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Bipolar Irrigated Radiofrequency Ablation of the Posterior-Inferior Left Atrium and Coronary Sinus is Feasible and Safe

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ABSTRACT

Background: Success of surgical therapy for atrial fibrillation (AF) mainly depends on creating a complete set of transmural atrial lesions. The established Cox procedures may be simplified by dropping lesions, but not without the risk of impaired results. We aimed to create a complete set of lesions using bipolar irrigated radiofrequency including ablation of the posterior-inferior left atrium (LA) and coronary sinus. Feasibility and safety were investigated.

Methods: Six patients (mean age 63 ± 14 years) with continuous AF (duration 15 ± 8 months) underwent elective heart surgery for isolated mitral valve procedures (n = 4), in combination with myocardial revascularization (n = 1) or isolated bypass surgery (n = 1). Ablation of AF was performed using bipolar irrigated radiofrequency to create a modified Cox minimaze pattern.

Results: No major intraoperative or postoperative complication occurred. Two patients left the operating room in sinus rhythm and 4 in junctional rhythm with atrioventricular pacing. AF ablation required 20 ± 5 minutes.

Conclusions: Bipolar irrigated radiofrequency ablation including ablation of the posterior-inferior LA and coronary sinus is feasible and can be performed safety. Long-term studies in large patient cohorts are necessary to show efficiency of this method.

INTRODUCTION

"*. . . the success of this procedure resides in the details,*" [Cox 1991].

The Cox technique for surgical therapy of atrial fibrillation (AF) has been modified several times, and various suggestions have been made regarding methods for interrupting conduction in the posterior-inferior portion of the left atrium (LA). In particular the necessity of isolating the coronary sinus is controversial. If the coronary sinus remains unattended, the concept of creating a corridor in the LA to control the direction of electrical conduction is violated, and the operation can no longer be considered a maze procedure [Cox 2000]. Ablation of the posterior-inferior LA can be performed by either incision or using newly developed cryo, microwave, or radiofrequency devices [Cox 1995, Kim 2001, Doll 2004, Sie 2004]. Endocardial application of energy to create ablation lesions is not always enough to reach transmurality, and thus it results in high recurrence rates of AF. New devices using bipolar radiofrequency can create transmural lesions, which may improve the success rate of the ablation procedure. However, these devices were not intended for ablation of the posterior-inferior LA [Prasad 2002, Bonanomi 2003]. Interruption of conduction along the coronary sinus was performed by Cox using a cryoablation device [Cox 1995]. Alternative techniques with other devices are not described. To overcome the issue of incomplete ablation pattern and incomplete transmurality we developed a slightly modified Cox minimaze procedure using a bipolar irrigated radiofrequency device to cure continuous AF. Our main goal was to investigate whether ablation of the posterior-inferior LA and coronary sinus using the mentioned device is feasible and safe.

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MATERIAL AND METHODS

Patients

Bipolar irrigated radiofrequency was used to ablate AF in 6 patients who presented for surgical treatment of mitral valve disease with (n = 1) or without coronary artery disease (n = 4). One patient had isolated coronary artery disease. Mean age of the 4 male and 2 female patients was 63 ± 14 years. All patients ranged in New York Heart Association functional class III. Mean left ventricular ejection fraction was 48% ± 8%. AF was continuous in all cases. Preoperative duration of AF was 15 ± 8 months. Mean diameter of the LA was 55 ± 11 mm.

Device

A bipolar irrigated radiofrequency device, the Cardioblate BP surgical ablation system (Medtronic, Minneapolis, MN, USA), was used to create all the ablation lesions. The system consists of a clamp and a radiofrequency generator. Ablation energy is released by 2 electrodes included in apposing jaws mounted on an articulated head of the clamp. The jaws are

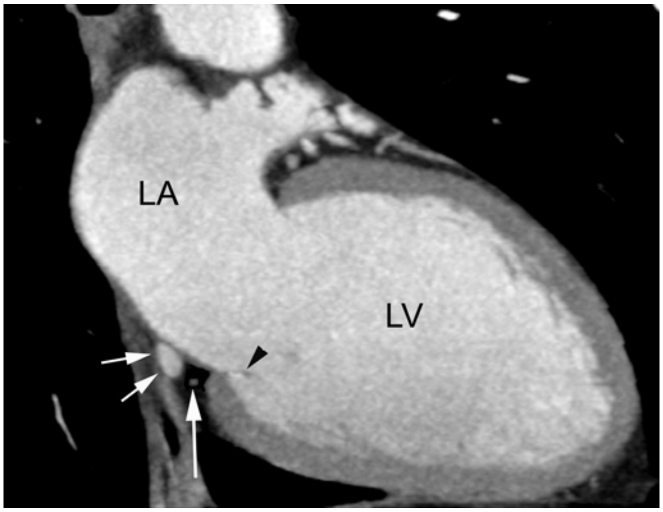

Figure 1. Sixteen-slice computer tomography of patient 2. Topography of the atrioventricular groove corresponding to the mid region of the posterior wall of the left atrium (LA) and left ventricle (LV). Black arrow indicates posterior cusp of the mitral valve; single white arrow, coronary artery; double white arrow, coronary sinus.

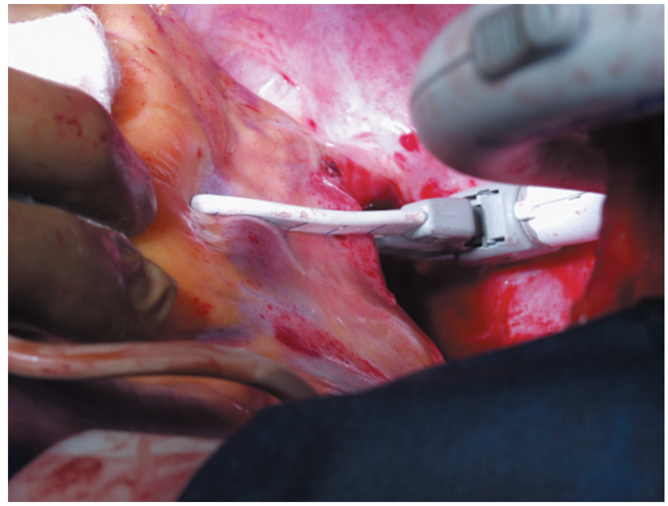

Figure 2. Concomitant ablation of the posterior-inferior left atrium and coronary sinus. The epicardial placed electrode of the Cardioblate BP device is oriented toward and perpendicular to the atrioventricular groove. The coronary sinus is included in the ablation line. Note that the end of the electrode does not overlap the ventricular margin of the coronary sinus.

malleable, allowing shaping to the target tissue. The head can be rotated up to 300° and angulated up to 90° allowing easy access to target structures. During energy release the ablation surface is continuously irrigated with normal saline.

Surgical Procedure

In this initial experience the Cardioblate BP device was used to create a lesion pattern similar to a Cox minimaze procedure. Only the right atrial (RA) isthmus lesion was omitted. Before starting clinical use of the device, we gained preliminary experience in human cadavers and studied anatomical feasibility of ablation of the posterior-inferior LA and coronary sinus using the Cardioblate BP device.

Preoperatively the midregion of the posterior wall of the LA and left ventricle was investigated in a sagittal view using 16-slice computer tomography. This investigation demonstrated the relationship between the coronary sinus, the coronary artery in the atrioventricular groove, and the mitral valve annulus (Figure 1).

Written informed consent was obtained from every patient.

The ablation procedure was performed in all cases concomitant to mitral valve surgery and/or myocardial revascularization. The operation was carried out by median sternotomy using total cardiopulmonary bypass, mild systemic hypothermia of 32°C, and cold crystalloid cardioplegic arrest. The ablation procedure was started off pump by snaring the common trunk of the right pulmonary veins at the junction with the LA. While pulling the snare with tension, we placed the 2 electrodes of the Cardioblate BP device around this region and applied irrigated radiofrequency. After institution of total cardiopulmonary bypass the heart was emptied by increasing the venous return, and the common trunk of the left pulmonary veins was snared on the beating heart. Likewise the right side, the junction of the left pulmonary veins with the LA, was ablated. The 2 electrodes of the Cardioblate BP device were adjusted to a curved shape to allow ablation of the atrial wall close to the ostia of the pulmonary veins. Surgery continued with arresting the heart and opening the LA in the Waterston groove. The mitral valve was inspected, and the procedure to correct mitral valve disease was determined. The LA appendage was inspected for thrombi. Ablation was continued by connecting the islands of isolated left and right pulmonary veins. This line started at the level of the left atriotomy, running to the orifice of the left inferior pulmonary vein, and was performed by clamping the atrial wall between the 2 electrodes of the Cardioblate BP device. Lifting the heart and turning it toward the surgeon facilitate exposure of the LA appendage. A circumferential radiofrequency lesion was created by epicardial application of the 2 electrodes around its base. A small, 5-mm incision was performed in the ablation line vis-à-vis to the left superior pulmonary vein. One electrode of the Cardioblate BP device was introduced through the incision into the LA up to the orifice of the left superior pulmonary vein. A connecting epicardial-endocardial ablation line was performed. The LA appendage was excluded using a running suture. The heart was lifted and turned cranially to expose the posterior wall of the LA. The ablation line between the ostia of the right and left inferior pulmonary veins was identified, and 5-mm incision was performed at this level. One of the electrodes of the Cardioblate BP device was introduced into the LA toward and perpendicular to the atrioventricular groove. The other electrode was applied epicardially, through the closure of the clamp of the coronary sinus in the ablation line (Figure 2). Following the completion of

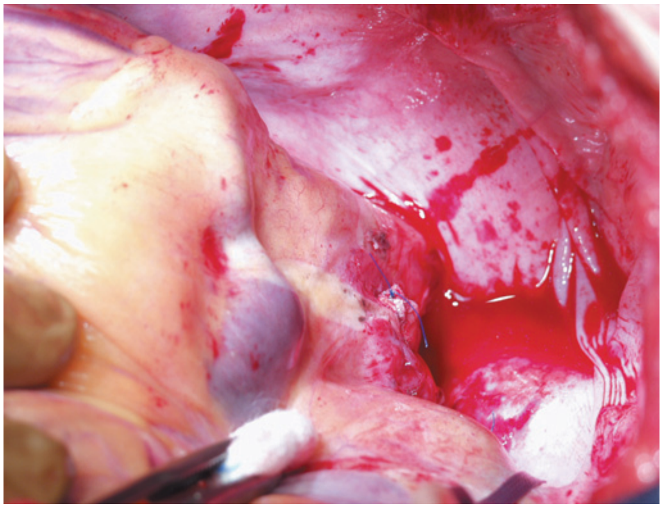

Figure 3. Status post ablation of the posterior-inferior left atrium and coronary sinus. The ablation line is demonstrated as a white band on the posterior wall of the left atrium toward the coronary sinus.

this last ablation line, the incision was closed (Figure 3) and the mitral valve again exposed. The so-called LA isthmus lesion was easily identified in all the cases and confirmed to reach the midportion of the posterior mitral valve annulus.

RESULTS

In addition to AF ablation, surgery included mitral valve repair in 2 patients; mitral valve replacement in 2 patients; mitral valve repair, left internal thoracic artery–to–left anterior descendens (LITA-to-LAD) and 2 aorto-to-coronary grafts in 1 patient; and LITA-to-LAD and 2 aorto-to-coronary grafts in 1 patient. Mean aortic cross-clamp time was 74 ± 17 minutes, and mean time required to perform AF ablation was 20 ± 5 minutes. Two patients left the operating room in sinus rhythm and 4 in junctional rhythm with atrioventricular pacing. Major intraoperative or postoperative complications did not occur. During the hospital stay recurrent AF was not treated. Digoxin or metoprolol was used to control the rate of ventricular response to AF in 3 patients. At hospital discharge 3 patients were in sinus rhythm and 3 in AF.

DISCUSSION

Discussing surgical therapy of continuous AF may sometimes be confusing owing to various modifications of the procedures and imprecise use of procedure names. The established technique of choice is the Cox maze III procedure consisting of standardized RA and LA incisions and cryoablation lesions. These isolating lines are performed to block all the potential macroreentrant pathways and narrow the atrial wall to block propagation of the microreentrant wavelets [Cox 1995]. Electrophysiological and clinical studies showed that the RA is not capable of sustaining AF by itself. Cox concluded that surgical treatment of AF can be focused on the LA. Consequently, the Cox minimaze procedure was developed. By definition, it consists of cut-and-sew lesions in the LA, cryoablation of the coronary sinus, and a RA isthmus lesion [Cox 2003]. During the past decade several devices were developed to produce cell death by using tissue heating or freezing in order to mimic the cut-and-sew pattern of the Cox maze III procedure. However, as described in several publications, the operative technique varies, but the procedure is always called "maze." A compartmentalization procedure using an energy delivery device is not a Cox maze III or Cox minimaze operation if it doesn't mimic the lesion pattern described by Cox and if the lesions created are not transmural. Incomplete so-called analog maze procedures do not reach the success rate of 98% as reported by Cox regarding restoration of sinus rhythm [Cox 2003]. Most commonly, interruption of conduction in the posterior-inferior LA is intentionally omitted, particularly cryoablation of the coronary sinus. Based on his results, however, Cox stressed the importance of this maneuver [Cox 2000]. He was able to demonstrate that even though the LA myocardium was completely divided in the LA isthmus region, electrical conduction from one atrium to the other propagated along the coronary sinus. Omitting interruption of conduction along the posterior-inferior LA and coronary sinus will not preclude the development of recurrent atrial flutter after the ablation procedure. The recurrence rate has been approximately 20% in the experience of Kawaguchi [1996]. Coronary sinus ablation may be performed by creating a lesion using saline-irrigated monopolar radiofrequency on the endocardial area of the LA corresponding to the end point of the coronary sinus. This maneuver, however, seems unsatisfactory because recurrent atrial flutter was observed in 19% of patients [Güden 2002]. Gaita et al reported a case of recurrence of atrial flutter after surgical ablation of AF. LA mapping identified a gap in the mitral annulus isthmus lesion. Radiofrequency catheter ablation in the region of the gap was able to interrupt the atrial flutter [Gaita 2002]. Even if the complete pattern of the Cox maze III procedure is performed, the possibility of recurrence of AF is present and can occur in up to 22% of cases [Sie 2004]. One of the causes may be the incomplete transmurality of the lesions, a condition that seems to be more frequent with monopolar radiofrequency.

After careful consideration of the previous experience with surgical therapy of AF we developed our concept and strategy using the Cardioblate BP device. The bipolar application of irrigated radiofrequency allows creation of transmural lesions. The ergonomic handle design, the articulation of the electrodes head, and the configuration and malleability of the electrodes allowed us easy access to all targeted LA structures. The ablation pattern performed by us was created on the basis of the Cox minimaze procedure. We were able to demonstrate that complete bipolar ablation of the coronary sinus simultaneous with the ablation of the LA isthmus is feasible and safe. The coronary sinus ablation scar was visible in all 6 cases. The endocardial ablation scar in the isthmus region was easy to identify and follow up to the mitral valve annulus in all of the 5 open cases. Clamping the LA isthmus tissue up to the mitral valve annulus respective to the atrioventricular groove did not result in heart wall perforation or coronary artery lesion. Because we were concerned about possibly causing injury of a coronary artery in the left posterior atrioventricular groove we performed some ablation procedures on human cadaver hearts. The coronary artery was not jeopardized by clamping the LA isthmus and coronary sinus up to its ventricular margin. Independent of the coronary artery–providing type, the artery always runs inferior but never underneath the coronary sinus. However, care should be taken that the tips of the electrodes do not overlap the ventricular margin of the coronary sinus. The topography of the coronary artery and the coronary sinus as described above was confirmed preoperatively with 16-slice computer tomography in the surgical patients. Postoperative electrocardiography as well as transesophageal and transthoracic echocardiography excluded intraoperative coronary artery injury.

The procedure performed by us comprises 3 modifications of the lesion pattern of the Cox minimaze operation. First, in our procedure the right and left pulmonary veins were individually isolated, and a connecting lesion was created from the right inferior pulmonary vein to the left inferior pulmonary vein. This lesion set substitutes for the en block isolation of the pulmonary veins used by Cox. The reason for this modification was the intention to preserve the natural LA activation sequence and to guarantee a close to normal transport function of the LA. Nitta et al suggested that the Cox maze III lesion pattern may impair the physiologic activation sequence in the LA, leading to mechanical dysfunction [Nitta 1999]. The en block isolation of the pulmonary veins excludes a large area of the LA posterior wall, leading to a loss in global contractility of the LA [Kim 2001]. Second, in order to avoid the risk of suture line bleeding, we excluded the LA appendage instead of excising it. As the third modification we omitted the RA isthmus lesion because we believe this incision is not necessary in the absence of RA ablation lesions. If the patient develops an RA flutter after a Cox minimaze procedure, the RA isthmus lesion can be performed percutaneous by radiofrequency catheter ablation.

Irrigated bipolar radiofrequency energy has the advantage of allowing the creation of all necessary ablation lesions without opening the LA and may therefore enable surgeons to perform a complete Cox minimaze operation on the beating heart. In our experience, in 5 of 6 cases we opened the LA to perform mitral valve surgery. An open LA was not a prerequisite for the ablation procedure but allowed the visualization of the topography of endocardial lesions. Previously, bipolar radiofrequency ablation has been reported in animal experiments [Prasad 2002, Bonanomi 2003]. However, the described lesion pattern omitted the LA isthmus and coronary sinus ablation lesions.

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