Surgical treatment of atrial fibrillation using radiofrequency ablation
Khargi, K.

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Irrigated radiofrequency ablation is a safe and effective technique to treat chronic atrial fibrillation; a cohort study comprising 124 consecutive patients

Krishna Khargi†, Thomas Deneke††, Frank Kuschkowitz†, Helmut Haardt†, Klaus-Michael Müller†‡, Bernd Lemke††, Axel Laczkovics†.

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† Department of Cardiothoracic Surgery, Berufsgenossenschaftliche Kliniken Bergmannsheil-University Hospital Bochum, Germany.
†* Department of Cardiology, Berufsgenossenschaftliche Kliniken Bergmannsheil-University Hospital Bochum, Germany.
‡ Department of Pathology, Berufsgenossenschaftliche Kliniken Bergmannsheil-University Hospital Bochum, Germany.
IRRIGATED RADIOFREQUENCY ABLATION IS A SAFE AND EFFECTIVE TECHNIQUE TO TREAT CHRONIC ATRIAL FIBRILLATION; A COHORT STUDY COMPRISING 124 CONSECUTIVE PATIENTS

Work in progress report - Arrhythmia

Irrigated radiofrequency ablation is a safe and effective technique to treat chronic atrial fibrillation

Krishna Khargi a,⁎, Thomas Deneke b, Bernd Lemke b, Axel Laczkovics a

a Department of Cardiothoracic Surgery, Berufsgenossenschaftliche Kliniken Bergmannsheil-University Hospital, Bochum, Germany
b Department of Cardiology, Berufsgenossenschaftliche Kliniken Bergmannsheil-University Hospital, Bochum, Germany

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Objective: The safety of intraoperative non-irrigated temperature-controlled radiofrequency ablation to treat atrial fibrillation is a matter of debate. This study evaluates a different operative technique using saline-irrigated-cooled-tip radiofrequency ablation (SICTRA) to treat atrial fibrillation.

Patients and methods: One hundred and twenty-four concomitant anti-arrhythmic procedures, using SICTRA were performed: 113 to treat chronic AF (>6 months) and 11 to cure paroxysmal AF.

Results: Twenty-eight MVP, 42 MVR, 17 AVR and six double valve procedures with or without CABG, one ASD closure and 30 solitary CABG were performed. The mean (S.D.) left atrial diameter, preoperative duration of AF, aortic cross-clamp time were 50.5 mm (9.8), 57 months (64) and 99 min (21). Thirty day mortality was 4.8% (6/124; euroscore 17.1, 11.8, 8.8, 6.6, 6). Autopsies did not reveal any esophageal, pulmonary orifice, or circumflex artery injuries. No ablation related bleeding was observed. Mean follow-up (S.D.) was 19.7 months (14.4). Fourteen patients died during follow-up. The cumulative postoperative SR at 6 and 12 months was 60% and 70%. The cumulative survival at 1 and 2 years was 86% and 83%. Conclusion: Irrigated radiofrequency ablation was effective. It was not associated with procedural complications in our series.

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Keywords: Arrhythmia; Electrophysiology; Radiofrequency ablation; Atrial fibrillation; Esophageal injury; Circumflex artery injury; Mitral valve surgery; CABG

1. Introduction

The operative technique using a temperature-controlled, non-irrigated radiofrequency ablation to treat atrial fibrillation has been reported to be associated with atrio-esophageal and circumflex artery injuries [1,2,3]. In our center a different type of energy source, as proposed by Sie and colleagues [4], was used to treat atrial fibrillation, namely the saline-irrigated, cooled-tip radiofrequency ablation (SICTRA). This study evaluates the safety and effectiveness of SICTRA.

2. Patients and methods

Between April 1997 and March 2002, 113 valve and/or CABG patients with chronic AF, preexisting longer than 6 months, and 11 patients with paroxysmal AF had a concomitant anti-arrhythmic surgery. Each patient had a preoperative standard ECG, a 24-h Holter registration and a transthoracic echocardiography. On admission to our hospital, each patient had an extended ECG recording of the V2 and II leads. If an episode of saw-toothed atrial wave pattern or an episode of regularity was observed on this recording, then a bi-atrial SICTRA lesion pattern was conducted. Otherwise a left atrial lesion pattern was performed only. All patients with paroxysmal AF had a sole left atrial lesion pattern. Our technique has been previously described [5,6].

2.1. Postoperative care

Patients were kept on AAI or DDD pacing if the heart rate was below 75 bpm during the first 7 postoperative days. The first 28 patients received metoprolol 40 mg twice a day on
the 1st postoperative day (pod), 80 mg twice a day on the 2nd pod and 160 mg twice a day after the 7th pod. This medication protocol was changed after the 28th patient, because two patients experienced a sudden cardiac death during follow-up. We changed to metoprolol 47.5 mg per day starting on the 1st pod. The dose was increased to 95 mg retard per day on the 3rd postoperative day and eventually to 190 mg per day if no bradycardia was noticed. The first 50 patients had a cardioversion at the 12th pod and the 3rd postoperative month. However, this strategy was abandoned because no beneficial effect, in our opinion, was noticed. Therefore, no cardioversion was performed before the 6th postoperative month in the last 74 patients. If the patient remained in AF after the 6th postoperative month, then one cardioversion with 240–360 J was performed. All patients received coumadine, starting on the 1st pod, targeting an INR value around 2.2 for solitary CABG patients and 2.8–3.2 for valve patients.

### 2.2. Follow-up

Data acquisition was obtained for each patient on the 1st pod, 12th pod (pre-discharge) and after the 3rd, 6th, 9th, 12th and 24th postoperative month. The medical history, clinical examination and an electrocardiogram (ECG) were obtained at each visit. A 24-h ECG analysis was performed after 3, 6 and 12 months. A transthoracic echocardiography, including transmural and transtricuspidal Doppler examination, was obtained on the 12th pod, after 3, 6 and 12 months. Survival information was complete. Continuous variables were expressed as mean with standard deviation. The survival rate was calculated according to the Kaplan–Meier method. The cumulative postoperative SR rate was calculated.

### 3. Results

Patients with chronic AF \((n = 113)\) had a mean (S.D.) age, euroscore, duration of preoperative AF, left atrial diameter (S.D.), left ventricular ejection fraction of 66.3 years (10.2), 6.4 euroscore (3.1), 57 months (64), 50.0 mm (9.8), 58% \([14]\). The operative data of all 124 patients are shown in Table 2. A left atrial lesion pattern was performed in 55 patients, while 69 patients had a bi-atrial lesion pattern. Our 30-day mortality was 4.8% \((6/124)\), as shown in Table 2. At autopsies no esophageal, pulmonary orifice or circumflex artery injuries were observed.

Postoperative complications included a transient low cardiac output 3.2% \((4/124)\), pulmonary infection or atelectasis 6.5% \((8/124)\), pneumothorax with drainage 1.6% \((2/124)\), sternal dehiscence 4.0% \((5/124)\), IABP 0.8% \((1/124)\), transient ischemic neurological attack 0.8% \((1/124)\). Postoperative bleeding occurred in 3.2% \((4/124)\). The bleeding sites were a right atrial suture line \((n = 2)\), a venous cannulation site and a left auricle wall artery. During follow-up 14 patients died, as shown in Table 3.

The overall cumulative postoperative SR rate is shown in Fig. 1.

Fig. 2 provides the cumulative SR rates of patients with preexisting chronic AF analyzed according to the bi-atrial \((n = 69)\) and left atrial \((n = 44)\) lesion pattern. All 11 patients with paroxysmal AF were in SR during their evaluation visits.

At 3 months 64 patients showed a stable SR, defined as 95–100% SR at Holter ECG. A bi-atrial contraction was observed in 44 \((69\%)\) patients, a right atrial contraction in 14 patients \((22\%)\), no atrial contraction in six \((9\%)\) patients. At 6 months 72 patients were in a stable SR, defined as 95–100% SR at 24-h Holter ECG. A bi-atrial contraction was observed in 61 \((85\%)\) patients, a right atrial contraction in eight \((11\%)\) patients, no atrial contraction in three \((4\%)\) patients. At 12 months 74 patients were in SR with similar distribution.

### Table 2

<table>
<thead>
<tr>
<th>Type of AF</th>
<th>Operation</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic</td>
<td>AVR + CABG</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>AVR + MVP + TVP + CABG</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td>Chronic</td>
<td>AVR + CABG</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td></td>
<td>MVP + CABG</td>
<td>Cardiac failure</td>
</tr>
<tr>
<td></td>
<td>CABG</td>
<td>Cerebral stroke</td>
</tr>
<tr>
<td></td>
<td>MVR + CABG</td>
<td>Atrioventricular dehiscence</td>
</tr>
</tbody>
</table>

* Abbreviations: MVP, mitral valve plasty; AVR, aortic valve replacement; E.C.C., extracorporeal circulation; AoX, aortic cross-clamp time.

### Table 1

<table>
<thead>
<tr>
<th>Operation</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVR + CABG</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td>AVR + MVP + TVP + CABG</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td>AVR</td>
<td>Low cardiac output</td>
</tr>
<tr>
<td>MVP + CABG</td>
<td>Cardiac failure</td>
</tr>
<tr>
<td>CABG</td>
<td>Cerebral stroke</td>
</tr>
<tr>
<td>MVR + CABG</td>
<td>Atrioventricular dehiscence</td>
</tr>
</tbody>
</table>

* Abbreviations: MVR, mitral valve replacement; MVP, mitral valve plasty; AVR, aortic valve replacement; euro, euroscore; Pt, patient's initials; LVEF, left ventricular ejection fraction.
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Table 3

Death during follow-up

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age (years)</th>
<th>LVEF (%)</th>
<th>Operation</th>
<th>Rhythm</th>
<th>Cause of death</th>
<th>Follow-up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>67</td>
<td>35</td>
<td>MVR + CABG</td>
<td>SR</td>
<td>Cardiac failure</td>
<td>1.2</td>
</tr>
<tr>
<td>GE</td>
<td>73</td>
<td>63</td>
<td>MVR + CABG</td>
<td>SR</td>
<td>Gastrointestinal bleeding with gastrectomy</td>
<td>1.3</td>
</tr>
<tr>
<td>KW</td>
<td>73</td>
<td>60</td>
<td>MVR</td>
<td>AF</td>
<td>Sudden cardiac death</td>
<td>1.5</td>
</tr>
<tr>
<td>NH</td>
<td>56</td>
<td>65</td>
<td>CABG</td>
<td>SR</td>
<td>Cerebral stroke</td>
<td>1.6</td>
</tr>
<tr>
<td>BE</td>
<td>75</td>
<td>65</td>
<td>MVR + CABG</td>
<td>SR</td>
<td>Mediastinitis</td>
<td>2.0</td>
</tr>
<tr>
<td>DA</td>
<td>49</td>
<td>56</td>
<td>MVR</td>
<td>SR</td>
<td>Renal bleeding, Nephrectomy</td>
<td>2.5</td>
</tr>
<tr>
<td>KJ</td>
<td>75</td>
<td>55</td>
<td>MVR + CABG</td>
<td>SR</td>
<td>Mediastinitis</td>
<td>2.6</td>
</tr>
<tr>
<td>RE</td>
<td>74</td>
<td>85</td>
<td>AVR</td>
<td>SR</td>
<td>Endocarditis</td>
<td>4.0</td>
</tr>
<tr>
<td>JE</td>
<td>80</td>
<td>40</td>
<td>AVR</td>
<td>SR</td>
<td>Sudden Cardiac death</td>
<td>5.0</td>
</tr>
<tr>
<td>PE</td>
<td>74</td>
<td>70</td>
<td>AVR</td>
<td>SR</td>
<td>COPD</td>
<td>8.9</td>
</tr>
<tr>
<td>DH</td>
<td>70</td>
<td>60</td>
<td>MVR</td>
<td>SR</td>
<td>COPD</td>
<td>15.7</td>
</tr>
<tr>
<td>SK</td>
<td>59</td>
<td>60</td>
<td>MVR</td>
<td>SR</td>
<td>COPD</td>
<td>22.5</td>
</tr>
<tr>
<td>MW</td>
<td>73</td>
<td>60</td>
<td>CABG</td>
<td>flutter</td>
<td>Unknown</td>
<td>32.8</td>
</tr>
<tr>
<td>RG</td>
<td>61</td>
<td>60</td>
<td>MVR</td>
<td>AF</td>
<td>COPD</td>
<td></td>
</tr>
</tbody>
</table>

* Abbreviations: MVR, mitral valve replacement; AVR, aortic valve replacement; Pt, patient’s initials; LVEF, left ventricular ejection fraction.

4. Discussion

4.1. Morbidity

In our series the incidence of postoperative complications were within the expected range. Postoperative bleeding was never related to a radiofrequency ablation line. During follow-up not a single patient showed signs or symptoms, which were associated with an esophageal or circumflex artery or pulmonary vein orifice injury. In contrast, Mohr and associates, who surgically treated atrial fibrillation in 234 patients, reported an incidence of an atrio–esophageal fistula in 1.3 % (3/234) and a circumflex artery stenosis in 0.4% (1/234) [1]. Gillinov and colleagues reported a fatal esophageal injury in a cachectic female patient [3].

A clear explanation for the discrepancy in observation of esophageal and circumflex injuries in our series and that from Mohr, Gillinov and colleagues cannot be provided. Nevertheless, important differences in operative techniques, ablation devices and lesion patterns can be distinguished. Mohr performed 133 right lateral minithoracotomies, whereas all our patients had a standard sternotomy. We dissected the left atrium free from its adjacent structures before the ablation was started. The left atrial roof was freed from the right pulmonary artery and the superior caval vein. The transverse and oblique sinuses were opened. Therefore, the heart was fully mobilized within its pericardial sac. Mohr used a 10-mm T-shaped, temperature-controlled, non-irrigated radiofrequency ablation probe targeting a temperature of 60 °C for 20 s for each lesion without taking the variability of the local atrial wall thickness into account. The probe was fixed and pressed against the atrial wall during the application [6]. Gillinov used an even higher temperature (80 °C) and a longer application time (60 s) [3]. We used a SICTRA catheter, which was a hand-held, flexible, pen-catheter that enabled the surgeon to match the delivered amount of radiofrequency energy to the estimated atrial wall thickness, creating a conduction block without

Cumulative SR Rate

n=113

Fig. 1. Postoperative cumulative frequencies of SR of patients with preexisting chronic AF. (Y-axis, cumulative frequency; X-axis, postoperative months).
any tissue dehiscence. The formation of yellow-white blistering endocard lesions, induced by oscillating catheter movements, was considered sufficient. Stable catheter–tissue contact was preserved without pressing the atrial wall against adjacent mediastinal structures. We performed circumferential lesions around each pulmonary vein orifice, without ever entering any of these orifices. The left auricle was always resected or closed from inside.

Williams and colleagues used a flexible, temperature-controlled radiofrequency ablation catheter in 48 patients. In contrast to the series of Mohr and associates a standard sternotomy was always performed [7]. Although Williams targeted a higher temperature level, 70–80 °C, and a longer application time of 1 min per lesion than Mohr and associates did, they did not report any esophageal or circumflex injuries, nor did Benussi, Melo, Sie and colleagues [4,8,9].

4.2. Mortality

No mortality was observed in the subset patients group who had mitral valve surgery alone. Indication and selection in high risk patients, necessitating combined surgical procedures, should be tailored carefully, since an increase of the postoperative morbidity and mortality can be anticipated. Nevertheless, the potential benefit of restoring SR with atrial contraction in high-risk patients can be significant because an improved left ventricular diastolic volume filling can be expected.

Since the occurrence of two sudden cardiac deaths (patients K.W., P.E.), our postoperative medication was changed from sotalol to metoprolol. We felt that bradyarrhythmias, induced by sotalol, could be the cause of death, although no clear documented evidence was available. However, up until now none of the metoprolol patients experienced any sudden cardiac death.

4.3. Sinus rhythm

In our series, the cumulative postoperative SR rate at 6 and 12 months was 60% and 70%. Our series includes patients with chronic atrial fibrillation with a mean duration of 57 months. All our patients had a concomitant valve and/or CABG procedure. Atrial fibrillation was never the primary indication for operation. Patients with paroxysmal AF were excluded from our analysis. Therefore, our group of patients is not similar to those reported by Cox, Schaff and Millar and associates [10,11,12].

Our observed postoperative SR rate is consistent with publications of Mohr, Benussi, Williams and Sie, who reported a SR rate between 66.7% and 81%.

The gradual increase of the SR conversion rate in our series, starting from 32% immediate postoperatively to 70% after 12 months is consistent with our previous observations [5,6]. Cox also described the occurrence of AF in the early postoperative period in 47% of his patients. This was related to the temporarily shortened refractory time during the early weeks postoperatively. In addition to that, Pasic and colleagues reported that the improvement of the sinus node function and atrial contraction was related to the functional reinnervation and recovery of the autonomic nervous system, which could take up to 1 year after operation [13,14].

4.4. Failures

At 6 months 34 patients remained in AF. Cardioversion was successful, determined as SR at next follow-up visit in only two patients. The actual failure rate in our series was 32% (36/113); a flutter in 3.5% (4/113) and atrial fibrillation in 28% (32/113). Two potential causes of these failures should be considered: (1) a non-transmural intra-atrial lesion due to an inadequate ablation line; and (2) an inadequate lesion pattern.
The atrial flutter may have two important origins: the isthmus in the right atrium or a preserved conduction line between the left and right atrium through the coronary sinus. Three patients needed a percutaneous arrhythmia corrective reintervention because of a right atrial flutter \((n = 2)\) and a left atrial flutter \((n = 1)\). The right atrial flutters could be ablated successfully, while the left atrial flutter was treated with AV node ablation and DDD pacemaker implantation.

In summary, a concomitant anti-arrhythmic surgical procedure using SICTRA obviously extended the operative procedure, however, without inducing any disproportionate morbidity or mortality. SICTRA resulted in a significant SR conversion rate in our series, which consisted of high-risk patients with a mean euroscore of 6.4, in whom curative treatment of chronic AF was a challenging objective. No SICTRA procedural complications were observed.

Acknowledgements

The cooperation and support of Frank Kuschkowitz, cardiothoracic surgical resident, Helmut Haardt, perfusionist and Klaus-Michael Müller pathologist is greatly appreciated.

References


Appendix A. ICVTS on-line discussion

Author: Leo Rockeria, Bakoulev Center for Cardiovascular Surgery, 135 Roudniskyye shose, Moscow 121552, Russian Federation

Date: 10-Jun-2003 15:06

Message: I have read the paper with great interest and would like to congratulate the excellent results of surgical treatment of chronic AF using SICTRA technique in patients with concomitant valve and/or CABG procedure. Complications and deaths occurred in the group of the most severe patients. The present method is especially useful for patients having mitral valve surgery alone, or combined with aortic valve replacement while using minimal invasive surgery when Maze III procedure is technically impossible.

It is doubtless that for different groups of researchers the studied groups of patients differ noticeably. This is especially true about electrophysiological properties of the atria, the length of the history of paroxysms of AF and their transfer into chronic AF, anatomy of the left atrium, the degree of straining of the posterior wall of the left atrium and the degree of fibrosis in atria.

It is difficult to expect excellent results in the group of patients having advanced mitral valve stenosis, long history of atrial tachycardia, as well as advanced atrial dilatation and cardiomyopathy, if both Maze procedure removal of appendage of left atrium and plication of a left posterior wall and left and right ishimum blocks are not used.

In the Bakoulev Institute for Cardiovascular Surgery one of us (L.A. Rockerlia) has been treating AF surgically since the middle of the 1980s, starting with the cryosurgical ablation of the aortia of pulmonary vein and isolation of left atrium, advancing to Maze procedure and its modification (total 188 pts). Starting in 1992, patients with paroxysmal AF had Maze procedure. This procedure has been later modified at our institute. We started using a combination of laser fotoablalion or cryosbalabion in the left atrium and near the atrioventricular rings and surgical dissection in the right atrium and atria appendages. The best results (87% of SR and 82% of preservation of atria transport function) were received in the group of middle-aged patients having AF (34 pts). At present, patients with AF have bilateral isolation of pulmonary vein and left ishimum block. Patients with chronic AF (6 months and more) having enlargement of atria have a modified Maze procedure with and plication of a left atrium posterior wall and left ishimum block. We have used cooled RFA for open heart surgery since 1997. However, because of different thickness of the atrial wall in various zones, we have to use additional cryosurgical ablation in critical zones. Like you we have had no complications connected with cooled RFA. We believe, that patients having severe atrial hypertrophy can not be treated with conventional RFA, while cooled RFA in these cases must also be supplemented by cryoablation in critical zones.