Surgical treatment of atrial fibrillation using radiofrequency ablation

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A possible surgical technique to avoid esophageal and circumflex artery injuries using radiofrequency ablation to treat atrial fibrillation

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Abstract

A surgical technique using unipolar radiofrequency ablation is described, which minimizes the risk of damaging adjacent cardiac structures. The left atrium was fully mobilized. Linear, non-thrombogenic, white blistering lesions were created with a hand-held malleable pen-catheter, making oscillating movements, while preserving a stable endocardium contact, without pressing the atrial wall to adjacent mediastinal structures. The ablated atrial tissue was lifted up with forceps. Each pulmonary vein orifice was circumferentially ablated and interconnected on the ipsi- and to the contra-lateral side, and to the left auricle and mitral valve annulus. No esophageal or circumflex artery injuries were observed.

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1. Introduction

Oesophageal and circumflex artery injuries have emerged as a concern in the surgical treatment of atrial fibrillation (AF) using unipolar RF \[1-3\]. In our opinion, it is the combination of various factors, such the type and handling of the ablation device, the ablation time, the lesion pattern and the surgical access, which attributes to this complication. This report describes a surgical technique which minimizes the risk of damaging the adjacent cardiac structures.

2. Patients and methods

A concomitant left atrial RF ablation was performed in 195 AF patients \((n = 152\) chronic permanent and 43 paroxysmal AF); mean (SD) age 68.0 (8.6) years, LVEF 58 (14)\%, EuroSCORE 6.2 (2.8), left atrial diameter 48.6 (8.5) millimeters, duration of AF 54 (59) months.

2.1. Set up of the RF ablation system

The RF lines were created with a hand-held flexible pen-catheter (Maze Penn, Cardioblate-Medtronic, Minneapolis, USA), which was connected to a NaCl 0.9\% infusion pump (IVAC) with a flow rate between 200 and 320 ml/h and to a RF generator (CardioRythm-ATAKR, Cardioblate-Medtronic, Minneapolis, USA), which was set between 28 and 32 W.

2.2. Creation of the RF lesions

Matching the delivered amount of RF energy to the estimated local atrial wall thickness to create a conduction block, without causing any atrial tissue dehiscence, was facilitated by using this catheter. As a consequence, the formation of an RF lesion in the left atrial doom was induced more rapidly than in the area around the mitral valve annulus, which usually is thicker than the atrial doom; 5-7 s versus 10-12 s per centimeter ablation line. Stable electrode–tissue contact was preserved, without pressing...
the atrial wall against the adjacent mediastinal structures. The ablated cardiac tissue was always lifted up, with forceps, during ablation. Formation of yellow-white blistering endocardial lesions, induced by oscillating catheter movements, were considered sufficient and provided a subjective but still consistent sign to advance the catheter.

2.3. Surgical access

A sternotomy with canulation of the ascending aorta and caval veins was performed. The superior caval vein was dissected from its pericardial attachments and the right pulmonary artery, which was then dissected away from the left atrium doom (Fig. 1). The pericardial attachments at the back of the left atrium were also divided. The Waterston's groove and oblique sinus were exposed. As a consequence, the left atrium was fully mobilized within its pericardial sac, obviating the necessity to use the adjacent mediastinal structures as a back resistance during RF ablation.

2.4. Left atrial ablation pattern

The left atrium was entered through the Waterston’s groove. The complete endocardial rim of each pulmonary orifice was selectively ablated. All pulmonary vein orifices were interconnected on the ipsi- and to the contralateral side. RF lesions were created from the left inferior pulmonary vein to the midportion of the posterior mitral annulus (Fig. 2) and from the left superior pulmonary vein to the left auricle, which was resected.

3. Results

Type of operations, with CABG (.), were 44 MVR (7), 29 MVP (19), 27 AVR (10), 50 CABG, 4 multiple valve surgery (3), 2 others. The mean (SD) aortic cross clamp and extracorporeal circulation time were 98 (24) and 159 (40) min, follow-up 19.6 (17.0) months. Thirty-day mortality was 6.2% (12/195); low cardiac output (n = 7), cerebral

Fig. 1. (a) A linear radiofrequency ablation lesion (dashed line) across the back wall of the left atrium was created while the doom of the left atrium is lifted up with forceps (X mark). The transverse sinus (TS) was exposed (TS arrow), which enhanced the mobility of the left atrium, avoiding any contact with the posterior mediastinum, including the esophagus. PA, pulmonary artery; TS, transverse sinus; RUPV, right upper pulmonary vein orifice. (b) Schematic drawing of (a). The cranial to caudal yellow line is the projected course of the esophagus. The arrows with subscripts cranial, caudal, left and right are provided for orientation.

Fig. 2. (a) A linear lesion (dashed line) was created from the orifice of the left inferior pulmonary vein (arrow IPV) to the mid portion of the mitral valve annulus (arrow MV). The left atrium was lifted up with forceps (X mark), avoiding any contact with the circumflex artery which was fixed in the AV groove. Therefore a transmural lesion atrial lesion (RF) could be created without damaging the circumflex artery (CX). IPV, left inferior pulmonary vein orifice; MV, mitral valve annulus; X, the area where the atrium is lifted-up with a forceps during ablation. (b) Schematic drawing of (a). The dashed yellow line, running from the left to the right side along the mitral valve annulus, is the projected course of the circumflex artery. The arrows with subscripts cranial, caudal and right are provided for orientation. (c) Histological cross section (Elastica-von Giesen-EvG staining) of the ablation area, marked as X in (a). The radiofrequency ablation lesion was transmural without affecting the circumflex artery as shown in the rectangular box. Vent, ventricular wall; RF, radiofrequency linear lesion in the left atrial wall, bordered by the dashed line; CX, lumen of the circumflex artery.
stroke, pancreatitis, myocardium infarction, pulmonary artery embolus, atrioventricular dehiscence (n = 1). Autopsies did not reveal any esophageal, circumflex artery or pulmonary orifice injuries. Cumulative survival rates (SE) at 12 and 24 months were 0.85 (0.03) and 0.83 (0.03). Cumulative sinus rhythm rates, for 153 patients with preoperative chronic permanent AF, at 6 and 12 months were 0.66 (0.04) and 0.74 (0.04).

4. Comment

4.1. Esophageal and circumflex artery injuries

There is a considerable difference in tissue handling and induced RF lesion geometry between non-irrigated temperature-controlled RF compared to irrigated RF ablation [4]. Esophageal and circumflex injuries have been reported while using temperature-controlled RF ablation systems. The temperature-controlled RF targets a certain temperature level (e.g. 80 °C) for a preset time duration (e.g. 60 s) to create a single lesion. This paper focuses on the potential advantages of the irrigated RF, which has a distinctly different intraoperative handling.

Doll and colleagues reported an incidence of 1% (4/387) esophageal perforations. They used a 10 mm T-shaped rigid temperature-controlled RF ablation probe (Radios 504, Osypka GmbH, Grenzach, Wyhlen, Germany) targeting a temperature of 60°F for 20 s for each lesion. A right lateral minithoracotomy was performed. So, we presume that dissection of the doom of the left atrium was omitted. Consequently, the close relationship between the left atrium and the esophagus was left intact. In addition, van Oppel and colleagues showed that the T-shaped rigid catheter was associated with a temperature overshoot during ablation, increasing the risk of necrotic perforation, especially when an overlap between two linear ablation lines was performed [5].

Sonmez and associates reported a 1.5 cm laceration on the anterior wall of the esophagus in a patient who had an aortic and mitral valve replacement. The transesophageal echo probe was removed before starting the RF ablation, using the Cobra RF systems (Boston Scientific, Boston Natick, MA). The authors clearly described and visualized the proximity between the left atrium and the esophagus while ablating on the back side of the left atrium at a temperature of 80 °C for 120 s per lesion. The application of the RF probe was secured and stuck to the left atrium. The esophageal perforation was discovered 22 days postoperatively.

McGillivray used a temperature controlled RF ablation system (Cobra RF Systems-Boston Scientific, Boston, MA) in a small and cachectic patient (29 kg, 146 cm) creating oval lesions around the left and right pulmonary veins, with an interconnecting transverse ablation line over the back of the left atrium wall. The lesions were made at 80 °C with 60 s per lesion. On the 10th postoperative day an esophageal perforation was discovered at 27 cm from the incisors, consisting of 2 linear perforations on the anterior wall of the esophagus behind the carina. The transesophageal probe was not present during ablation [2].

Fayad reported a late circumflex artery stenosis, 1 year after an RF ablation procedure using a temperature-controlled RF catheter (Thermaline, Boston Scientific, San Jose, CA). Six applications were performed around the left and right pulmonary veins and to the mitral valve annulus targeting a temperature of 75 °C and 120 s per lesion [6]. Demaria showed that epicardial RF ablation (Biosense Webster Inc, Johnson and Johnson) could induce coronary endothelial functional and morphological damages when the RF application occurred within a distance of 5 mm from the coronary artery [7].

However, circumflex artery injuries have also been reported using other sources of energy. Berrekleuwe reported an acute circumflex artery stenosis after using cryoablation (Frigitronics; Cooper vision Company, Shelton, CT) during a ‘cut and sew’ MAZE III procedure [8]. Manasse reported a main stem coronary artery lesion using epicardial microwave ablation [9].

In our technique the irrigated hand-held malleable RF catheter is adherent to the atrial tissue while making an oscillating movement, but without inducing any manual pressure. At the same time, the atrial wall is lifted up and away from the back part of the pericardium and the adjacent mediastinal structures using forceps. In addition, we do not use any preset application RF times to create a lesion, since the atrial wall thickness varies considerably between the doom of the left atrium and the area around the mitral valve. It is our belief that these maneuvers contribute to the safety of the procedure.

4.2. Mortality

Our operative mortality was 6.2% (12/195). These patients had an increased EuroSCORE of 6.5, which is correlated at least with an expected mortality between 10.0 and 11.5% [10]. The STS database showed an unadjusted operative mortality for MV with CABG between 8 and 12.5%. The main cause of death was a low cardiac output, which occurred in 50% (6/12) of the deceased patients. All six patients had an impaired left ventricular contraction function, reflected by a low LVEF fraction between 15 and 50%. Four patients, who had combined mitral valve and CABG procedure, could be considered cardiac failure patients, in whom the surgical treatment comprised several aspects: correcting the mitral regurgitation, reversing myocardial ischemia and restoring sinus rhythm. Obviously, this type of surgery is associated with an increased mortality. The other causes of death were a pre-existing extensive pulmonary artery trunk embolus, a myocardium infarction due to graft failure, an atrioventricular dehiscence due to excessive decalcification of a completely destroyed...
mitral valve annulus, a cerebral stroke because of debris embolization from a calcified ascending aorta and a necrotizing pancreatitis. So, in our opinion, mortality in our series was not related to the use of the irrigated RF ablation.

4.3. Sinus rhythm conversion rate

Our sinus rhythm conversion rate is similar to that of Mohr, who reported an SR at 1 year of 72.5% (58/80) and Sie, who observed an SR conversion rate of 72% (77/122) at 6 months follow up [1,11]. These results corroborate our previous observation [12].

4.4. Summary

Our technique creates deep, non-thrombogenic, atrial wall lesions, however, without causing any collateral damage. The keystones of this surgical technique are:

- mobilization of the left atrium,
- lifting up the atrial tissue during ablation,
- oscillating movements using a hand-held RF pen-catheter
- the occurrence of yellow-white blistering endocardium lesions.

References