# Sinus rhythm restores ventricular function in patients with cardiomyopathy and no late gadolinium enhancement on cardiac magnetic resonance imaging who undergo catheter ablation for atrial fibrillation

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**BACKGROUND** Atrial fibrillation (AF) and systolic heart failure (HF) frequently coexist. Restoration of sinus rhythm by catheter ablation may result in a variable improvement in left ventricular (LV) function. Late-gadolinium enhancement (LGE) on cardiac magnetic resonance (CMR) imaging identifies irreversible structural change and may predict incomplete recovery of LV function.

**OBJECTIVE** To prospectively select patients with AF and symptomatic HF but without LV LGE and report the impact of AF ablation on LV function.

**METHODS** Patients with AF and symptomatic HF (LV ejection fraction $<50\%$) resistant to at least 1 antiarrhythmic drug and prior electrical cardioversion underwent contrast-enhanced CMR. LGE-negative patients underwent pulmonary vein isolation and left atrial roof line with continued antiarrhythmic medications until follow-up CMR 6 months postablation. Sixteen patients (aged 52 $\pm$ 11 years; mean AF duration 37 $\pm$ 39 months; left atrial size 44 $\pm$ 13 mL/m$^2$) underwent AF ablation.

**RESULTS** At 6 months, 15 of the 16 patients maintained sinus rhythm and underwent CMR. LV ejection fraction increased from 40% $\pm$ 10% at baseline to 60% $\pm$ 6% ($P < .001$) and LV end-systolic volume index decreased from 52 $\pm$ 12 to 36 $\pm$ 9 mL/m$^2$ ($P < .001$). Left atrial size decreased from 44 $\pm$ 13 to 36 $\pm$ 11 mL/m$^2$ ($P < .01$).

**CONCLUSIONS** In patients with AF and LV dysfunction in the absence of LGE on CMR, ventricular function normalizes following the restoration of sinus rhythm. CMR may assist in the selection of patients with combined AF and systolic HF most likely to benefit from catheter ablation.

**KEYWORDS** Atrial fibrillation; Ablation; Heart failure; Cardiac magnetic resonance; Late-gadolinium enhancement

**ABBREVIATIONS** **AF** = atrial fibrillation; **CMR** = cardiac magnetic resonance; **EF** = ejection fraction; **HF** = heart failure; **LA** = left atrial; **LGE** = late-gadolinium enhancement; **LV** = left ventricular; **PV** = pulmonary vein

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## Introduction

Atrial fibrillation (AF) occurs in up to 30% of the patients with left ventricular (LV) dysfunction, and its prevalence increases with severity of heart failure (HF) symptoms.[1] Restoration of sinus rhythm may lead to recovery of LV function; however, pharmacologic options are limited and AF recurrence is common following electrical cardioversion.[2] Catheter ablation of AF in patients with combined AF and systolic HF (AF-HF) improves LV function,[3–8] exercise capacity, and quality of life.[3–5] Despite its apparent efficacy, AF ablation has not been widely applied to this rapidly growing population.[3–6] Barriers to its wider use include the challenge of selecting patients most likely to benefit, a more complex ablation strategy that may be required in persistent AF, the lower success rate of pulmonary vein isolation alone, and the risk of complications.[9,10]

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The AF-CHF trial randomized patients with AF-HF to rate control vs rhythm control and did not demonstrate a difference in cardiovascular death, worsening HF, or stroke.[11] However, inclusion criteria permitted recruitment of patients with a low AF burden and few patients underwent catheter ablation. In contrast, catheter ablation studies have been retrospective single-center studies in highly selected patients showing remarkable improvements in LV function. Although ventricular function generally improves with the restoration of sinus rhythm, the magnitude of recovery is variable.[10,12]

Late-gadolinium enhancement (LGE) on contrast-enhanced cardiac magnetic resonance (CMR) imaging identifies regional scar and irreversible structural heart disease.[13,14] Leong et al[15] demonstrated minimal response to medical therapy in patients with newly diagnosed dilated cardiomyopathy and ventricular LGE on CMR. The present study aimed to determine the impact of the restoration of sinus rhythm by catheter ablation on LV function by selecting patients with AF-HF but without LGE on CMR.

## Methods

### Study population

The study was performed at the Alfred Hospital in Melbourne, Australia, from January 2009 to December 2011 and was approved by the Alfred Hospital Human Research Ethics Committee. Consecutive patients referred for consideration of AF ablation who were resistant or intolerant to at least 1 antiarrhythmic agent, had failed at least 1 attempt at direct current reversion, and had New York Heart Association class II or greater symptoms despite 6 months of optimal medical therapy were recruited if they had an ejection fraction (EF) of $<50\%$ in the absence of LV LGE on contrast-enhanced CMR. Optimal medical therapy included titration of atrioventricular nodal blocking agents according to ventricular rate response to AF as assessed by 24-hour Holter monitoring.

Exclusion criteria were as follows: an implanted pacemaker or defibrillator precluding CMR, an alternative explanation for cardiomyopathy, left atrial (LA) diameter >55 mm, anticipated cardiac transplantation in $<6$ months, or life expectancy $<1$ year.

AF was categorized as paroxysmal where episodes were self-terminating within 7 days or persistent where episodes lasted longer than 7 days or required electrical cardioversion. All recruits underwent repeat contrast-enhanced CMR 6 months after initial ablation.

### CMR imaging

Pre- and postablation CMR was performed by using a clinical 1.5-T magnetic resonance imaging scanner (Signa HD 1.5-T, GE Healthcare, Waukesha, WI, USA, WI). Sequences were acquired during breath-holds of 10–15 seconds. Initial cine CMR sequences were performed in 3 standard long-axis (4-, 3-, and 2-chamber views) and short-axis (basal, mid, and apical) slices, kept identical for each subsequent sequence throughout the CMR examination.[16] From an end-diastolic, 4-chamber, long-axis view, 5 equally spaced short-axis slices were planned such that the 2 outer slices lined up with the tip of the apex and the mitral annulus. The 2 outer slices were then deleted, leaving 3 slices corresponding to typical basal, mid, and apical short-axis views. To calculate LV volume and function, a contiguous short-axis steady-state free precession stack was acquired (8-mm-thick slice, no gap), extending from the mitral valve annulus to the LV apex.

Delayed hyperenhancement was obtained in both long- and short-axis views 10 minutes after a bolus (0.2 mmol/kg body weight to a maximum of 20 mmol) of gadolinium-diethylenetriamine pentaacetic acid (Magnevist, Schering, Germany) to identify regional fibrosis by using a $T_1$-weighted inversion-recovery gradient echo technique (repetition time 7.1 ms; echo time 3.1 ms; inversion time individually determined to null the myocardial signal; range 180–250 ms; slice thickness 8 mm; matrix $256 \times 192$; number of acquisitions 2). For CMR scans performed before AF ablation, contrast-enhanced left atriography was performed before LGE imaging to generate an LA model for use with a 3-dimensional catheter navigation system at the time of ablation.

### Evaluation of LV function and regional fibrosis

Volumetric analysis of the LV from which EF was derived was performed by using the summation of discs method. The LA volume was determined by using the area-length method. Regional fibrosis was identified by LGE within the LV myocardium, defined quantitatively by a myocardial post-contrast signal intensity 5 SDs above that within a reference region of remote nonscarred myocardium within the same slice (Figure 1). Myocardial LGE was defined as being present only if it was identified in 2 orthogonal views.

### Catheter ablation

Patients underwent AF ablation within 72 hours of baseline CMR. Antiarrhythmic drugs were not discontinued in preparation for the procedure. Warfarin with a target international normalized ratio of 2–3 was administered for 4 weeks before the procedure, and catheter ablation was performed on warfarin.

Under general anesthesia, transoesophageal echocardiography was performed to exclude LA thrombus and assist transseptal access. A femoral venous approach was used to place a decapolar catheter in the coronary sinus and a hexapolar catheter at the His position. Double transseptal access was obtained with standard techniques by using a BRK1 needle and SL1 sheathes (St Jude Medical, St. Paul, MN, USA, MN), and intravenous heparin was administered with a target activated clotting time of 350. A duodecapolar circular mapping catheter (Reflexion Spiral, St Jude Medical) was used to guide pulmonary vein isolation, and a 4 mm externally irrigated tip catheter (Contact Therapy Cool Path Duo, St Jude Medical) was used for mapping and