Catheter Ablation for Reversal of Myocardial Remodeling in Arrhythmia-Induced Cardiomyopathy: A Case Series Study

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Abstract

Background: Persistent atrial fibrillation (AF) can result in arrhythmia-induced cardiomyopathy (AIC) and heart failure (HF), with heart failure with reduced ejection fraction (HFrEF) being the predominant form. Objective: To discuss the diagnostic and therapeutic experience and prognostic characteristics of catheter radiofrequency ablation in patients with AIC. Methods: A retrospective analysis was conducted of the radiofrequency catheter ablation procedures and follow-up outcomes of 3 patients with AIC admitted to the Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine between March 2022 and February 2023. Results: All 3 patients demonstrated varying degrees of LVEF improvement on the first postoperative day; follow-up at 3 and 6 months post-surgery revealed improvements compared with baseline, including increased overall LVEF levels and significant amelioration of mitral and tricuspid regurgitation and NYHA classification. Conclusion: Persistent AF can result in AIC and HF, primarily HFrEF. Catheter ablation (CA) can rapidly improve left ventricular ejection fraction (LVEF) in AIC patients within 24 hours post-procedure, with the rate of improvement far exceeding expectations, and continues to reverse myocardial fibrosis within 6 months. Through early CA with adequate arrhythmia control, myocardial fibrosis may undergo complete or partial reversal. However, the efficacy of CA for AF-mediated HFrEF and AIC remains under-recognized in clinical practice and warrants increased awareness among clinicians.

Full Text

Efficacy Analysis of Catheter Ablation in Reversing Arrhythmia-Induced Cardiomyopathy and Myocardial Remodeling: A Case Series Study

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Abstract

Background: Persistent atrial fibrillation (AF) can lead to arrhythmia-induced cardiomyopathy (AIC) and heart failure (HF), predominantly heart failure with reduced ejection fraction (HFrEF). **Objective:** To discuss the diagnostic and therapeutic experiences and prognostic characteristics of patients with AIC undergoing catheter radiofrequency ablation. **Methods:** A retrospective analysis was conducted on the radiofrequency catheter ablation procedures and follow-up outcomes of three patients with arrhythmia-induced cardiomyopathy treated at the Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine between March 2022 and February 2023. **Results:** All three patients demonstrated varying degrees of improvement in left ventricular ejection fraction (LVEF) on the first postoperative day. Follow-up assessments at 3 and 6 months showed overall improvement compared to preoperative levels, including increased LVEF, significant reduction in mitral and tricuspid regurgitation, and marked improvement in NYHA functional class. **Conclusion:** Catheter ablation (CA) rapidly improves LVEF in AIC patients within 24 hours postoperatively, with a rate far exceeding expectations, and continues to reverse myocardial fibrosis within 6 months. Following early CA-induced arrhythmia control, myocardial fibrosis may be fully or partially reversed. However, the clinical efficacy of CA for AF-mediated HFrEF and AIC remains underappreciated and warrants greater attention from clinicians.

Keywords: arrhythmia-induced cardiomyopathy; catheter-based radiofrequency ablation; heart failure with reduced ejection fraction; atrial fibrillation

Introduction

Atrial fibrillation (AF) is the most common clinical arrhythmia [1-2]. Persistent AF can lead to arrhythmia-induced cardiomyopathy (AIC), characterized by new-onset cardiac dysfunction, progressive left ventricular dilation, impaired

systolic and diastolic function, and eventual heart failure (HF) [3]. While the pathogenesis of AIC remains incompletely understood, early and adequate control of arrhythmia burden through pharmacological or catheter ablation (CA) therapy can lead to favorable atrioventricular remodeling and may terminate AF-related occult AIC [4]. This report summarizes and analyzes the radiofrequency catheter ablation procedures, follow-up outcomes, and prognostic characteristics of three patients with arrhythmia-induced cardiomyopathy treated at our institution between March 2022 and February 2023.

Case Reports

Case 1: A 76-year-old male was admitted on February 15, 2023, with recurrent exertional dyspnea and palpitations for over one year, worsening for half a month. He was previously diagnosed with dilated cardiomyopathy and atrial fibrillation at an external hospital. Symptoms exacerbated after a cold two weeks prior, with nocturnal paroxysmal dyspnea and orthopnea. Admission NYHA class was IV. Electrocardiogram confirmed AF with an average ventricular rate of 112 bpm. Echocardiography revealed LVEF 39%, left atrial diameter (LAD) 40 mm, left ventricular end-diastolic diameter (LVED) 53 mm, pulmonary artery pressure 46 mmHg, severe tricuspid regurgitation, and severe mitral regurgitation.

Case 2: A 43-year-old male was admitted on March 9, 2022, with recurrent palpitations and dyspnea for over two years, accompanied by upper abdominal discomfort for ten days. He had been diagnosed with atrial fibrillation and cardiac enlargement two years prior. Symptoms recurred ten days before admission with palpitations, chest tightness, exertional dyspnea, and nocturnal orthopnea. Admission NYHA class was III. Electrocardiogram showed AF with an average ventricular rate of 144 bpm. Echocardiography demonstrated LVEF 29.8%, LAD 51 mm, LVED 58 mm, pulmonary artery pressure 56 mmHg, severe tricuspid regurgitation, and moderate mitral regurgitation.

Case 3: A 64-year-old female was admitted on April 13, 2022, with recurrent palpitations and dyspnea for over two years, worsening for ten days. She was diagnosed with atrial fibrillation two years prior. Symptoms progressed ten days before admission with exertional dyspnea and 呼吸困难. Admission NYHA class was III. Electrocardiogram confirmed AF with an average ventricular rate of 106 bpm. Echocardiography revealed LVEF 35.2%, LAD 54 mm, LVED 57 mm, pulmonary artery pressure 55 mmHg, moderate-to-severe tricuspid regurgitation, and severe mitral regurgitation.

Methods and Results

All three patients presented with coexisting AF and HFrEF. Based on AIC diagnostic criteria [5], AIC was highly suspected. Preoperative evaluation included blood biochemistry, liver and renal function, coagulation profile, electrocardiogram, chest radiography, and echocardiography. Transesophageal echocardio-

graphy confirmed absence of left atrial appendage thrombus. After informed consent, patients underwent elective radiofrequency ablation. The AF ablation strategy comprised circumferential pulmonary vein isolation (PVI) and linear ablation, with electrical cardioversion when necessary. The procedural endpoint was achievement of bidirectional electrical isolation and ablation line block. Postoperative anticoagulation was prescribed, and patients were followed as outpatients with cardiac function parameters recorded at postoperative day 1, 3 months, and 6 months.

The cohort included two males and one female, aged 43-76 years (mean 61 years), with disease duration of 1-2 years (mean 1.6 years). All three patients showed varying degrees of LVEF improvement on postoperative day 1. Follow-up at 3 and 6 months demonstrated consistent improvement compared to baseline, with overall LVEF elevation stabilizing by three months post-procedure. LAD decreased compared to preoperative measurements, while mitral and tricuspid regurgitation and NYHA functional class showed significant improvement. Postoperative symptoms including palpitations and dyspnea were markedly reduced. No AF recurrence or adverse cardiovascular events occurred after discontinuation of anticoagulation, and all patients maintained good general condition during follow-up. See Table 1 .

Discussion

Heart failure represents the most common complication and cause of death in AF patients. According to the Framingham Heart Study, approximately 40% of patients with AF or HF develop the other condition [6]. AF affects one-third of HFrEF patients, with prevalence increasing alongside higher NYHA functional class [7,24]. Since Gossage' s 1913 report of the first case of dilated cardiomyopathy (DCM) induced by atrial fibrillation and Gallagher' s 1985 introduction of the tachycardiomyopathy (TCM) concept [8-11], AIC has gradually gained recognition. Persistent AF can induce AIC and subsequent HF, predominantly HFrEF. Therefore, the coexistence of AF and HFrEF should raise strong suspicion for AIC, necessitating aggressive treatment of both conditions.

Restoration and maintenance of sinus rhythm can improve LVEF [12-14], and CA represents the most effective method for rhythm control. Compared with pharmacological rate control, CA in patients with AF and HFrEF reduces mortality and hospitalization rates [15-18]. The CASTLE-AF trial by Brachmann J et al. [19] compared CA with rate-control medications in 363 HF patients with AF, demonstrating an 18% reduction in mortality or hospitalization risk and an 8% LVEF improvement in the CA group versus only 0.25% in the medical therapy group. The CABANA trial by Packer DL et al. [20] similarly confirmed that CA significantly improved mortality in the AF and HF subgroup. These findings align with our case series.

Early intervention is crucial for patients with AF and HF, with domestic and international guidelines recommending prompt treatment to halt disease pro-

gression and improve prognosis. The recently published "Chinese Guidelines for the Diagnosis and Treatment of Atrial Fibrillation" classifies CA as a Class I recommendation for AF patients with HFrEF and Class IIa for those with heart failure with preserved ejection fraction (HFpEF) [25]. Following early CA achieving adequate arrhythmia control, myocardial fibrosis may be fully or partially reversed [21-23], preventing AF-related AIC. In our case series of AF patients with HFrEF undergoing CA, all three patients demonstrated LVEF improvement within 24 hours, LAD reduction at three months, and significant improvement in valvular regurgitation and NYHA class. No adverse events occurred after medication discontinuation, confirming reliable overall efficacy.

AIC diagnosis is primarily retrospective, with the core feature being significant reduction or normalization of enlarged cardiac chambers following treatment. All three patients in this series exhibited these characteristics. Two patients achieved normalized ejection fraction after more than one year of follow-up, with significant improvement in atrial and ventricular dimensions, and neither required readmission for arrhythmia management, further supporting the AIC diagnosis. Our findings, combined with previous research, demonstrate that CA helps maintain sinus rhythm, improve ejection fraction, and restore valvular competence in AF patients with HFrEF, while also facilitating atrioventricular synchrony and optimal beta-blocker efficacy, thereby improving ventricular remodeling and quality of life.

This case series provides the first clinical evidence that catheter ablation can rapidly improve LVEF within 24 hours post-procedure in AIC patients—a rate of improvement exceeding expectations—while continuing to reverse myocardial fibrosis over six months. The concurrent improvement in valvular regurgitation and NYHA functional class provides multidimensional confirmation of CA efficacy. These findings address the current gap in guideline data regarding the temporal profile of myocardial fibrosis reversal following CA and provide crucial clinical evidence for the reversibility of myocardial remodeling in AIC.

Conclusion

For patients with AF and HFrEF, rhythm control is essential in addition to standard HF therapy, appropriate anticoagulation, and lifestyle management. A subset of these patients develops AF-mediated HF and AIC, which can be partially or completely reversed. Compared with rate-control medications, CA facilitates sinus rhythm restoration, improves quality of life, prognosis, and outcomes in HFrEF patients, and is now recommended as first-line therapy by domestic and international guidelines. Restoration of sinus rhythm through CA eliminates cardiac electrical dyssynchrony caused by AF, which in turn eliminates atrioventricular dyssynchrony, thereby improving ejection fraction—potentially explaining the immediate LVEF improvement observed on postoperative day 1 echocardiography. However, the clinical efficacy of CA for AF-mediated HFrEF remains underappreciated, possibly due to concerns about AF recurrence rates and prolonged procedural times. This underrecognition leads to persistent

AF, delayed treatment, and compromised prognosis, warranting greater clinical awareness.

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Note: Figure translations are in progress. See original paper for figures.