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A Radiofrequency Modified Maze and Valve Procedure through a Port-Access Approach

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ABSTRACT

Background: The aim of the study was to assess the feasibility and effectiveness of the irrigated radiofrequency modified maze procedure through a port-access approach during mitral valve surgery.

Methods: Forty-three patients with atrial fibrillation (AF) and mitral valve disease underwent a combined procedure through a port-access approach. The indication was a history of continuous AF for more than 6 months in patients eligible for minimally invasive mitral valve surgery.

Results: The incidence of early mortality was 1 patient (2.3%), and that of freedom from AF was 100% at the end of the operation (70% of patients with normal sinus rhythm, 30% with a pacemaker). One patient (2.3%) required permanent pacemaker implantation after surgery. One patient (2.3%) required reoperation for bleeding. There were no reoperations for failed valve repairs. The incidences of freedom from AF were 87% and 92% at 6 and 12 months, respectively. At 12 months, functional capacity had improved significantly ($P < .05$). There were no procedure-related complications. No thromboembolic events were detected during follow-up.

Conclusion: The port-access approach provided a good access for both valve surgery and the radiofrequency maze procedure. The combination of direct and videoscopic vision allowed an adequate view and led to a safe and efficient combined procedure. Short- and intermediate-term follow-up results were favorable.

INTRODUCTION

Atrial fibrillation (AF) is a common arrhythmia seen in up to 80% of patients undergoing mitral valve surgery [Feinberg 1995]. Patients experience a reduced quality of life, even after successful valve surgery, due to continuing AF and associated morbidity. Radiofrequency (RF) energy, which creates blockage in lines of conduction by thermal damage and subsequent scar formation, is a relatively new energy modality being used for surgical ablation and treatment of AF and has been shown to be highly effective [Sie 2001b, Güden 2002]. Because significant mitral valve disease is often associated with AF, combining minimally invasive valve surgery and AF treatment in a single operation becomes an attractive goal for surgeons.

The aim of this report is to share our experience with the RF modified maze procedure via a port-access approach during mitral valve surgery and to underline some of the technical details of the procedure.

MATERIALS AND METHODS

Forty-three patients with AF and mitral valve disease underwent the combined procedure via a port-access approach. The inclusion criterion was a history of continuous AF for more than 6 months in patients eligible for minimally invasive mitral valve surgery. Patients with severe chest wall deformities, significant coronary artery disease, aortic valve insufficiency, lung adhesions, and iliac artery disease were excluded.

There were 15 male and 28 female patients. The mean age was 53 ± 9 years. The mean left ventricular function was 54% ± 5%, and the mean left atrial diameter was 60 ± 9 mm. The mean duration of AF was 22 ± 9 months. Patient demographics and the concomitant procedures carried out are shown in Tables 1 and 2.

Surgical Procedure

Transesophageal echocardiography (TEE) was used routinely to evaluate the results of valve repair and to help detect the evacuation of air. Patients were positioned in a supine position with the right shoulder elevated, and external defibrillation pads were placed. A right lateral minithoracotomy (4-6 cm) in the fourth intercostal space was performed. A soft tissue retractor (Heartport, Redwood City, CA, USA) was used for exposing the surgical field and avoiding the division or traction of any rib. A 5-mm camera port (Karl Storz, Tutlingen, Germany) was introduced through the fourth intercostal space. A second port was introduced through the sixth intercostal space in the midaxillary line for left atrial venting and carbon dioxide insufflation. The right femoral artery and vein were prepared simultaneously by means of a 2-cm oblique incision in the groin. Cardiopulmonary bypass (CPB) was established with femoral arterial and venous cannulas. An

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Table 1. Patient Demographics*

Female/male sex, n	28/15
Age, y	53 ± 9
LVEF, %	54 ± 5
LAD, mm	60 ± 9
Duration of AF, mo	22 ± 9
NYHA class	2.9 ± 0.4

*LVEF indicates left ventricular ejection fraction; LAD, left atrial diameter; AF, atrial fibrillation; NYHA, New York Heart Association.

18F to 20F arterial cannula (DLP, Grand Rapids, MI, USA) was used for arterial cannulation. Venous drainage was obtained with a 24F to 29F femoral venous cannula (DLP) and the 17F arterial cannula, which had previously been inserted in the right internal jugular vein. The pericardium was opened 2 cm above and parallel to the phrenic nerve. Exposure was optimized with several pericardial stay sutures. Patients were cooled down to 28°C. Both vena cavae were encircled with tape for a dry surgical field. A transthoracic aortic clamp (Chitwood clamp; Scanlan International, St. Paul, MN, USA) was introduced percutaneously from the second intercostal space on the front axillary line. After the aorta was cross-clamped, blood cardioplegia was administered through a custom-made (DLP) antegrade cardioplegia cannula inserted in the ascending aorta. The left atrium was opened parallel to the interatrial groove. The Heartport atrial retractor system was used to expose the atrium.

RF Ablation

The Cardioblate (Medtronic, Minneapolis, MN, USA) RF ablation system was used during the ablation procedure. In this system, the electrode tip is irrigated with saline that cools the tissue, and the pen is slowly oscillated over the tissue during the procedure. The power generator produces a power output of 20 to 30 W/5 mL irrigation per minute. In our experience, we most frequently have used 25 W with an irrigation rate of 5 mL/min. The pen-shaped probe allowed sufficient endothoracic movement and enabled the surgeon to create precise ablation lines through a limited incision (Figure 1). The videoscopic vision allowed excellent viewing of the left atrium during the maze procedure (Figure 2).

The Ablation Procedure

Patients underwent either a left (n = 34) or a biatrial (n = 9) maze procedure. The left-sided RF maze procedure started with isolation of the left atrial appendage via a circumferential RF lesion created around its base. This ablation action was followed by bilateral isolation of the pulmonary vein in a circular fashion. An ablation line from the left atrial appendage to the left superior pulmonary vein was created, followed by a connecting lesion between both islands of the pulmonary veins drawn as near to the left atrial roof as possible to avoid injury to the esophagus. In addition, an ablation line connecting the left pulmonary veins to the P2-P3 segment of the posterior mitral annulus was performed. Finally, an ablation line from the middle of this line toward the base of the atria was performed to prevent reentry pathways between the atria via the coronary sinus. The left atrial appendage was oversewn from inside the left atrium, and then the mitral valve procedure was performed (Figure 3).

Table 2. Concomitant Procedures*

MVR, n	31
MP, n	12
MVR or MP + TP, n	9
Reoperation, n	2

*MVR indicates mitral valve replacement; MP, mitral valvuloplasty; TP, tricuspid valvuloplasty.

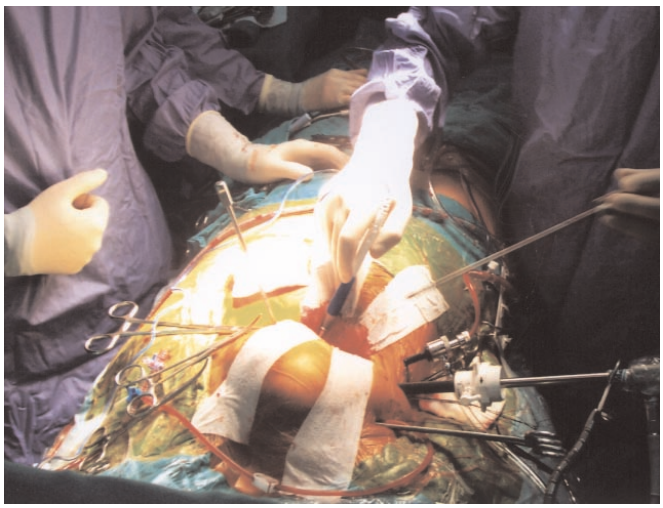

Figure 1. The surgical view during the port-access radiofrequency maze procedure.

The right-sided RF maze procedure started with a circumferential ablation line performed around the base of the right atrial appendage, followed by a 4-cm anterior epicardial ablation line toward the inferior vena cava. The right atrium was entered through a posterior longitudinal and lateral incision at the dorsolateral aspect, extending to the atrioventricular

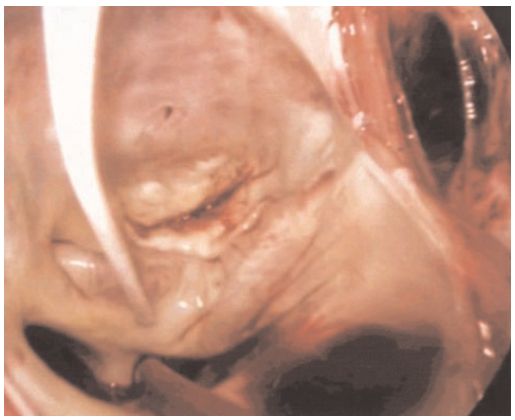

Figure 2. Endoscopic view of the left atrium during ablation.

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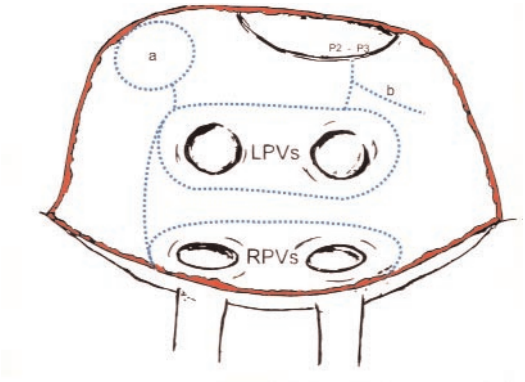

Figure 3. Left atrial ablation lines are shown in dots. Indicated are the left atrial appendage (a), ablation toward the coronary sinus (b), left pulmonary veins (LPVs), and right pulmonary veins (RPVs).

groove and reaching the interatrial septum. The epicardial ablation continued toward the superior and inferior vena cavae, meeting with the surgical incision in the middle. The rest of the ablation lines were performed endocardially in the right atrium (Figure 4).

Technical Details

The ablation was always performed before any other procedure to avoid any damage to the suture lines from the heat produced by the RF energy. The TEE probe was always removed during the ablation to prevent any injury to the esophagus from the transmission of heat waves. To avoid any collateral damage to the circumflex coronary artery while we performed the ablation line toward the mitral annulus, we targeted the P2-P3 segment of the mitral valve. The biatrial maze procedure was reserved for cases in which the right atrium had to be opened for a tricuspid valve procedure or if the patient had a history of atrial flutter. Otherwise, the procedure was limited to the left side.

RESULTS

The mean operating time was 190 ± 44.2 minutes, the mean duration of CPB was 120 ± 24.2 minutes, the mean cross-clamp time was 80.4 ± 27.4 minutes, and the mean time of the ablation procedure was 14.3 ± 2.8 minutes. Early mortality occurred with 1 patient (2.3%). This patient died from multiorgan failure after a pulmonary infection. There was one conversion to right anterolateral thoracotomy because of adhesions in the right thoracic cavity. The incidence of freedom from AF was 100% at the end of the operation (70% of patients with normal sinus rhythm, 30% with pacemaker). One patient (2.3%) required reoperation for bleeding, and 1 patient (2.3%) required a pacemaker implantation 1 month after the surgery because of a third-degree atrioventricular block. There were no reoperations for failed valve repairs. However, 2 patients had minor insufficiency that did not need any intervention, and these 2 patients were closely followed up (Table 3).

The incidences of freedom from AF were 87% and 92% at 6 and 12 months, respectively. Atrial transport function was evaluated 12 months postoperatively with transthoracic echocardiography and Doppler analysis of mitral valve flow, which revealed that 90% of patients had recovered atrial transport function. At 12 months, the functional capacity had improved significantly (2.9 ± 0.4 to 1.2 ± 0.2; $P < .05$). No thromboembolic events were detected in any patient.

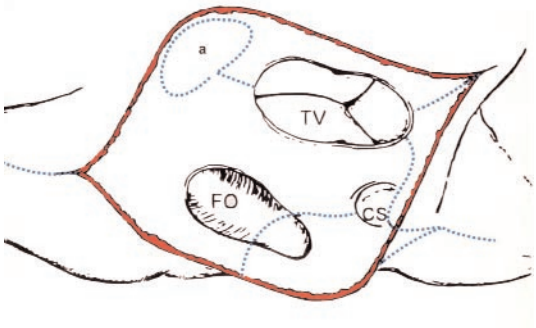

Figure 4. Right atrial ablation lines are shown in dots. Indicated are the right atrial appendage (a), the tricuspid valve (TV), the coronary sinus (CS), and the fossa ovalis (FO).

DISCUSSION

AF is the most common sustained arrhythmia and is associated with considerable morbidity and related mortality [Benjamin 1998]. Cox and associates introduced the maze procedure in 1991 as a curative therapy for patients with chronic AF [Cox 1991]. Although the maze procedure is highly effective, it has the disadvantage of being a technically demanding and time-consuming procedure. Therefore, the maze procedure did not find widespread application outside a few centers of excellence. This technical complexity has lead to multiple attempts to create a faster and simpler procedure using various energy sources to replace the incisions of the original cut-and-sew technique. These energy sources include RF, cryoablation, bipolar cautery, microwave, and laser [Patwardhan 1997, Lee 2001, Sie 2001b]. Most of the literature has focused on the use of RF energy with various modifications, and the efficacy of these systems has been well documented [Khargi 2001, Sie 2001b].

After the initial success with these various energy sources, efforts were aimed toward performing these procedures via

Table 3. Patient Complications

Permanent pacemaker, n	1 (2.3%)
Reoperation for bleeding, n	1 (2.3%)
Wound infection, n	0
Prolonged ventilation, n	1 (2.3%)
Mortality, n	1 (2.3%)
Endocarditis, n	0
Paravalvular leak (minor), n	1 (2.3%)
Late tamponade, n	1 (2.3%)
Thromboembolic event, n	0

less invasive approaches. The feasibility of an epicardial approach has been demonstrated with RF or microwave energy during off-pump coronary artery bypass surgery. However, an epicardial approach during valvular procedures does not offer any clear advantage, because eliminating CPB is not possible [Benussi 2000, Melo 2001]. Significant mitral valve disease is often associated with chronic AF, and approximately 60% to 80% of mitral valve cases referred for surgery are reported to have AF [Feinberg 1995]. This fact has stimulated surgeons to approach these two problems in a combined minimally invasive approach. Different minimally invasive surgical approaches have recently been applied to treat mitral valve disease with AF in efforts to minimize surgical trauma and improve cosmetic results. Reports from different institutions have demonstrated the efficacy and safety of these minimally invasive techniques [Mohr 2002, Sharony 2002].

Mohr and associates were among the first to show in a large series the feasibility of creating ablation lines with RF energy during minimally invasive valve procedures. They reported 6-month and 1-year sinus rhythm restoration rates of 78% and 69%, respectively, in a group of 133 patients. This patient group was a subset of 234 patients who underwent operations during a 3-year period that showed the feasibility of RF ablation through a port-access approach [Mohr 2002].

Sie et al and Khargi et al were among the first groups to use the irrigated RF device for the surgical treatment of AF [Khargi 2001, Sie 2001b]. Sie et al reported incidences of freedom from AF at 1 and 2 years of 98% and 86%, respectively [Sie 2001a]. A recent review of the literature shows that the incidence of sinus rhythm restoration at 1 year varies between 62% and 98% among series using RF energy [Benussi 2000, Güden 2002]. These differences can be attributed to variations in patient selection, ablation patterns, and the technical equipment used. Patient selection probably remains the most important factor affecting the outcome of the procedure [Kosaka 1999]. Patients with an atrial f-wave amplitude near 0, patients with a large left atrium, and patients with an enlarged cardiothoracic ratio seem to have a decreased rate of sinus rhythm restoration [Kosaka 1999]. The choice of lesion pattern may also have an effect on the success of the procedure. Kress et al have shown in an animal model that a lesion pattern consisting of electrically isolating the pulmonary veins and the left atrial appendage and the creation of left atrial connecting lesions was 100% effective in terminating AF, compared with other models consisting of pulmonary vein isolation alone [Kress 2002]. This pattern is similar to the ablation pattern the authors have been using [Güden 2002]. On the other hand, series based on simple pulmonary vein isolation seem to have slightly lower rates of sinus rhythm restoration [Mohr 2002]. One advantage of the left-sided limited procedure is that it obviates some incisions. However, if a patient develops atrial flutter after the operation, it usually needs to be managed with catheter ablation techniques. These series reported postoperative incidences of atrial flutter reaching 10% to 15% [Usui 2002]. Although catheter-based techniques can be applied in these patients, a second procedure will increase costs considerably, and this option may not be available in all centers. Our current policy is to adopt the biatrial approach in patients with a history of atrial flutter and who require the opening of the right atrium. Otherwise, the procedure is restricted to the left atrial side in an effort to reduce the number of surgical incisions [Güden 2002]. The right-sided procedure, especially ablation around the isthmus area, slightly increases the risk of atrioventricular block, which happened in 1 patient in our group (2.3%). Esophagus injury and coronary artery damage (the circumflex artery) are two serious complications that have been reported during RF ablation [Gillinov 2001, Patwardhan 2002]. Esophageal injury reported in most series is attributed to heat waves transmitted by the TEE probe. Therefore, the removal of the probe before beginning the ablation is mandatory. In addition, the type of RF device, the amount of the energy delivered, and the ablation pattern are other points that need to be considered to minimize such complications. The pulmonary vein is a thin structure that is close to the esophagus, and ablation inside the pulmonary veins may increase the chance of esophageal injury [Gillinov 2001, Mohr 2002, Patwardhan 2002]. During our technique, the ablation lines are located outside the pulmonary veins, thus minimizing the chance of esophageal damage. The saline irrigation has some theoretical advantages over dry RF systems. It lowers the surface temperature so that direct heating is transmitted below the surface, resulting in a lesion of greater depth and higher chances of creating a transmural lesion. Irrigation obviates firm contact and pressure. This procedure also avoids the use of excessive energy levels that can cause the collateral damage that has been reported in some series [Gillinov 2001, Mohr 2002]. Probes designed to stamp at the tissue at a certain pressure with constant high energy levels bring the tissue being ablated into a closer relationship to underlying structures, and this kind of action can be a potential cause of collateral damage. The importance of probe design becomes even more crucial during minimally invasive procedures. The pen-shaped probe used during this study enabled the surgeon to perform ablation lines through a limited incision, allowing sufficient endothoracic movement without any pressure to the atrial tissue. It has been postulated that many patients undergoing mitral valve surgery convert to sinus rhythm irrespective of ablation and that ablation may not be necessary in this group of patients. It has also been suggested that routine prophylactic use of antiarrhythmic drugs has a major role in the high rates of conversion to sinus rhythm. However, these ideas do not seem to be justified by the data coming from recent studies [Patwardhan 1997, Kosaka 1999, Benussi 2000].

During this trial, the port-access approach provided a good access for both valve surgery and the RF maze procedure. The combination of direct and videoscopic vision allowed adequate view of both the valve and the left atrium, leading to a safe and efficient combined procedure. There were no procedure-related complications. Short- and intermediate-term follow-up results were favorable, with 92% of the patients who received the procedure being free of AF at 12 months. We believe that this less invasive combined approach can increase the accessibility of treatment for a larger number of AF patients with minimal procedure-related complications.

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