Manifestations of coronary arterial injury during catheter ablation of atrial fibrillation and related arrhythmias

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BACKGROUND The prevalence and clinical consequences of coronary arterial injury in a large series of patients undergoing radiofrequency ablation (RFA) of atrial fibrillation (AF) are unknown.

OBJECTIVE The purpose of this study was to describe the frequency and clinical consequences of coronary arterial injury in a large series of patients undergoing catheter ablation of AF and postablation atrial tachycardia.

METHODS The medical records of 5,709 consecutive patients undergoing RFA of AF were reviewed. Heart specimens were also dissected to analyze the course of the coronary arteries.

RESULTS Arterial injury occurred in 8 patients (0.14%). Three patients developed ventricular fibrillation (VF) due to occlusion of the distal or proximal circumflex (Cx) artery related to RFA in the distal coronary sinus (CS) or base of the LA appendage, respectively. Two VF patients underwent stenting. Five patients developed acute sinus node (SN) dysfunction. In 4/5 patients, the culprit site was subjacent to the SN artery (per computed tomography) coursing over the anterior LA (n = 3) or the septal RA (n = 1). Two patients required a permanent pacemaker. In the heart specimens, the SN artery, after its origin from the proximal Cx artery, coursed along the anterior LA. Also, the proximal Cx artery was found in the atrioventricular groove underneath the base of the LA appendage.

CONCLUSION Clinically apparent injury to the coronary arteries during LA ablation for AF is rare. However, it may be associated with potentially life-threatening ventricular arrhythmias and acute SN dysfunction requiring permanent pacing. The culprit sites seem to be in the distal coronary sinus and the anterior LA, and correlate well with the course of the coronary arteries in pathologic specimens. Vigilance and low-power settings are important in minimizing the risk of arterial injury.

KEYWORDS Atrial fibrillation; Catheter ablation; Arterial injury; Complications

ABBREVIATIONS **AF** = atrial fibrillation; **AT** = atrial tachycardia; **CS** = coronary sinus; **CT** = computed tomography; **Cx** = circumflex; **LA** = left atrium; **LAA** = left atrial appendage; **PV** = pulmonary vein; **RA** = right atrium; **RF** = radiofrequency; **RFA** = radiofrequency ablation; **SN** = sinus node; **SNA** = sinus node artery; **VF** = ventricular fibrillation

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Prior studies have documented injury to a coronary artery during radiofrequency ablation (RFA) of atrial fibrillation (AF) or related arrhythmias.[1,2] However, the prevalence, clinical manifestations, and the culprit sites have not been reported in detail. The purpose of this study was to describe the frequency and clinical consequences of coronary arterial injury in a large series of patients undergoing catheter ablation of AF and postablation atrial tachycardia (AT).

Methods

Among 5709 consecutive patients who underwent left atrial (LA) ablation of AF or postablation AT, 8 patients (0.14%) developed clinical evidence of coronary arterial injury. Among the entire patient population, catheter ablation was performed in the coronary sinus (CS) in 853 patients. Linear ablation across the anterior LA was performed in 243 patients. Patient characteristics are listed in Table 1. All patients had failed treatment with antiarrhythmic therapy (mean number of drugs 1.4 ± 0.7); however, none had developed adverse effects such as sinus node (SN) dysfunction as a result. One patient (no. 5) had previously received an implantable cardioverter-defibrillator for primary prevention. He had no history of ventricular arrhythmias and received only *in*appropriate shocks for AF.

The patients had previously undergone a mean of 1.8 ± 1 LA ablation procedures prior to the one during which arterial injury occurred. Seven of the 8 patients presented for an ablation procedure for postablation AT; the remaining patient presented for her first procedure for paroxysmal AF.

One patient (no. 5) had experienced 12 years before the ablation procedure an anterior myocardial infarction that was treated with a stent. The other two coronary arteries were

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Table 1 Patient characteristics

	Gender	Ejection fraction	Left atrium (mm)	Atrial fibrillation type	Heart disease
1	Male	70	57	Persistent	HCM/CHF
2	Female	65	54	Persistent	LVH
3	Male	60	47	Persistent	
4	Male	55	52	Persistent	
5	Male	15	54	Persistent	ICM
6	Female	60	34	Paroxysmal	CAD
7	Male	65	40	Persistent	LVH
8	Female	60	43	Persistent	

CAD = coronary artery disease; CHF = congestive heart failure; HCM = hypertrophic cardiomyopathy; ICM = ischemic cardiomyopathy; LVH = left ventricular hypertrophy.

normal. Two years before the procedure, patient 6 underwent stenting of the mid–left anterior descending artery. The other arteries were normal. The remaining patients had no history of coronary artery disease based on normal stress perfusion imaging (n = 5) or coronary angiography (n = 1).

Electrophysiologic procedure

The ablation procedure was performed from a femoral vein with the patients under conscious sedation. The procedure was performed during therapeutic oral anticoagulation with warfarin. Intravenous heparin was administered to keep the activated clotting time between 300 and 350 seconds. In patients presenting for AT, an activation map was constructed using a three-dimensional mapping system (CARTO, Biosense Webster, Diamond Bar, CA). In the patient with paroxysmal AF, antral pulmonary vein (PV) isolation was performed guided by a three-dimensional mapping system (NavX, St. Jude Medical, Minneapolis, MN). All patients underwent mapping and ablation with an irrigated ablation catheter (ThermoCool or Celsius, Biosense Webster). Radiofrequency (RF) energy was delivered at a maximum power of 25 W at a flow rate of 17 mL/min near the PVs and along the posterior wall, and at a power of 35 to 50 W at a flow rate of 30 mL/min elsewhere in the atria. During RF energy delivery in the CS, the power was limited to 20 W. The maximum temperature was set at 48ºC.

Anatomic specimens

From the archive of the Royal Brompton Hospital, we reviewed images from 12 heart specimens, which were dissected by stripping the epicardium to display the major coronary and the atrial arteries. We selected two hearts that best illustrated the course of the coronary arteries relevant to the clinical series.

Postprocedure care and follow-up

Patients were monitored in a telemetry unit overnight. Oral anticoagulation was continued. Patients were encouraged to call the clinical care nurse in case of arrhythmia recurrence or other cardiac symptoms. An auto-triggered event monitor (for 3–4 weeks) was prescribed 6 to 12 months after the ablation procedure to objectively evaluate for arrhythmia recurrence.

Results

Ventricular fibrillation

Ventricular fibrillation (VF) occurred in three patients (Table 2). Patient 7 developed an acute myocardial infarction and cardiac arrest due to VF 1 hour after mitral isthmus ablation (Figure 1A). Both endocardial (maximum 50 W) and epicardial (20 W) ablation in the distal CS were performed. Coronary angiography revealed a large, dominant left circumflex (Cx) artery that was occluded distally with thrombus (Figure 1B). The lesion required thrombectomy and a stent (Figure 1C). The peak troponin I level was 142 ng/mL.

Patient 5 developed VF 6 hours after the ablation procedure that required multiple implantable cardioverter-defibrillator discharges. There was no angina or acute ST/T wave changes. During the procedure, RF energy (35 W) was delivered at the base of the left atrial appendage (LAA) for a reentrant AT (Figure 2A). Angiography showed an 80% stenosis of the proximal Cx artery that was treated with a stent. The peak troponin I level was 0.93 ng/mL. During a repeat procedure, the mapping catheter was navigated to the anterior base of the LAA, and the distal tip was shown to be in close proximity to the stent (Figure 2B). After the repeat procedure, he has remained free of atrial (and ventricular) arrhythmias.

Table 2 Procedural characteristics

Patient no.	Procedure	Culprit site	Power (W)	Coronary artery	Result	Outcome
1	AT	Anterior LA	45	SNA (from Cx)	SN dysfunction	PPM 7 days post RFA
2	AT	Base of RAA	30	SNA (from RCA)	SN dysfunction	Resolved after discontinuation of RF energy
3	AT	Anterior LA	35	SNA (from Cx)	SN dysfunction	Resolved after 48 hours
4	AT	Distal CS	20	Distal Cx	VF	Medical therapy
5	AT	Base of LAA	35	Proximal Cx	VF	Coronary stenting
6	PVI for PAF	?	25	?	SN dysfunction	PPM 6 days post-RFA
7	AT	Distal CS	20	Distal Cx	VF/acute MI	Coronary stenting
8	AT	Anterior LA	30	SNA (from Cx)	SN dysfunction	Resolved after discontinuation of RF energy

AT = atrial tachycardia; CS = coronary sinus; Cx = circumflex; LA = left atrium; LAA = left atrial appendage; MI = myocardial infarction; PAF = paroxysmal atrial fibrillation; PPM = permanent pacemaker; PVI = pulmonary vein isolation; RAA = right atrial appendage; RCA = right coronary artery; RF = radiofrequency; RFA = radiofrequency ablation; SN = sinus node; SNA = sinus node artery; VF = ventricular fibrillation.