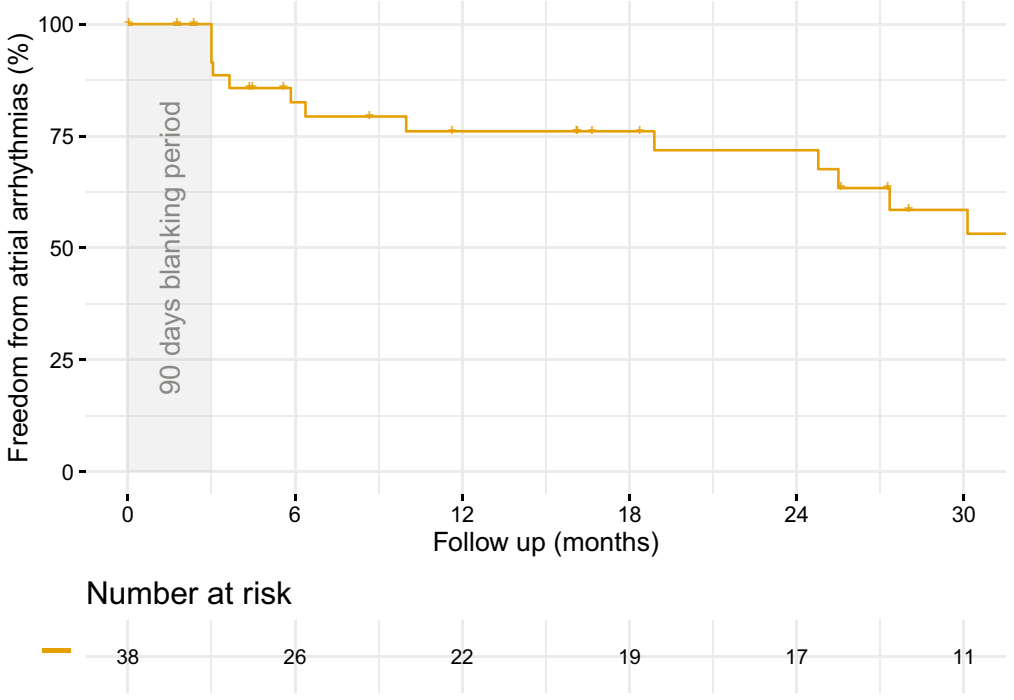


**Figure 4** Ablation strategy during repeat ablation procedures. Ant. line = anterior line; CFAE = complex fractionated atrial electrogram; CTI = cavotricuspid isthmus; LAAI = left atrial appendage isolation; MI = mitral isthmus; Re-PVI = repeat pulmonary vein isolation.

**Table 3** Functional status after catheter ablation at the time point of last follow-up

| Variable | Value after ablation | Difference in values before ablation | *P* |
|---|---|---|---|
| Biventricular capture (%) | 99.0 (96.0, 99.0) | 7.5 (0, 23.75) | ≤.0001 |
| LVEF (%) | 32.1 ± 9.1 | 2.2 ± 7.1 | .0225 |
| Functional NYHA class | | | ≤.0001 |
| I | 3 (8.1) | ±0: 9 (24.3) | |
| II | 27 (73.0) | −1: 24 (64.9) | |
| III | 7 (18.9) | −2: 4 (10.8) | |
| IV | 0 (0.0) | | |

Values are presented as mean ± SD, as median (25th, 75th percentile), or as n (%). Patients who underwent atrioventricular node ablation were excluded from the analysis.

LVEF = left ventricular ejection fraction; NYHA = New York Heart Association.

In contrast, AV node ablation in patients with CRT devices and AF has been investigated and proved to increase exercise capacity.[23] Gasparini et al[24] found the amount of biventricular capture to be comparable to patients in sinus rhythm. Moreover, improved LV systolic function and beneficial reverse remodeling after AV node ablation in patients with CRT devices were assessed. In addition, the Cardiac Resynchronization Therapy in Atrial Fibrillation Patients Multinational Registry study demonstrated lower total mortality and cardiac mortality after AV node ablation as compared to rate control.[25]

The disadvantage of AV node ablation is the loss of restored atrial function, which is seen after restoration of stable sinus rhythm. This points to a potential benefit of catheter ablation approaches aiming at rhythm control in patients with CRT devices and AF, which might restore sinus rhythm and atrial function. There is a study that neither investigate the effects of AF ablation with the aim of rhythm control in patients with CRT devices nor compare PVI and AV node ablation in these patients. In our study, we found an improvement in CRT effectiveness after catheter ablation for AF including PVI as the cornerstone ablation strategy. This finding was accompanied by an improvement in NYHA class.

## Ablation strategies in patients with heart failure and mode of recurrence

Effectiveness of AF ablation is known to be reduced in patients with heart failure as compared with patients with normal LV function,[17,18,26,27] especially in patients with heart failure and persistent AF.[28] The reasons are not yet fully understood, but enlarged atrial dimensions, a high possibility of the presence of atrial scarring, and a large number of patients with heart failure being in persistent AF, which are known markers for AF recurrence after ablation,[29–31] have been suggested to play an important role. This is reflected in our study by a high rate of recurrence after the first ablation procedure and a large number of patients still being on AAD therapy after catheter ablation. Nevertheless, our results after multiple ablation procedures are considerably better, with an estimation of ~70% of patients being in sinus rhythm after 24 months.

The optimal ablation strategy for patients with persistent AF and for patients with AF and heart failure is not known. In the CASTLE-AF study, the ablation strategy was at the discretion of the operator and therefore not uniformly performed.[22] In the AATAC study, PVI was the cornerstone ablation strategy in all patients randomized to catheter ablation, but additional isolation of the posterior wall and ablation of non-PV triggers was performed in ~80% of the ablated patients.[21] The subgroup of patients who underwent additional ablation strategies had a significantly better outcome than did PVI alone.[21]

In our study, PVI was conducted in all patients. Additional ablation strategies including linear lesions and complex fractionated atrial electrogram ablation was conducted during the initial and repeat procedures in only 32% of patients. Arrhythmia recurrence was high after the initial ablation procedure in our study, but the results improved after repeat ablation procedures. The mechanism of recurrence cannot be clarified by our data, but in all except 1 patient we found PV reconduction during repeat procedures and the majority of patients had AF as a mode of recurrence. This finding is in line with previous studies of patients without structural heart disease.[32] Our findings indicate that PVI as the main ablation strategy in the index procedure is effective in a majority of patients to maintain stable sinus rhythm, which is similar to patient cohorts with long-standing persistent AF.[33] We therefore conclude that PV reconduction might be the most important determinant for arrhythmia recurrence in the investigated patient cohort.

## When should we aim at rhythm control in patients with heart failure?

AF ablation is a procedure with potential complications, especially in patients with marked comorbidity. In contrast, AV node ablation bears the potential of sufficient rate control after only a single ablation procedure in the majority of patients, and a low procedural risk profile. Nevertheless, in the light of the positive results of the recent AATAC and CASTLE-AF trials and the results of our proof-of-concept study, we conclude that AF ablation should be considered before rate control or AV node ablation in selected patients without CRT response.

## Study limitations

This study is a retrospective single-center study with a limited number of patients. Nevertheless, this is to our knowledge the first report on the effect of AF ablation including PVI in patients with CRT devices and AF.

## Conclusion

Catheter ablation of AF, including PVI, improved CRT response in patients with heart failure and AF with enhanced biventricular capture, LVEF, and functional NYHA class. Larger prospective trials are needed to confirm our findings.

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