Microwave and radiofrequency ablation yield similar success rates for treatment of chronic atrial fibrillation

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Abstract

Objective: To evaluate the influence of two different ablation devices (microwave AFx® and radiofrequency Medtronic®), designed to create linear lesion lines, with respect to efficacy and restoration of sinus rhythm (SR). Methods: Between February 2001 and December 2002, 42 patients with chronic, persistent atrial fibrillation (AF) >6 months were submitted to different combinations of valve surgery (mitral ± tricuspid, n = 30; mitral and aortic ± tricuspid reconstruction, n = 6; aortic ± tricuspid, n = 8) and concomitant Maze procedure. The biatrial Maze followed the concept of the Cox III procedure, using either microwave energy (AFx Lynx) (group I: age 65.8 ± 11.9 years, mean duration of AF 61.9 ± 28.9 months, n = 23) or radiofrequency (Medtronic Cardioblate) (group II: age 64.1 ± 11.1 years, mean duration of AF 53.5 ± 49 months, n = 19). Results: There was one death with group I (4%), due to liver failure. Both groups were comparable with regard to Euro Score, ejection fraction, cross clamp time, cardiopulmonary bypass time, ICU (median 1 day in both groups) and hospital stay, and type of indication. The preoperative diameter of the left atrium was 69.7 ± 10.8 and 74.0 ± 14.3 mm in groups I and II, respectively (P = 0.359). The Maze procedure resulted in 23 ± 2 and 17 ± 1 min additional cross clamp time in groups I and II, respectively (P = 0.013). At the 12-month follow up, freedom from AF was 81 and 80% in groups I and II, respectively. Twenty percent in group I and 21% in group II needed a pacemaker (PM), due to sick sinus syndrome (2 versus 2 cases), AV bloc (2 versus 1 case) and preoperative bradycardia (0 versus 1 case), respectively. Conclusions: The combination of complex valve surgery and Maze procedure was safe and reproducible. Following the Cox Maze III line concept, microwave and radiofrequency ablation gave similar results even in patients with more complex double or triple valve procedures.

Keywords: Chronic atrial fibrillation; Maze; Radiofrequency; Microwave

1. Introduction

The surgical Maze described by Cox [1,2] is an accepted effective therapeutic option for patients with atrial fibrillation (AF). However, it constitutes an extensive and complex procedure. In recent years, several different ablation devices have been developed, facilitating the creation of linear lesion lines [3–5]. In addition, different concepts of lesion patterns have been applied [6], further reducing the complexity of the original Cox Maze procedure.

Throughout the literature, the efficacy with respect to restoration of sinus rhythm (SR) is around 70–80% regardless of which device and lesion concept was used. This is significantly lower than the results given for the original Cox procedure [7]. This may be caused by a different lesion concept or by the lack of transmurality created by different forms of energy. The reason for it remains unclear, since hardly any papers are comparable with regard to device and pattern used. In addition, some authors [8] reported mixed patient cohorts including both paroxysmal and permanent AF.

The Maze procedure and all kinds of ablation procedures are usually performed in patients suffering from isolated
mitral valve pathologies. Sparse data exist about its application in conjunction with more complex double and triple valve procedures [5]. One could argue that widening the indication criteria will include patients who most likely will profit most from restoring SR.

The first step aims to clarify the impact of different energy forms. Therefore, a prospective study was conducted to analyse the influence of two different ablation devices (microwave AFx and radiofrequency Medtronic) with respect to efficacy and restoration of SR. The gold standard of the Cox Maze procedure was chosen as the underlying lesion concept.

Secondly, it had to be elucidated whether patients undergoing more complex heart surgery, such as double and triple valve procedures, yielded the same success rates with the Maze procedure.

2. Materials and methods

2.1. Patients

Between February 2001 and December 2002, 42 consecutive patients (21 male, mean age 64.3 ± 11.4 years, ranging from 38 to 82 years) presenting with different forms of valve pathologies and chronic AF were enrolled in the study. All patients had chronic permanent AF longer than 6 months (61.1 ± 87 months, ranging from 6 months to 32 years). Patients with paroxysmal AF were excluded from the investigation. The biatrial Maze followed the concept of the Cox III procedure, using either microwave energy (AFx inc., Fremont, CA) (group I, n = 23) or radiofrequency (Medtronic Cardioblate, Minneapolis, MN) (group II, n = 19). The patients were submitted to different combinations of valve surgery.

The indications for surgery in group I were mitral valve regurgitation (n = 4), mitral valve + tricuspid valve regurgitation (n = 3), mitral valve regurgitation + aortic valve stenosis (n = 1), mitral valve stenosis (n = 3), mitral valve stenosis + tricuspid valve regurgitation (n = 1), mitral valve stenosis + aortic valve stenosis (n = 1), mitral valve stenosis + tricuspid valve regurgitation + aortic valve stenosis (n = 1), mixed mitral valve lesion (n = 2), mixed mitral valve lesion + tricuspid valve regurgitation (n = 2), aortic valve stenosis (n = 4) and aortic valve insufficiency (n = 1).

The indications for surgery in group II were mitral valve regurgitation (n = 4), mitral valve + tricuspid valve regurgitation (n = 2), mitral valve regurgitation + aortic valve stenosis (n = 1), mitral valve regurgitation + aortic valve stenosis + tricuspid valve regurgitation (n = 1), mitral valve regurgitation + coronary artery disease (n = 2), mitral valve regurgitation + aortic valve insufficiency + coronary artery disease (n = 1), mitral valve stenosis + tricuspid valve regurgitation (n = 1), mixed mitral valve lesion (n = 4), aortic valve stenosis (n = 2) and aortic valve stenosis + tricuspid valve regurgitation (n = 1).

A tricuspid valve plasty was performed in all patients presenting with a tricuspid valve regurgitation grade 2 or greater.

All patients presented with chronic, permanent AF longer than 6 months despite complete antiarrhythmic therapy. The duration of AF was up to 32 years in group I and 12 years in group II. For demographic and preoperative data, refer to Table 1. No significant difference was calculated for any variable. The 95% confidence intervals for the Euro Score were −2.3 to 0.8 (SE 0.7), for the left atrial diameter −16.8 to 5.4 (SE 5.4) and for the right atrial diameter −12.8 to 5.5 (SE 4.3).

2.2. Surgical procedure

After median sternotomy, cardiopulmonary bypass was established in standard fashion, by cannulating both vena cava. The operative procedure was based on the Maze III procedure as described by Cox et al. [9]. All atrial incisions were replaced by endocardial, linear ablation lines except for the incisions to enter the right and left atrium and the resections of the appendages.

After onset of normothermic cardiopulmonary bypass, the venous inflow was occluded. At first the right-sided lesions were performed on the beating heart. The right atrial appendage was amputated and a lesion line was drawn to the annulus of the tricuspid valve. The right atrium was entered through a second incision on the lateral wall. From the corner of this incision a line was drawn cranially into the superior vena cava and caudally into the inferior vena cava.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Age (years)</td>
<td>65.6 ± 11.9</td>
<td>64.1 ± 11.1</td>
</tr>
<tr>
<td>Gender (%male)</td>
<td>44</td>
<td>58</td>
</tr>
<tr>
<td>EF (%)</td>
<td>55.7 ± 8.2</td>
<td>56.4 ± 15.5</td>
</tr>
<tr>
<td>Euro Score</td>
<td>5.2 ± 2.4</td>
<td>6.0 ± 1.8</td>
</tr>
<tr>
<td>Range</td>
<td>2–9</td>
<td>3–9</td>
</tr>
<tr>
<td>NYHA</td>
<td>3.3 ± 0.7</td>
<td>3.4 ± 0.6</td>
</tr>
<tr>
<td>Paroxysmal AF (%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>AF duration (months)</td>
<td>61.9 ± 28.9</td>
<td>53.5 ± 49.0</td>
</tr>
<tr>
<td>LA (mm)</td>
<td>69.7 ± 10.8</td>
<td>74.0 ± 14.3</td>
</tr>
<tr>
<td>RA (mm)</td>
<td>68.6 ± 9.1</td>
<td>72.3 ± 9.8</td>
</tr>
</tbody>
</table>

Primary valve pathology

| Mitral valve regurgitation        | 8       | 11       |
| Mitral valve stenosis            | 6       | 1        |
| Mixed mitral valve lesion        | 4       | 4        |
| Aortic valve stenosis            | 4       | 3        |
| Aortic valve insufficiency       | 1       | 0        |
| Coronary artery disease          | 0       | 1        |
| Aneurysm ascending aorta         | 1       | 0        |

EF, ejection fraction; AF, atrial fibrillation; LA, diameter of left atrium; RA, diameter of right atrium.
Then a lesion line was made from the incision to the posterior segment of the annulus of the tricuspid valve. The ablation was completed by a line from the edge of the incision, crossing the fossa ovalis and the isthmus into the coronary sinus and then down into the inferior vena cava. Thereafter, the patient was cooled to 32 °C, the aorta was cross clamped and the heart arrested. Myocardial protection was achieved with cold blood cardioplegia infused ante and retrogradely. The left atrium was entered through the interatrial groove and the left sided Maze was performed. In contrast with the original Maze procedure, the left and right pulmonary veins were encircled separately, leading to two isolated isles, which were connected at the back of the left atrium creating a figure of ‘H’. Then the remaining lesions to the mitral annulus and the left atrial appendage were carried out.

After completion of the Maze procedure, the necessary valve surgeries were performed and the left atrium and/or the ascending aorta closed by a double running suture. The cross clamp was released and the closure of the right atrium and the reconstruction of the tricuspid valve, if necessary, were done on the beating heart.

### 2.2.1. The microwave system

The microwave generator (AFx®) delivers a continuous wave of 2.45 GHz and allows for variable power output. The Lynx probe consists of a 2 cm long ablation antenna. The energy was set at 40 W with an application time of 25 s. The ablation element was placed on the endocardium creating linear lesions, which were overlapped to ensure continuous transmural ablation.

### 2.2.2. The radiofrequency system

The system (Medtronic®) used consists of a unipolar surgical ablation pen, which is saline irrigated (5 ml/min) to cool the surface of the endocardium. The patient is grounded by an indifferent electrode applied to the skin. The power generator was set at 30 W. The tip was slowly oscillated about 10 times over the same area, to create continuous endocardial lesions.

### 2.3. Postoperative treatment

Immediately after surgery, no antiarrythmic therapy was given. In the case of AF, amiodarone was administered. Patients were loaded with 3 × 200 mg amiodarone daily. After reaching therapeutic blood levels and still persisting AF, electrical cardioversion by DC shock (up to twice 360 J) was performed. If AF was observed during the later follow up period, cardioversion was performed at most twice.

All patients received coumadine, targeting an international normalised ratio value between 2.2 and 2.5.

### 2.4. Follow up

Patients were evaluated at 3, 6, 12 months after operation and then on a yearly basis. Rhythm was determined on the basis of 12-lead electrocardiogram and 24 h Holter monitoring. Hemodynamic response of atrial contraction was assessed by identification of a biphasic wave at the level of the tricuspid and mitral valves using colour-coded Doppler echocardiography.

### 2.5. Statistics

Data were analysed using JMP System software (SAS Institute, Cary, NC). Differences of preoperative data between the groups were analysed through Fisher’s Exact test for categorical variables and Mann–Whitney test for continuous variables. A P-value < 0.05 was chosen as significant. All values are expressed as mean ± SD.

### 3. Results

Only 8 patients in group I and 8 patients in group II underwent isolated mitral valve repair or replacement. The remaining patients underwent different combinations of valve procedures (Table 2). In addition, 1 patient had a replacement of the ascending aorta and 1 patient a closure of...
an atrial septal defect. One patient died during hospitalisation in group I (4.3%), which was not attributable to the ablation procedure. The reason was accepted as liver failure. During later follow up, 1 patient in group I died, due to unexplained cause.

Postoperative complications included IABP 4.3% (1 patient in group I) and transient low cardiac output 4.3 and 5.3% (1 patient in each group). Postoperative bleeding occurred in 8.6% (2 patients in group I), which necessitated rethoracotomy. In both patients, the bleeding site was the right atrial suture line. One patient in each group experienced a severe systemic inflammatory response syndrome on the first postoperative day, which extended the necessary intensive care to 49 and 46 days in groups I and II, respectively. The remaining patients had a stay in the ICU of 1.7 ± 2.5 and 1.6 ± 1.2 days in groups I and II, respectively. The length of hospitalisation was 12.8 ± 3.4 and 12.0 ± 5.1 days in groups I and II, respectively. The duration of ventilation in these patients was 18.2 ± 23.7 and 16.4 ± 19.8 h in groups I and II, respectively. Operative data are given in Table 3.

No statistically significant difference was found between any preoperative variable except the follow up time, which was 24.2 ± 1.3 and 12.1 ± 1.2 months for groups I and II, respectively (\( P < 0.01 \)). This is due to the fact that we started our study with the microwave tool and implemented the radiofrequency tool later; this was caused by institutional circumstances. The follow up was complete, except for one patient of group I, who was referred from a foreign country and did not attend the scheduled follow up investigations.

All patients were either in SR or electrically paced in DDD or AAI mode immediately after surgery on admission to the intensive care unit. No patient had any cerebral thromboembolic complications postoperatively.

In group I, 5 patients (20%) received a permanent pacemaker (PM) for atrioventricular block (3 cases; 1, 3 and 6 months postoperatively) and sick sinus syndrome (2 cases; 3 and 5 months postoperatively). At 3 months, 13, 1, 3 and 5 patients were in SR, junctional rhythm, on PM and in AF, respectively. At 6 months, 12, 1, 4, 1 and 4 patients were in SR, junctional rhythm, on PM, atrial flutter and in AF, respectively. At 12 months, 13, 5 and 4 patients were in SR, on PM and in AF, respectively. At 24 months, 12, 4 and 4 patients were in SR, on PM and in AF, respectively.

In group II, 4 patients (21%) received a permanent PM for atrioventricular block (2 cases; 1 month postoperatively) and sick sinus syndrome (1 case; 9 months postoperatively). One patient had a PM implanted preoperatively due to bradycardia. At 3 months, 9, 2, 3, 1 and 4 patients were in SR, junctional rhythm, on PM, atrial flutter and in AF, respectively. At 6 months, 11, 3 and 4 patients were in SR, on PM and in AF, respectively. At 12 months, 8, 3 and 3 patients were in SR, on PM and in AF, respectively. Data are depicted in Fig. 1.

At the 12-month follow up, freedom from AF was 81 and 80% in groups I and II, respectively, which was not statistically significant.

To evaluate the postoperative atrial transport function in patients with SR, additional pulsed-wave Doppler examinations were carried out between 6 and 12 months postoperatively. For organizational reasons, the data were available for 12 patients. A biatrial contraction was observed in 33% of the patients and a right atrial contraction in 50% of the patients.

### Table 3

<table>
<thead>
<tr>
<th>Operating data</th>
<th>Group I</th>
<th>Group II</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time (min)</td>
<td>165 ± 34</td>
<td>164 ± 48</td>
<td></td>
</tr>
<tr>
<td>XCL time (min)</td>
<td>88 ± 15</td>
<td>91 ± 25</td>
<td></td>
</tr>
<tr>
<td>ABL (min)</td>
<td>23 ± 2</td>
<td>17 ± 1</td>
<td>0.013</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>498 ± 292</td>
<td>526 ± 145</td>
<td></td>
</tr>
</tbody>
</table>

CPB, cardiopulmonary bypass time; XCL, cross clamp time; ABL, duration of ablation procedure.

Fig. 1. Cardiac rhythm. Bar graph showing cardiac rhythm at 3, 6, 12 and 24 months follow up for groups I (A) and II (B). SR, sinus rhythm; junct, junctional rhythm; PM, pacemaker; Aflutt, atrial flutter; AF, atrial fibrillation.
4. Discussion

The surgical Maze procedure [1,2] is a well-established, effective, but complex concept for treatment of AF. Since adding a variety of different ablation tools [3–5] to the surgeon’s armory, the complexity of the procedure has diminished. In addition, other authors further developed the lesion concept [6], leading to a more simplified, only left atrial procedure.

In the literature, the efficacy of these procedures with respect to restoration of SR lies between 70 and 80%, regardless of which device was used or which lesion concept was followed. These results are significantly lower than those given for the original Cox procedure [7]. The reason for this is still unclear, since hardly any papers are comparable with regard to device and pattern used. In addition, some authors [8] reported mixed patient cohorts including both paroxysmal and permanent AF.

One main principle of the Maze procedure is the creation of transmural, isolating scars. It is evident that this can be definitely accomplished by the classic cut and sew technique. The application of different forms of energy, however, carries the potential risk of lack of transmurality.

In a first step, a prospective study was conducted to analyse the influence of two different ablation devices (microwave AFx and radiofrequency Medtronic) with respect to efficacy and restoration of SR. The gold standard of the Cox Maze procedure was chosen as the underlying lesion concept for direct comparison. To our knowledge, the microwave tool has never been used for creating Cox Maze lesion lines, which makes any comparison impossible. We used these two widely accepted energy forms, based upon different physical principles, because both have some advantages.

The microwave (AFx inc.) consists of electromagnetic waves delivered at high frequency (2.45 GHz) provoking the vibration and rotation of the dipoles of water molecules, thus generating heat by friction. The release of the heat creates lesions at predictable depth [10]. Like in a microwave oven, the electromagnetic waves and the energy are not absorbed by air, blood or a previous ablation on the same spot; the ablation probe itself need not have permanent contact with the tissue. This often is advantageous, because it sometimes is difficult to achieve a complete dry field during surgery. The probe delivers energy, which heats tissue to a depth of 6 mm, without risk of endocardial surface charring or coagulation [11]. Histologic investigations showed dense scar tissue at 6 months with sharp demarcation lines towards the normal tissue [12]. Although the Lynx device is rather bulky, and in some situations hard to use, the malleable antenna of the next generation called Flex 4 can be applied easily.

In contrast, radiofrequency (Medtronic, Cardioblate) is applied with a frequency of 484.2 kHz by a pen which is as simple as drawing. The current flows from the tip of the radiofrequency catheter to an indifferent electrode, placed firmly behind the right shoulder of the patient, and resistively heats tissue in tip contact. However, to apply enough energy for creation of transmural lesions, the pen has to be moved in a pendulum swing fashion on an average of 10 times over the same area. The addition of saline irrigation has the theoretical advantage of cooling the tissue surface, providing a low impedance path, thus resulting in a lesion of greater depth and a higher chance of creating transmural lesions [13]. Nevertheless, the exact duration of application varies according to the tissue thickness and is a matter of experience. Whereas too little energy will not guarantee transmurality, too much energy may cause significant problems. The more energy is applied, the more possibly rapid heating will occur, which may result in rapid boiling of the intracellular fluid causing the so-called ‘tissue pops’. Though we observed these sudden ruptures of atrial wall rarely, they usually required suturing.

In our experience we found the drawing of the lesion lines much easier with the radiofrequency pen, which accounted for the significantly shorter ablation time. On the contrary, it is sometimes cumbersome to be sure that the lesions are really transmural; this is largely dependent on experience. It is important that the movement of the pen covers exactly the same area often enough. This is facilitated by the fact that the myocardial wall swells after the first oscillating movements. The swelling can be felt by the tip of the pen, thus serving as guidance. Conversely, the microwave Lynx probe creates a linear lesion of 2 cm with one application ensuring a fixed depth of ablation. However, it is much bulkier than the radiofrequency pen, which may be the reason why this device is rarely used to perform circular lesions around the pulmonary veins endocardially. Especially, encircling the upper left pulmonary veins is sometimes hard to accomplish. For ease of access the ablation can be performed through the resected left atrial appendage. In fact the complete lesion pattern was performed in all patients. During our study, the newly designed Flex 4 probe came to the market; it has a smart, malleable tip, which is promising for the future. The antenna and the shaft of this catheter can be bent as needed, simplifying the Maze procedure as with the radiofrequency pen.

Despite these differences between the two energy forms, we found similar success rates in terms of SR conversion rate. Our observed rates of freedom from AF of 80 and 81.2%, respectively, are consistent with other publications [5,14,15]. When looking at a subgroup of patients who underwent isolated mitral valve surgery alone, the success rate was 92%. Although this finding is very limited because of the small numbers, it may suggest that patients undergoing isolated mitral valve surgery yield almost similar results with the Maze procedure compared to Cox reports [2].

As reported in the literature [5], all our patients were either in SR or electrically paced immediately after surgery. Like others we observed, early atrial arrhythmias occurred
within the first weeks postoperatively. The majority of these events responded to antiarrhythmic therapy and seemed to diminish when the healing process was completed. Cox speculated [1] that the inflammatory response and healing process may account for the early occurrence of atrial arrhythmias.

One possible complication during the Maze procedure is the production of AV-bloc. The incidence in our series was 13.6 and 10.5% in groups I and II, respectively, which was considerably higher than in the literature. Although some papers reported the need for PM implantation up to 25%, the incidence is mostly between 6 and 7% [15,16,21,23]. The reason for our high proportion of AV-blocs is unclear, but is definitely related to the lesion lines, which may have been too close to the AV node. The difference between the groups was not significant, but may be due to the fact that we eagerly took care of the AV node after the first observations of this complication.

Besides the restoration of SR, the aim of AF surgery is reestablishment of atrial transport function. This goal was achieved only in 33 and 50% of our patients for bivariate and right atrial contraction, respectively. Throughout the literature, data given vary widely between 30 and 91% for right atrial contraction, respectively. Throughout the literature, data given vary widely between 30 and 91% for right atrial contraction, respectively. Throughout the literature, data given vary widely between 30 and 91% for right atrial contraction, respectively. Throughout the literature, data given vary widely between 30 and 91% for right atrial contraction, respectively. Throughout the literature, data given vary widely between 30 and 91% for right atrial contraction, respectively. Furthermore, there might be another explanation for our success rate in terms of transport function [17]. Therefore, Cox suggested using transesophageal echo as a screening test only.

If this holds true, we probably underestimated the occurrence of left atrial contractile function in our patients. Furthermore, there might be another explanation for our results. In our own series, we were very liberal from the very beginning in terms of inclusion criteria. We accepted any patient with chronic AF for the Maze procedure, even those requiring double or triple valve procedures or patients with a long history of AF and huge left atria. This is in contrast to most published papers. Only 9 and 8 patients in groups I and II, respectively, presented with isolated mitral valve pathology, which is the main or sole patient cohort in most studies.

Secondly, our patients presented with much higher diameter (69 and 74 mm, groups I and II) of the left atrium preoperatively compared to most studies [3–6,14,15, 18–24], in which the left atrial diameter was 50–60 mm. Interestingly, we observed similar success rates in terms of freedom from AF. However, the poor outcome with respect to contractility may rely on this fact as well. We can only speculate on this, since our patient cohort is too small to analyse this aspect in subgroups. Nonetheless, these findings suggest that patients with excessively large atria might regain SR, but not atrial transport function. This is in accordance with Itoh and colleagues [25], who emphasised that for the original Cox Maze operation left atrial dilatation seems to have negative effects on atrial contraction.

In conclusion, microwave and radiofrequency ablation yield similar results in terms of restoration of SR. Even patients with more complex double or triple valve procedures benefit from the Maze procedure with regard to freedom from AF. Nevertheless, further investigations have to clarify the impact of atrial size in this subset of patients upon the reestablishment of atrial transport function.

References


Appendix A. Conference discussion

Dr L. Bockeria (Moscow, Russia): In case we have such results, overall success about 80%, why should we return to a classical Maze procedure, which gives better results? How do you think about that?

Dr Wisser: I think we should not return to the classical Cox Maze, because the traditional Cox Maze procedure is very complex and I would hesitate to offer it to a patient undergoing triple valve surgery, adding, at least in our hands, approximately one hour additional cross clamp time to the patient.

Dr F. Mohr (Leipzig, Germany): So which is your preferred technique now? We want to learn a lesson from you.

Dr Wisser: Well, in fact, as everyone else, we are changing our protocols towards a left atrial approach. We are more and more doing left atrial Mazes only. In patients undergoing only an aortic valve procedure, for instance, I think there is no reason left to perform a real biatrial Maze procedure we did in our series here.

Dr M. Albreht (Lafayette, Colorado): Would you mind commenting on the similar end point result of an 80% success rate after a year comparing left atrial versus biatrial radio ablation?

Dr Wisser: I cannot comment on that as regard to our series, because our series consisted of patients who underwent all biatrial ablation, and the left atrials I just alluded to have been done by microwave ablation so far. This is why I have no personal data on radiofrequency ablation of the left side only which could be compared with the presented series.