Concomitant anti-arrhythmic surgery, using irrigated cooled-tip radiofrequency ablation, to treat permanent atrial fibrillation in CABG patients: expansion of the indication?

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Abstract

Objectives: The effectiveness of a concomitant anti-arrhythmic surgical procedure in coronary artery bypass grafting (CABG) patients with permanent atrial fibrillation (AF) was evaluated. Methods: This prospective study included 36 CABG patients, who had a concomitant anti-arrhythmic procedure using irrigated cooled-tip radiofrequency ablation. Follow-up included a 24 h EKG and ultrasound examination at 3, 6, 12 months. Results: Mean (SD) age was 68.7 years (8.0), left atrial diameter 44.9 mm (6.7), preoperative duration of AF 67 months (73), left ventricular ejection fraction 54% (14), euroscore 5.5 (2.6), number of distal anastomoses 3.3 (1.2), aortic cross-clamp time 90 (19) min, extracorporeal bypass time 156 (38) min. Thirty-day mortality was 2.8% (1/36). Mean (SD) follow-up was 25.3 months (17.9). Cumulative survival rates (SE) at 12 and 24 months were 0.94 (0.04) and 0.90 (0.06). Cumulative postoperative sinus rhythm (SR) rates (SE) at 6 and 12 months were 0.60 (0.08) and 0.75 (0.08). Restored bi-atrial contraction occurred in 73% (19/26) of all SR patients. As a consequence coumadine was stopped, after the 6th postoperative month, in 76% (16/21) in this subset of patients, corresponding with 44% (16/36) of all study group patients. One patient experienced a sick sinus syndrome 12 months postoperatively, for which a DDD pacemaker was implanted. Three out of five patients with a preexistent VVI pacemaker regained a stable postoperative SR with bi-atrial contraction, obviating the need of any pacemaker support.

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1. Introduction

The benefit of a concomitant anti-arrhythmic surgical procedure to treat permanent atrial fibrillation (AF) in coronary artery diseased patients is unknown. The maze procedure, as described by Cox and colleagues, is predominantly combined with mitral valve surgery and has proven to be effective in abolishing AF [1–3]. Damiano and associates, recently, described their results in 47 coronary arterial bypass grafting (CABG) patients with paroxysmal or persistent AF [4]. Nevertheless, this technique and its modifications are infrequently combined with a solitary CABG, because the atria have to be opened intentionally to perform the various intraatrial lesions. Whether an extension of the operative procedure to treat AF, in this subset of patients, is justified will eventually be determined by the induced additional morbidity and mortality, balanced against the success of the obtained sinus rhythm (SR) conversion rate. Therefore, simplifying the operative technique, without compromising the SR conversion rate, is important. This can be obtained by using the saline irrigated cooled-tip radiofrequency ablation (SICTRA) to create intraatrial functional lesions [5,6].

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1 Krishna Khargi, author of this manuscript, has an education and training agreement on the surgical treatment of atrial fibrillation with Medtronic Europe SA, since 15 November 2001.
The aim of this study was to assess whether concomitant anti-arrhythmic surgery, using SICTRA, in CABG patients proved to be safe, effective and beneficial.

2. Patients and methods

This study was approved by the local ethical committee. From 1998 till 2003 4015 isolated CABG procedures were performed in our institution. Permanent AF was observed in 65 patients. Preoperative signs of unstable angina, shock, cardiac failure and the indication for additional surgical procedures were exclusion criteria. Only patients in whom an informed consent could be obtained were included in this study. Thirty-six CABG patients with permanent AF and coronary artery disease had a CABG with either a left atrial (n = 21) or a bi-atrial SICTRA lesion pattern (n = 15). Each patient had a preoperative standard ECG and 24 h Holter registration. If an AF with a distinct atrial flutter pattern was observed than a bi-atrial SICTRA lesion pattern was pursued, otherwise only a left atrial lesion pattern performed. Our technique has been described in detail previously [6]. Fig. 1A–C summaries the right and left ablation patterns.

2.1. Postoperative care

The patients were kept on AAI or DDD pacing if the heart rate was lower than 75 beats per minute during the first 7 postoperative days. Metoprolol 47.5 mg per day was started on the 1st postoperative day (pod). The dose was increased to 95 mg retard per day on the 3rd pod and eventually to 190 mg per day if no bradyarrhythmia was noticed. No cardioversion was attempted before the 6th postoperative month. If a patient remained in AF after the 6th postoperative month, than one cardioversion with 240–360 J was performed. All patients received coumadine, started on the 1st pod, targeting an INR value between 2.2 and 2.5.

2.2. Follow-up

Data acquisition was obtained for each patient on the 1st pod, 12th pod (pre-discharge) after the 3rd, 6th and 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.

2.3. Statistic analysis

Continuous variables were compared with the Student’s t-test. The binary logistic regression was used to assess
predictors of postoperative SR. Categorical data comparisons were made with the Fisher exact test. The cumulative survival and the postoperative SR rates were calculated according to the Kaplan–Meier method. Differences were calculated with the log-rank test. \( P \) values < 0.05 were considered significant.

3. Results

The mean (SD) number of distal anastomoses was 3.3 (1.2), aortic cross-clamp time 90 (19) min, extracorporeal bypass time 156 (38) min, 30-day mortality 2.8% (1/36). The mean (SD) follow-up was 25.3 months (17.9) (Table 1). Patient’s characteristics and operative data for the left and bi-atrial lesion pattern were similar except for the extracorporeal circulatory time (Table 2). No predictors of postoperative SR could be determined (Table 3). No relationship could be determined between the type of lesion pattern and the occurrence of postoperative SR (Fisher exact test, \( P = 0.71 \)). Cumulative postoperative SR rates (SE) at 6 and 12 months were 0.60 (0.08) and 0.75 (0.08) (Fig. 2A). The cumulative postoperative SR rate at 12 months, specified for the left and bi-atrial anti-arrhythmic procedure, were 0.80 and 0.68 (\( P = 0.17 \); Fig. 2B).

Restored bi-atrial contraction occurred in 73% (19/26) of all patients in SR. Coumadine was stopped, after the 6th postoperative month, in 76% (16/21) of the SR patients, who had a minimal follow-up of 6 months. This corresponded with 44% (16/36) of all study group patients. A single right atrial contraction was observed in 8% (2/26), while 19% (7/36) of all study group patients. A single right atrial contraction was observed in 8% (2/26), while 19% (7/36) of all study group patients. A single right atrial contraction was observed in 8% (2/26), while 19% (7/36) of all study group patients.

One patient (patient SR) experienced a sick sinus syndrome 12 months postoperatively and consequently had a DDD pacemaker implanted. Three patients (WG, RH, KC; Table 1) out of five patients (WG, RH, KC, MW, BJ; Table 1) with a preexistent VVI pacemaker regained a stable SR conversion rate without causing any major morbidity or mortality. The SICTRA treatment in this subset of patients was associated with an acceptable SR conversion rate without causing any major morbidity or mortality.

3.1. Morbidity and mortality

Six patients experienced a postoperative pulmonary complication; a transient respiratory insufficiency due to atelectases (\( n = 3 \)), pleural effusions with drainages (\( n = 2 \)) and a pneumonia (\( n = 1 \)). Nevertheless, all patients were extubated before the 2nd pod. A postoperative myocardial infarction with a transient low cardiac output syndrome, due to a ramus descending posterior venous graft occlusion, occurred in one patient (MW). A sternal dehiscence, necessitating refixation, occurred in two patients (SR, SH).

A postoperative bleeding with rethoracotomy was performed in one patient (KH). All these complications could be treated successfully. The hospital stay was extended with a mean 1.5 days for these patients.

One patient (SW) died 4 days postoperatively due to a massive cerebral stroke due to a severe atherosclerotic calcified ascending aorta. Autopsy did not show any SICTRA-related complications. During follow-up two patients died after 1.6 and 22.5 months; a cerebral vascular accident (Patient NH) and an unknown cause (MW). Patient MW had a flutter at 6 months, which could not be cardioverted.

4. Discussion

Damiano and associates reported their results in 28 CABG patients with paroxysmal AF and 17 CABG patients with persistent AF. This study focused on CABG patients with documented permanent AF. The aim of the study was to assess whether an additional arrhythmia surgical procedure, using SICTRA, in CABG patients proved to be safe and effective. The SICTRA treatment in this subset of patients was associated with an acceptable SR conversion rate without causing any major morbidity or mortality.

4.1. Sinus rhythm

In this series, the cumulative postoperative SR percentages at 3, 6 and 12 months were 28, 60 and 75%. The gradual increase of the SR conversion rate, in this series, starting from 28% immediate postoperatively to 75% after 12 months is consistent with our previous observation in the mitral valve patients who also had a SICTRA treatment [6]. The increase of the SR rate occurred due to spontaneous SR conversions over time. Only one patient (Patient KE) had a successful cardioversion after 6 months. A potential explanation of the spontaneous cardioversion is that the temporarily shortening of the refractory time of the atrial tissue, in the immediate postoperative period, disappears during follow-up. This shortening of the refractory time is caused by the surgical trauma causing edema and inflammation, and by the elevated catecholamine levels. Therefore, multiple wavelet re-entrant circuits can still persist during the early postoperative period. When the refractory time lengthens then the re-entrant circuits will extinguish themselves [2]. Another explanation is the re-innervation of the autonomous nervous system, which contributes to the sinus node vitality [7].

Damiano reported a 98% freedom of AF at a mean follow-up of 5.7 ± 3.3 years in a different subset of 47 CABG patients who had paroxysmal or persistent AF [4].
| Pt | Age | LA | Dur | PM | EF | Euro | Byp | LP | Dth | Fu | Occ. SR | SR | A wave | Remarks | An | Ao-X | ECC | Complication |
|----|-----|----|-----|----|----|------|-----|----|-----|----|--------|----|---------|----------|----|-----|-----|--------------|
| SW | 73  | 50 | 132 | 15 | 11 | 5    | L   | y  | 0.1 | 0.1 | 1      | R – L – | Marc   | 123 | 209 | CVA |
| TT | 73  | 48 | 3   | 65 | 6  | 5    | L   | y  | 0.1 | 0.1 | 1      | R + L + | Marc   | 75  | 105 |
| NH | 76  | 45 | 53  | 65 | 3  | 3    | L/R | y  | 1.6 | 1   | 1      | R – L – | Marc   | 88  | 160 |
| WW | 77  | 46 | 18  | 55 | 4  | 5    | L   | y  | 2.5 | 0.25| 1      | R + L + | Marc   | 90  | 157 | Pneumonia |
| BJ | 79  | 50 | 6   | 40 | 5  | 2    | L   | y  | 3.2 | 0.25| 1      | R + L + | Marc   | 73  | 139 | Pleural effusion |
| KN | 71  | 45 | 60  | 45 | 6  | 2    | L/R | y  | 10.1| 1   | 1      | R + L + | ASS    | 84  | 152 |
| LH | 70  | 44 | 168 | 35 | 7  | 4    | L/R | y  | 12.0| 1   | 1      | R + L + | ASS    | 94  | 150 | Allergies |
| B1 | 81  | 36 | 120 | 25 | 11 | 4    | L/R | y  | 13.2| 0.25| 1      | R + L + | ASS    | 66  | 96  | Stenosis |
| SR | 63  | 48 | 24  | 37 | 4  | 1    | L   | y  | 13.8| 0.25| 1      | R + L + | ASS    | 99  | 162 | Atelectasis |
| PF | 73  | 55 | 7   | 65 | 7  | 5    | L/R | y  | 17.2| 12  | 1      | R – L – | ASS    | 116 | 181 | DVT |
| YY | 52  | 50 | 36  | 60 | 2  | 3    | L/R | y  | 17.2| 3   | 1      | R + L + | ASS    | 71  | 128 | |
| KA | 65  | 57 | 180 | 56 | 4  | 6    | L/R | y  | 22.6| 3   | 1      | R + L + | ASS    | 115 | 177 |
| WG | 80  | 45 | 24  | 65 | 7  | 5    | L   | y  | 23.3| 3   | 1      | R + L + | ASS    | 92  | 208 |
| SA | 66  | 42 | 120 | 50 | 5  | 4    | L/R | y  | 28.5| 3   | 1      | R + L + | ASS    | 92  | 208 |
| ZE | 75  | 40 | 66  | 55 | 6  | 5    | L/R | y  | 29.3| 3   | 1      | R – L – | ASS    | 91  | 173 |
| RH | 72  | 50 | 251 | 35 | 8  | 4    | L/R | y  | 31.4| 3   | 1      | R + L + | ASS    | 103 | 193 |
| HG | 72  | 32 | 6   | 40 | 9  | 5    | L   | y  | 32.5| 0.25| 1      | R + L + | ASS    | 88  | 124 |
| BM | 73  | 50 | 12  | 65 | 9  | 3    | L   | y  | 35.3| 0.25| 1      | R + L – | ASS    | 70  | 96  |
| LE | 72  | 43 | 60  | 75 | 6  | 5    | L/R | y  | 40.1| 7   | 1      | R + L + | ASS    | 107 | 153 |
| LF | 79  | 32 | 6   | 75 | 11 | 3    | L/R | y  | 40.2| 0.25| 1      | R + L + | ASS    | 122 | 171 |
| KW | 58  | 31 | 43  | 60 | 2  | 1    | L/R | y  | 40.3| 1   | 1      | R + L – | ASS    | 93  | 166 |
| HM | 54  | 51 | 6   | 45 | 3  | 1    | L   | y  | 41.0| 1   | 1      | R – L – | ASS    | 58  | 112 |
| KE | 68  | 36 | 12  | 67 | 5  | 4    | L/R | y  | 41.2| 6   | 1      | R + L + | ASS    | 103 | 168 |
| KC | 66  | 42 | 6   | 55 | 4  | 4    | L/R | y  | 47.7| 6   | 1      | R + L + | ASS    | 94  | 168 |
| GL | 59  | 57 | 12  | 70 | 4  | 2    | L/R | y  | 57.3| 3   | 1      | R + L + | ASS    | 91  | 181 |
| PW | 75  | 35 | 132 | 45 | 4  | 3    | L/R | y  | 58.9| 0.25| 1      | R + L + | ASS    | 111 | 274 |
| BL | 74  | 45 | 120 | 65 | 7  | 3    | L/R | y  | 0.8 | 0.25| 2      | R – L – | ASS    | 97  | 134 |
| RR | 66  | 41 | 6   | 50 | 3  | 3    | L/R | y  | 7.1 | 6   | 2      | R – L – | ASS    | 72  | 110 |
| TK | 75  | 53 | 108 | 60 | 8  | 3    | L/R | y  | 7.1 | 6   | 2      | R – L – | ASS    | 71  | 148 |
| SH | 55  | 40 | 240 | 60 | 5  | 2    | L/R | y  | 12.0| 12  | 2      | R – L – | ASS    | 66  | 152 |
| HM | 62  | 39 | 194 | 60 | 3  | 4    | L   | y  | 21.7| 12  | 2      | R – L – | ASS    | 102 | 146 |
| MW | 73  | 40 | 6   | 60 | 6  | 3    | L/R | y  | 22.5| 12  | 2      | R – L – | ASS    | 90  | 158 |
| BJ | 71  | 41 | 20  | 60 | 5  | 4    | L/R | y  | 26.3| 12  | 2      | R – L – | ASS    | 93  | 174 |
| KV | 55  | 50 | 6   | 45 | 2  | 3    | L/R | y  | 40.9| 12  | 2      | R – L – | ASS    | 120 | 183 |
| MS | 72  | 53 | 150 | 73 | 2  | 2    | L/R | y  | 52.5| 24  | 2      | R – L – | ASS    | 70  | 170 |
| MH | 70  | 48 | 12  | 45 | 3  | 3    | L/R | y  | 57.9| 24  | 2      | R – L – | ASS    | 101 | 190 |
| Mean | 68.7 | 44.9 | 67.4 | 53.9 | 5.5 | 3.3 | 25.3 | 89.7 | 156.1 |
| SD  | 8.0  | 6.7  | 73.3 | 14.0 | 2.6 | 1.2 | 17.9 | 18.6 | 37.5 |

Pt, patient; LA, left atrial diameter; Dur, preoperative duration of atrial fibrillation; EF (%), left ventricular ejection fraction (%); PM, preoperative pacemaker implantation; euro, euroscore; Byp, number of distal coronary artery anastomoses; LP, SICTRA lesion pattern performed in the atria; L, left atrium; L/R, left and right; Fu, follow-up; Occ. SR, occurrence of postoperative SR in months; Ao-X, aortic cross-clamp time in minutes; ECC, extracorporeal circulation time in minutes; A wave, A wave on echocardiogram; An, type of anticoagulation; Marc, marcoumar or coumadine; ASS, aspirin.
4.2. Atrial contraction

Restored bi-atrial contraction occurred in 73% (19/26) of all patients in SR, enabling to stop coumadine, after the 6th postoperative month, in 76% (16/21) of all SR patients who had a minimal follow-up of 6 months. Patients SW and NH (Table 1), who were in SR, died after 0.1 and 1.6 months postoperatively. Ausma, however, showed that the recurrent of atrial contraction after a successful cardioversion for AF was time dependant, since loss of contractile myofibrils impaired the immediate contraction [8]. The other five SR patients, who had a follow-up between 17.2 and 41 months, probably experienced an irreversible loss of atrial contractility. No predictors of failure could be determined (Table 4). Nevertheless, stopping coumadine medication in 44% of all study group patients is, in our opinion, a considerable advantage.

4.3. Pacemakers

Three (WG, RH, KC; Table 1) out of five patients (WG, RH, KC, MW, BJ; Table 1) with a pre-existent VVI pacemaker regained a stable postoperative SR with bi-atrial contraction, obviating the need of any pacemaker support. Coumadine could be stopped. All three patients preoperatively suffered from a bradycardiac permanent AF. The postoperative conversion into SR in this subset of patients is, in our opinion, beneficial. The two remaining patients did not reveal any atrial contraction; one patient (MW), who died 2 years postoperatively, suffered from a postoperative atrial flutter, which could not be cardioverted successfully and the other one (patient BJ) was still in AF.

One pacemaker implantation was performed, because of a sick sinus syndrome, which occurred 12 months postoperatively. Damiano revealed a 19% (9/47) postoperative pacemaker implantation [4].

Table 2
Patient’s characteristics: left versus bi-atrial lesion pattern

|                      | Left\(^a\) (n = 21) | Bi-atrial\(^a\) (n = 15) | P value |
|----------------------|---------------------|-------------------------|---------|
| Age (years)          | 69.6 (8.1)          | 67.5 (7.9)              | 0.43    |
| LA (mm)              | 43.7 (6.8)          | 46.5 (6.4)              | 0.21    |
| AF duration (months) | 53 (66)             | 102 (80)                | 0.07    |
| LVEF (%)             | 53 (16)             | 55 (12)                 | 0.74    |
| Euroscore            | 5.9 (2.9)           | 5.0 (2.0)               | 0.30    |
| Bypasses (number)    | 3.4 (1.4)           | 3.3 (1.0)               | 0.79    |
| Follow-up (months)   | 23.3 (16.6)         | 28.0 (19.9)             | 0.45    |
| Ao-X (min)           | 90 (21)             | 90 (15)                 | 0.98    |
| ECC (min)            | 141 (34)            | 177 (33)                | 0.003   |

LA, left atrial diameter; Ao-X, aortic cross-clamp time; ECC, extracorporeal circulation.

\(^a\) Mean values, SD in the brackets.

Table 3
Characteristics of patients and binary logistic regression analysis: SR versus AF

|                      | SR\(^a\) (n = 26) | AF\(^a\) (n = 10) | P value | BLR P value |
|----------------------|------------------|------------------|---------|-------------|
| Euroscore            | 6.0 (2.6)        | 4.4 (2.1)        | 0.10    | 0.06        |
| Age (years)          | 69.3 (8.2)       | 67.3 (7.5)       | 0.52    | 0.15        |
| LA (mm)              | 44.8 (7.2)       | 45.0 (5.6)       | 0.94    | 0.77        |
| Duration AF (months) | 60 (67)          | 86 (88)          | 0.35    | 0.13        |
| LVEF (%)             | 52 (15)          | 58 (9)           | 0.31    | 0.30        |
| Bypasses (number)    | 3.5 (1.4)        | 3.0 (0.7)        | 0.33    | 0.20        |
| Fu (months)          | 25.4 (17.6)      | 24.9 (19.7)      | 0.94    | 0.44        |
| Ao-X (min)           | 90 (19)          | 88 (18)          | 0.77    | 0.25        |
| ECC (min)            | 156 (42)         | 157 (24)         | 0.97    | 0.41        |
| Lesion pattern; left versus bi-atrial (number) | 16–10 | 5–5 | 0.46 |

LA, left atrial diameter; mm, millimeters; Fu, follow-up; Ao-X, aortic cross-clamp time; ECC, extracorporeal circulation; BLR, binary logistic regression analysis; SR versus AF.

\(^a\) Mean values, SD in the brackets.

Fig. 2. (A) Postoperative cumulative SR rate (y-axis, the cumulative SR rate; x-axis, postoperative months). (B) Postoperative cumulative SR rates according lesion pattern (y-axis, the cumulative frequency of SR; x-axis, postoperative months).

4.3. Pacemakers

Three (WG, RH, KC; Table 1) out of five patients (WG, RH, KC, MW, BJ; Table 1) with a pre-existent VVI pacemaker regained a stable postoperative SR with bi-atrial contraction, obviating the need of any pacemaker support. Coumadine could be stopped. All three patients preoperatively suffered from a bradycardiac permanent AF. The postoperative conversion into SR in this subset of patients is, in our opinion, beneficial. The two remaining patients did not reveal any atrial contraction; one patient (MW), who died 2 years postoperatively, suffered from a postoperative atrial flutter, which could not be cardioverted successfully and the other one (patient BJ) was still in AF.

One pacemaker implantation was performed, because of a sick sinus syndrome, which occurred 12 months postoperatively. Damiano revealed a 19% (9/47) postoperative pacemaker implantation [4].
4.4. Failures

Ten patients remained in AF (Table 1), but actual follow-up of patients BL, RR and TKH was limited to 0.8, 7.1 and 7.1 months. Especially patient BL might show a spontaneous SR over time. Five patients remained in a permanent AF and one patient had a flutter. No predictors of failure could be distinguished (Table 3). Especially the lesion pattern, left atrial diameter and duration of AF could not be determined as risk factors for failure, although these factors were presumed to be associated with a postoperative failure. Five AF patients had an unsuccessful cardioversion at 6 months, while two AF patients refused any cardioversion attempt, two AF patients still need to be cardioverted and one AF patient still has to complete his 6-month follow-up.

Two potential causes of postoperative permanent AF should be considered; first a non-transmural intraatrial lesion due to an inadequate ablation line, secondly an inadequate lesion pattern. A precise electrophysiological mapping of these patients was indicated, but not logistically feasible in our clinic at that time.

Patient MW had an atrial flutter. This 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. The patient refused any additional intervention.

4.5. Morbidity and mortality

The incidence of pulmonary complications, atelectasis, pleural effusion and pneumonia was 17% (6/36). This tended to be higher than normal, but still acceptable. The RDP venous graft occlusion occurred due to a technical failure on a poor severe atherosclerotic coronary artery. The size of infarction was limited, without compromising the overall left ventricular function. The sternal dehiscence complications (n = 2) were related to poor surgical chest closure in small patients with poor sternal bone quality. No signs of infection occurred. The postoperative bleeding (n = 1) was not related to a SICTRA lesion. Damiano reported a 27% (13/47) major postoperative complication rate including bleeding (n = 3), intraaortic balloon implantation (n = 2), prolonged mechanical ventilation (n = 2), mediastinitis (n = 1), renal failure (n = 1), myocardial infarct (n = 2), unspecified (n = 2).

Our previous publication reported an additional mean aortic cross-clamp time of 17 min in patients who had an anti-arrhythmic procedure in conjunction with mitral valve surgery [6]. In the CABG patients this time was doubled, because it was technically more demanding to get into the left atrium and do the various ablation lines, because the mean size of the left atrium in CABG patients was 14.9 mm smaller than in mitral valve diseased patients; 44.9 versus 59.8 mm [9]. Prolongation of the ECC time was due to the increased reperfusion time and because of the right atrial anti-arrhythmic procedure as was performed in 15 patients.

| Table 4 | Atrial contraction of patients in SR (n = 26) |
|---------|------------------------------------------|
|         | No atrial contraction (n = 7) | With atrial contraction (n = 19) | P value |
| Age (years) | 65.9 (9.6) | 70.5 (7.6) | 0.21 |
| LA (mm) | 46.7 (6.7) | 44.1 (7.4) | 0.42 |
| Duration (months) | 46 (45) | 65 (75) | 0.51 |
| LVEF (%) | 53 (18) | 52 (15) | 0.94 |
| Euroscore | 5.9 (3.4) | 6.0 (2.4) | 0.90 |
| Bypasses (number) | 3.3 (1.8) | 3.5 (1.3) | 0.70 |
| Follow-up (months) | 23.5 (17.5) | 26.1 (18.0) | 0.75 |
| Ao-X (min) | 83 (25) | 93 (17) | 0.26 |
| ECC (min) | 141 (48) | 161 (40) | 0.28 |

LA, left atrial diameter; Ao-X, aortic cross-clamp time; ECC, extracorporeal circulation.

* Mean values, SD in the brackets.

Fig. 3. (A) Cumulative survival (y-axis, the cumulative frequency; x-axis, postoperative months). (B) Cumulative survival according to lesion pattern (y-axis, the cumulative frequency; x-axis, postoperative months).

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The mean euroscore in this study was 5.5. According to the international literature, an increased perioperative mortality of 10–11% can be anticipated if the euroscore exceeds five points. CAGB patients with permanent AF can be considered a higher risk group when compared with an overall group of isolated, non-selected CAGB patients. The mean euroscore and 30-day mortality of 559 consecutive isolated CAGB, patients without AF, in our clinic was 4.43 and 2.7%. The 30-day mortality in our SICTRA CAGB patients was 2.8% (1/36). Damiano reported an operative mortality of 2% (1/47). So, the 30-day mortality in our study group was not disproportionate and, therefore, acceptable.

4.6. Left versus bi-atrial procedure

The cumulative postoperative SR rate at 12 months for the left and bi-atrial lesion pattern was not significantly different. However, our small patient’s study group impedes the detection of major differences. Larger series are, therefore, indicated. Nevertheless, we believe that a left atrial lesion pattern is an appropriate alternative to the bi-atrial lesion pattern to abolish permanent AF. Harada and associates, who performed intraoperative electrophysiological mapping in mitral valve patients with AF found regular and repetitive activation originating from the left atrial appendage and/or the left pulmonary vein orifice. As a consequence, they only performed a left atrial appendage resection and cryoablation of the left pulmonary orifice with excellent results; 83% SR with mean follow-up of 24.8 months [10]. Whether this electrophysiological pattern can be extrapolated to CAGB patients with permanent AF remains unclear. But the same surgical group also reported a similar electrophysiological pattern in a CAGB patient, which was also successfully ablated with cryoablation on the epicardium of the left atrial appendage [11]. Based upon these studies, we speculated that the left atrial maze would be an effective alternative to the bi-atrial maze procedure in CAGB patients.

4.7. Limitations of the study

Patients’ recruitment was not consecutively performed, because informed consent could not always be obtained. Patient randomization surgery versus medical anti-arrhythmic treatment for AF was due to logistical and organizational factors not feasible. So, inevitably this study comprised a selected patients’ group.

4.8. Implication

If our observations are correct, then the treatment of permanent AF in CAGB patients is warranted. The estimated prevalence of patients with AF in the USA is 2.3 million. The projected prevalence of patients with AF in 2050 will be 5.6 million, ranging from 5.0 to 6.3 million [12]. Go and colleagues reported that the incidence of coronary artery disease among 17,974 patients with non-transient AF was 34.6%. These 17,974 patients were recruited out of a patient population of 1.89 million people. So, a substantial increase in the absolute number of patients with CAGB patients with AF can be anticipated. The known risk factors for coronary artery disease such as hypertension, diabetes mellitus, congestive heart failure, are also associated with the occurrence of AF [12]. The mean age of our surgical patients has increased over the last 10 years. This will further lead to an increase of the incidence of AF. The present mean age of the CAGB patients in our clinic is 66 years. The reported prevalence of AF in this age group varies between 1.7 and 3.0%. So we anticipate that a fair number of patients will be eligible for this therapy.

References

[1] Schaff HV, Dearani JA, Daly RC, Orszulak TA, Danielson GK. Cox-Maze procedure for atrial fibrillation: Mayo clinic experience. Semin Thorac Cardiovasc Surg 2000;12:30–7.
[2] Cox JL, Ad N, Palazzo T, Fitzpatrick S, Snyderhoud JP, DeGroot KW, Pirovic EA, Lou HC, Duvall WZ, Kim YD. The Maze III procedure combined with valve surgery. Semin Thorac Cardiovasc Surg 2000;12:53–5.
[3] Millar RC, Arcidi JM, Alison PJ. The maze III procedure for atrial fibrillation: should the indication be expanded. Ann Thorac Surg 2000;70:1580–6.
[4] Damiano Jr RJ, Gaynor SL, Bailey M, Prasad S, Cox JL, Boineau JP, Schuessler R. Long term outcome of patients with coronary artery disease and atrial fibrillation undergoing the Cox-Maze procedure. J Thorac Cardiovasc Surg 2003;126:2016–21.
[5] Sie HT, Benkema WP, Ramdat Misier A, Elvan A, Ennema JJ, Haelebos MMP, Wellens HJJ. The radiofrequency modified maze in patients undergoing concomitant cardiac surgery. J Thorac Cardiovasc Surg 2001;122:249–55.
[6] Khargi K, Deneke Th, Haardt H, Grewe P, Muller KM, Laczkovics A, Lemke B. Saline irrigated, cooled-tip radiofrequency ablation is an effective technique to perform the maze procedure. Ann Thorac Surg 2001;72:1090–5.
[7] Pasic M, Musci M, Smiawski H, Graulahn O, Edelmann B, Tederiyi T, Weng Y, Hetzer R. The Cox-Maze III procedure: parallel normalization of the sinus node dysfunction, improvement of the atrial function and recovery of the cardiac autonomic nervous system. J Thorac Cardiovasc Surg 1999;118:266–87.
[8] Ausma J, Wijffels M, Thone F, Wouters L, Alessee M, Borgers M. Structural changes of atrial myocardium due to sustained atrial fibrillation in the goat. Circulation 1997;96:3157–63.
[9] Deneke Th, Khargi K, Grewe PH, Laczkovics A, Dryander von S, Lawo Th, Mueller KM, Lemke B. Efficacy of an additional Maze procedure using cooled tip radiofrequency ablation in patients with chronic atrial fibrillation and mitral valve disease; a randomized trial. Eur Heart J 2002;23:558–66.
[10] Harada A, Konishi T, Fukata M, Higuchi K, Sugimoto T, Sasaki K. Intraoperative map guided operation for atrial fibrillation due to mitral valve disease. Ann Thorac Surg 2000;69:446–50.
[11] Harada A, Sugimoto T, Asano T, Yamada K. Intraoperative map guided operation for chronic atrial fibrillation. Ann Thorac Surg 1998;66:1401–3.
[12] Go AS, Hylek EM, Philips KA, Chang Y, Henault LE, Selby JV, Singer DE. Prevalence of diagnosed atrial fibrillation in adults. National implications for rhythm management and stroke prevention: the anticoagulation and risk factors in atrial fibrillation (ATRIA) study. J Am Med Assoc 2001;285:2370–5.