The surgical treatment of atrial fibrillation with microwave ablation: preliminary experience and results

Bruno Chiappini*, Roberto Di Bartolomeo, Giuseppe Marinelli

Department of Cardiovascular Surgery, Policlinico S. Orsola-Malpighi, University of Bologna, via Massarenti 9, 40138 Bologna, Italy

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Abstract

Atrial fibrillation (AF) is associated with a significant mortality and morbidity. Microwave (MW) ablation is a new technology for surgical treatment of this arrhythmia. We present our preliminary experience with MW ablation in patients with AF who underwent a concomitant open-heart surgery. From October 2001 to March 2002, a total of 10 patients underwent MW ablation of AF and an open-heart surgery at the Department of Cardiovascular Surgery of the University of Bologna. All patients experienced chronic AF and the mean duration of rhythm disturbance was 82.8 months, ranging from 24 to 360 months. There was no complication related to the surgical procedure. The overall survival rate, after discharge, was 100% and sinus rhythm recovery rate was 77.8% after a mean follow-up time of 12.4 months (10–15 months). Our preliminary results show that MW ablation may be a very effective way of converting patients with atrial fibrillation into sinus rhythm.

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1. Introduction

Atrial fibrillation (AF) affects nearly 1% of the general population, with a striking increase of incidence in the elderly [1].

Patients have increased morbidity and mortality rates because of hemodynamic impairment and thromboembolism. Although several methods for the surgical treatment of AF have been described, the most widely accepted surgical approach for AF is the maze procedure, developed by Dr James Cox. Excellent results have been reported with this technique but it is associated with extended operative efforts and increased morbidity [2–5].

Therefore, several alternative ablation methods have been proposed to interrupt macro-reentry circles [6,7].

MW energy is supposed to be potentially useful for catheter ablation because it is capable of effective and controlled heating of large tissue volumes without causing endocardial charring [8].

Based on the lesion line concept introduced by Allessie et al. and recognizing the potential benefits of MW energy, Knaut et al. have introduced MW ablation for the intraoperative use in the treatment of chronic AF [9].

This was a new concept for creation of continuous ablation lines between anatomic barriers to interrupt macroreentry circles. We report our preliminary clinical experience with this approach for the treatment of AF.

2. Materials and methods

From October 2001 to March 2002, 10 patients with chronic AF underwent open-heart surgery and MW ablation to treat AF at the Department of Cardiovascular Surgery of the University of Bologna. They were six women and four men, with a mean age of 61.7 ± 9.2 years (47–71 years). Twelve patients were in NYHA II, seven patients were in NYHA III and one patient was in NYHA IV. Average duration of AF was 82.8 months (24–360 months). The average size of the left atrium, measured by transesophageal echocardiography, was 56.3 ± 6.9 mm (45–66 mm). The breakdown of the primary surgical procedures was as follows: four patients underwent mitral valve replacement and tricuspid valveplasty; three patients underwent aortic and mitral valve replacement; one patient underwent mitral...
valve replacement; one patient underwent tricuspid valve replacement and one patient underwent atrial septal closure and tricuspid valveoplasty. All surviving patients were followed up after operation with a clinical examination, echocardiogram and electrocardiography (ECG). To promote maintenance of early postoperative sinus rhythm, all patients were kept on low-dose amiodarone (200 mg/day) for 6 months after operation.

2.1. Operative technique

We used the Flex 4 MW ablation system (Afx, Inc, Fremont, CA) consisting of a surgical ablation probe with a 4-cm ablating element and flexible shaft, used for both endocardial and epicardial ablation. The MW generator delivers a continuous wave of 2.45 GHz and allows for variable power output between 35 and 45 W. All patients underwent cardiopulmonary bypass with bicalval and aortic cannulation under moderate hypothermia (32 °C); myocardial protection was assured by antegrade crystalloid cardioplegia. After a standard lateral left atriotomy, the probe was placed on the left atrial endocardium 5–10 mm medially from the right pulmonary vein orifices. The energy was set at 65 W and the application time was 45 s. Two MW applications were generally required to complete isolation of the right pulmonary veins. The ablation tool was then used to create a circumferential lesion around the left pulmonary veins, at least 5 mm from their orifices. Connecting lesions were created from the left atrial appendage to the ablation line around the left pulmonary veins and from here to the antero-medial commissure of the mitral valve. A final lesion connecting the two pulmonary vein encircling lesions was created. The left atrial appendage was then excised and the stump of the left atrial appendage was closed with running 4/0 polypropylene suture. We also performed the ablation in the right atrium to prevent the early postoperative onset of atrial flutter: a single lesion was created along the crista terminalis from the superior vena cava to the inferior vena cava. A connecting lesion was performed on to the atrioventricular groove low down opposite the orifice of the coronary sinus to create a block in the cavitricuspid isthmus area (Fig. 1).

3. Results

The increase in aortic occlusion time for MW ablation averaged 10 min. The mean cross-clamp time was 98.9 min (40–173 min.) and the mean cardiopulmonary bypass time was 123.3 min (63–209 min.). All patients were weaned off cardiopulmonary bypass in a regular paced rhythm \((n = 2)\) or sinus rhythm \((n = 8)\). On postoperative day 5 there was one in-hospital death due to the rupture of the left ventricle in a patient who underwent mitro-aortic valve replacement with a severely calcified mitral annulus. All patients received anticoagulation therapy with warfarin; in case of reconstructive surgery or biologic prosthesis the anticoagulant was stopped after 6 months in patients with sinus rhythm and left atrial contraction, well documented by echocardiography. Every day after the operation, rhythm was controlled by a rest ECG. Before hospital discharge, patients received transthoracic echocardiography. Follow-up results were available in 100% of the discharged patients, after a mean period of 12.4 months. Rhythm was evaluated using the results of rest ECG and Holter electrocardiography, mechanical atrial function and atrial A-wave detection in a transthoracic Doppler-study. Hemodynamic response of atrial contraction was assessed by identification of a biphasic wave at the level of the tricuspid and mitral valve using color-Doppler echocardiography. Seven patients (77.8%) were in sinus rhythm, two patients (22.2%) were in AF. No patient needed permanent pacemaker implantation. Warfarin was stopped in all patients who underwent a reconstructive procedure or a biologic valve replacement and no thromboembolic events occurred. A significant improvement of NYHA class was noted at follow-up: six patients (66.7%) were in NYHA I and three patients (33.3%) were in NYHA II.

4. Discussion

Over the past 2 years, MW energy has been available in Europe and more recently in the USA to create lesions in the atrium. MW are electromagnetic waves delivered at very high frequency (2.45 GHz) provoking the induction of vibration of dipoles, such as water molecules and the generation of heat. Therefore, when the MW probe is applied directly to the tissue surface, the release of topical heat is able to create large and deep lesions [10,11]. Histologic preparations of ablated myocardium show a well-demarcated area of thermal injury characterized by necrotic myocardium at the center, a borderline area of edema and intramural hemorrhage and surrounding normal tissue. Long-term lesions at 6 months show dense scar tissue that is sharply demarcated from normal tissue [12]. MW heating has a potential advantage over the other ablation techniques in that the depth and volume of heated tissue are greater for the same tissue surface temperature. This may result in a higher probability of transmural lesions [13].

The biggest clinical experience in the MW ablation has been accrued by Dr. Knaut in Dresden: in a recent analysis involving 120 patients, he found 81% of the patients in sinus rhythm at 30 days postoperatively and 75% in sinus rhythm at 1 year. As the Dresden group we did not report any complications due to the ablation procedure with comparable results in terms of sinus rhythm recovering 1 year after surgery (77.8%).

Williams et al. has performed MW ablations in 31 patients during mitral valve surgery with 84% of success in achieving sinus rhythm at hospital discharge. Although
this group reported only short-term data, it was able to identify a left atrial diameter greater than 6 cm and an atrial fibrillation duration greater than 4 years as predictors for failure (defined as discharge from the hospital in atrial fibrillation) [14].

An important aim of restoring sinus rhythm is to produce the contraction of both atria, restoring an adequate electromechanical synchrony and decreasing the risk of thromboembolism: in our study biatrial contraction allowed us to interrupt the anticoagulant therapy, 6 months after surgery, in all patients who underwent reconstructive surgery or biologic valve replacement without thromboembolic complications. Potential advantages of MW energy ablation include reduced time of application, long linear lesions, under continuous visual check during operation, and sparing of endocardial surface with reduced risk for thromboembolic complications [15].

According to our preliminary experience and the literature data, we believe that MW energy will likely play a prominent role as a rapid and minimally invasive cure for atrial fibrillation.

References


