Impact of beating heart left atrial ablation on left-sided heart mechanics

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Objective: The cut-and-sew Cox–Maze procedure is the gold standard for surgical treatment of atrial fibrillation, but it is associated with long-term impairment of left atrial mechanical function. We developed a bipolar, irrigated radiofrequency ablation device. We hypothesized that beating heart radiofrequency left atrial ablation would result in minimal acute changes in left atrial hemodynamics.

Methods: Six healthy subjects were studied. Combination pressure-conductance catheters were inserted into the left atrium and ventricle. With the use of the device, atrial ablation was performed on the beating heart without cardiopulmonary bypass, including electrical isolation of the posterior left atrium and atrial appendage myocardium. Simultaneous left-sided heart pressure–volume and intracardiac echocardiography data were acquired before ablation, after left atrial appendage ablation alone, and after all ablation (with and without appendage occlusion). The derived indices of left-sided heart mechanical function were examined.

Results: Relative to baseline, no significant diminishment in pressure–volume or intracardiac echocardiography-derived indices of global left-sided heart mechanical function were observed after ablation, with or without appendage occlusion. Mitral valve morphology and function were not significantly altered. A significant diminishment of atrial appendage systolic flow was noted after appendage ablation in association with spontaneous echocardiographic contrast in this region.

Conclusions: In this model, ablation does not seem to compromise global left-sided heart mechanical function. However, these findings mask regional diminishment in atrial appendage systolic function. This observation demonstrates that electrical isolation of the appendage should be accompanied by its occlusion or excision. Appendage occlusion after ablation does not seem to compromise left-sided heart mechanical function.

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David Francischelli reports that he is an employee of Medtronic, the manufacturer of the ablation tool used in this study, an equity owner of Medtronic, and the inventor of patents related to the ablation device with rights assigned to Medtronic. Douglas Hettrick is an employee of Medtronic. David Schwartzman reports consulting fees and grant support from Medtronic. Marco Zenati reports grant support from Medtronic. This study was supported in part by Medtronic.

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An ideal treatment for atrial fibrillation (AF) should achieve both restoration and maintenance of sinus rhythm and recovery of biatrial contractile function. In addition, an integral component of any therapeutic approach for AF should be the reduction of thromboembolic risk primarily targeting the left atrial (LA) appendage. As operative atrial ablation intended to cure or prevent AF progresses toward the mainstream, questions have appropriately been raised as to the possibility that this technique may have detrimental effects. Apart from prolongation of a concomitant surgical procedure, such effects could potentially include mechanical, intrinsic cardiac neurologic, and/or humoral impairment. For example, evaluation of atrial function after cut-and-sew Maze III surgery indicated that diminishment of LA mechanical function may result from the surgical lesions and tissue excision.[1,2]

Unlike in cut-and-sew Maze III surgery, recent advances in ablation technology have permitted the deployment of lesions in the beating heart and with less atriotomy.[2] In addition, expanding insight into the atrial electrophysiologic substrate

Abbreviations and Acronyms
AF = atrial fibrillation
ICE = intracardiac echocardiography
LA = left atrial
LAA = left atrial appendage
LV = left ventricle
RF = radiofrequency

has led to a progressive reduction in ablation territory relative to that of classic Maze surgery.[2] Each of these elements has the potential to influence the impact of the surgery on cardiac mechanical function.

In the present study, we sought to assess the impact of LA ablation on left-sided heart mechanical function using a porcine model in which a typical contemporary lesion set was deployed in a beating heart.

Materials and Methods

Animals

Six healthy Duroc cross female pigs (weight 36 ± 13 kg) formed the study cohort. We and others previously demonstrated that atrial chamber dimensions, blood flow velocities, and wall thicknesses are similar to those of a human adult.[3,4] All animals received humane care in a facility sanctioned by the Council on Accreditation of the Association for Assessment and Accreditation of Laboratory Animal Care, in accordance with the "Guide for the Care and Use of Laboratory Animals" published by the National Institutes of Health (publication 85-23, revised 1985). The study protocol was approved by the Institutional Animal Care and Use Committee of the University of Pittsburgh.

Operative Technique

Animals were premedicated with intramuscular ketamine and inhaled isoflurane before endotracheal intubation. Once the animals were intubated, a surgical plane of anesthesia was achieved and maintained with isoflurane 1% to 5% inspired. Arterial blood pressure, blood gases, and serum electrolytes were monitored serially. Each animal was systemically anticoagulated (heparin, adjusted for body weight) for the duration of the procedure. For insertion of diagnostic catheters, endocardial access to the right atrium was gained through a right femoral venipuncture, to the LA subsequently through an atrial transseptal puncture, and to the left ventricle (LV) through a carotid arteriotomy and retrograde transaortic passage. For ablation, epicardial access to the LA was gained through median sternotomy and pericardiotomy, and endocardial access was gained through focal atriotomies (see below). Some dissection in the posterior mediastinum was necessary to create sufficient access

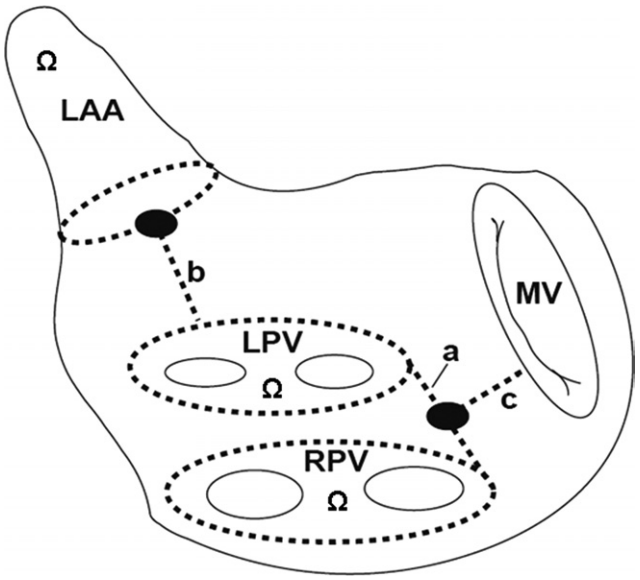

Figure 1. Ablation lesions, encircling lesions (*dashed circles*), and linear lesions (*dashed lines*, A-C). Approximate atriotomy sites (●) required for access of 1 of the jaws of the ablation device during deployment of linear lesions (see text). Approximate sites (Ω) of pacing to assess for exit conduction block after encircling lesions (see text). *LAA,* Left atrial appendage; *LPV,* left pulmonary veins; *RPV,* right pulmonary veins; *MV,* mitral valve.

for the ablation device; this required approximately 15 minutes per animal. At the completion of the experiment, each animal was euthanized while under deep anesthesia using an injection of potassium chloride.

Ablation

Device. Ablation was performed using a commercial bipolar device (Cardioblate BP2, Medtronic Inc, Minneapolis, Minn).[5] The device was composed of 2 stainless steel electrodes, arrayed as cathode and anode on opposing jaws of a clamp-morphology skeleton, and embedded in a porous polymer through which room-temperature normal saline was irrigated at a rate of 4 mL/min. The device was coupled to a commercial radiofrequency (RF) energy generator (Cardioblate, Medtronic Inc) from which real-time (updated every 200 ms) impedance, power, lesion duration, and cumulative delivered energy data were obtained. The generator used a proprietary algorithm that titrated power, assessed lesion transmurality based on changes in impedance, and signaled the user when the lesion was completely transmural.

Lesion deployment and assessment. In each animal, the same lesion set was deployed in the beating heart without cardiopulmonary bypass (Figure 1). Encircling lesions (appendage and pulmonary veins) were applied

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