*Original Article*

# Short and Midterm Results of Epi and Endocardial Cryoablation

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**Background: Cryoablation is a new surgical technique for the treatment of atrial fibrillation. Because long-term results are scarce, we report on our findings with this antiarrhythmic therapy.**
**Methods: Forty-three patients (men: 22; women: 21) with paroxysmal (20 patients) or permanent (23) atrial fibrillation underwent different cardiac procedures with simultaneous cryoablation from 2002 to 2007. Cryoablation was performed epicardially with the SurgiFrost™ Cryosurgical system in patients with closed-heart procedures and endocardially in patients with mitral valve surgery. Data were collected by reviewing charts of the patients. Follow-up data were obtained by phoning the general practitioners and/or cardiologists of the patients.**
**Results: The mean age of the patients was 66.2 ± 9.0 years. Fifteen different operations were performed, with coronary artery bypass grafting and mitral valve replacement occurring most frequently. Four patients (9.3%) died postoperatively, 22 were discharged with sinus rhythm (56.4%), and the others demonstrated atrial fibrillation (43.6%). A cardioversion performed on 9 patients postoperatively was successful in 5. All patients were treated with phenprocoumon and amiodarone for a minimum of 6 months postoperatively. Follow-up data were collected 26 ± 15 months after surgery. The number of patients with sinus rhythm had increased to 26 (66.7%), whereas 13 (33.3%) patients still suffered from atrial fibrillation.**
**Conclusion: Cryoablation seems to be an effective tool in the treatment of atrial fibrillation.**
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**Key words:** atrial fibrillation, cryoablation, midterm results

## Introduction

Atrial fibrillation is the most common arrhythmia, and its only curative treatment concept with proven efficiency is the "cut-and-sew" technique, which is an extensive and time-consuming surgical procedure.[1,2] Therefore other surgical strategies have been developed. If atrial fibrillation is treated effectively with ablative procedures, the ablation lines must be complete and transmural.[3] Cryoablation creates homogeneous and irreversible lesions that were also proven by the SurgiFrost™ Cryosurgical System.[3–7] Furthermore, there was no tissue damage to the surrounding tissue or the esophagus up to –160°C.[4] Therefore we continued our cryoablation program after the first successful experiences with endo- and epicardial cryoablation[8,9] and report here on the short- and midterm results.

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## Materials and Methods

Forty-three patients (men: 22; women: 21) with paroxysmal (20 patients) or permanent (23) atrial fibrillation underwent different cardiac procedures with simultaneous cryoablation in our department from 2002 to 2007. The left atrium was described as dilated in 35 patients. In 6, a cardioversion had been tried in the past, but remained

unsuccessful. Cryoablation was performed epicardially in patients with closed-heart procedures and endocardially in patients with mitral valve surgery. Epicardial ablation lines were placed around the left and right pulmonary veins, from the left upper pulmonary vein to the left atrial appendage, and from the left lower pulmonary vein to the mitral annulus. Endocardial ablation lines were placed from the mitral annulus to the left lower pulmonary vein, to the left upper pulmonary vein, to the right upper pulmonary vein, and to the right lower pulmonary vein. The duration for each cryoablation line was 45 seconds, and the mean time for the whole cryoablation procedure was 10 minutes. We used the SurgiFrost™ Cryosurgical System (Endocare Inc., Irvine, California, USA) for all cryoablation procedures. It has already been described in detail elsewhere.[8, 9] The study was performed retrospectively, and the data were collected by reviewing the charts of the patients. Follow-up data were obtained by phoning their general practitioners and/or the cardiologists. A Holter monitoring was the basis for evaluation of the cardiac rhythm; values are given as mean and standard deviation. All calculations were done with Microsoft Excel software.

## Results

The most important preoperative data are summarized in Table 1. The mean age of patients was 66.2 ± 9.0 years, and the body mass index was 26.2 ± 3.9 kg/m$^2$. Left ventricular function was assessed as normal in 26 patients (60.5%), slightly reduced in 12 (27.9%), moderately reduced in 4 (9.3%), and severely reduced in 1 (2.3%).

Table 2 presents an overview of the cardiac diseases and operative procedures. In summary, 15 different operations were performed, with coronary artery bypass grafting (CABG) and mitral valve replacement (MVR) being the most frequent (8 patients each).

Table 3 summarizes all implanted heart valve prostheses and annuloplasty systems, whereas Table 4 presents the urgency of operation and kind of surgery.

Table 5 shows the most important operative and postoperative parameters.

The postoperative complications are presented in Table 6.

Four patients (9.3%) died postoperatively: Two expired because of a multiorgan failure, 1 suffered from an intestinal ischemia requiring bowel resection, and 1 succumbed to an aortic rupture during resuscitation.

Twenty-two patients were discharged with sinus rhythm (56.4%), and the others demonstrated atrial fibrillation (43.6%). A cardioversion was performed in 9 patients postoperatively and was successful in 5. All patients were treated with phenprocoumon and amiodarone for a minimum of 6 months postoperatively to stabilize sinus rhythm and to prevent thromboembolic events. The therapy with both drugs was finished thereafter when the patients demonstrated a continuous sinus rhythm and a well-contracting left atrium without any thrombotic material. The therapy with phenprocoumon was continued if it was

**Table 1. Preoperative data**

| | Patients | Percentage |
|---|---|---|
| Arterial hypertension | 31 | 72.1 |
| Hyperlipidemia | 26 | 60.5 |
| Nicotine abuse | 21 | 48.8 |
| Angina pectoris | 18 | 41.9 |
| Cardiac vertigo | 10 | 23.3 |
| Diabetes mellitus | 9 | 20.9 |
| Previous cardiac decompensation | 7 | 16.3 |
| Previous myocardial infarction | 7 | 16.3 |
| Peripheral arterial occlusive disease | 4 | 9.3 |
| Cardiac syncopes | 3 | 7.0 |
| Previous cerebral infarction | 3 | 7.0 |
| Endocarditis | 3 | 7.0 |
| Pacemaker implantation | 2 | 4.7 |

This table shows that arterial hypertension was the most frequent concomitant disease, followed by hyperlipidemia and nicotine abuse. The severity of hypertension was classified according to guidelines of the World Health Organization.[19] Therefore all patients with coronary artery bypass grafting[18] who suffered simultaneously from arterial hypertension must be classified as grade III hypertension. These 18 also suffered from other consequences of arterial hypertension, which are mentioned in Table 1 (including cardiac vertigo, previous cardiac decompensation, cerebral or myocardial infarction, peripheral arterial occlusive disease, and/or cardiac syncopes). From the remaining 13 patients, 5 suffered from grade I hypertension and 8 from grade II.

Hyperlipidemia is usually classified in three types in Germany: isolated hypercholesterolemia (increased total cholesterol and normal total triglycerides), isolated hypertriglyceridemia (normal total cholesterol and increased total triglycerides), and combined hyperlipidemia (increase of both: total cholesterol and total triglycerides). All 26 patients of our study with hyperlipidemia (Table 1) suffered from obesity and demonstrated enhanced values for cholesterol and triglycerides in the routinely performed preoperative blood tests. Therefore all patients of our study suffered from a combined hyperlipidemia.

The indication for pacemaker implantation was a symptomatic bradytachycardia in both patients.

**Table 2. Cardiac diseases and types of operation**

| Cardiac disease | Operation | Patients | Percentage |
|---|---|---|---|
| Isolated coronary artery disease | coronary artery bypass grafting | 8 | 18.6 |
| Isolated mitral stenosis | mitral valve replacement | 8 | 18.6 |
| Aortic stenosis with coronary artery disease | aortic valve replacement and coronary artery bypass grafting | 6 | 14.0 |
| Isolated aortic stenosis | aortic valve replacement | 5 | 11.7 |
| Mitral insufficiency with coronary artery disease | mitral valve replacement and coronary artery bypass grafting | 3 | 6.9 |
| Mitral and tricuspid insufficiency | mitral and tricuspid valve reconstruction | 2 | 4.7 |
| Aneurysm of the ascending aorta | replacement of the ascending aorta | 2 | 4.7 |
| Aortic and mitral stenosis | Aortic and mitral valve replacement | 2 | 4.7 |
| Isolated mitral insufficiency | mitral valve replacement | 1 | 2.3 |
| Isolated mitral stenosis | mitral valve replacement | 1 | 2.3 |
| Aortic stenosis and aneurysm of the ascending aorta | aortic valve replacement and replacement of the ascending aorta | 1 | 2.3 |
| Aortic stenosis, mitral insufficiency, and coronary artery disease | coronary artery bypass grafting and, aortic and mitral valve replacement | 1 | 2.3 |
| Mitral and tricuspid insufficiency with persistent foramen ovale | mitral and tricuspid valve reconstruction and direct closure of the persistent foramen ovale | 1 | 2.3 |
| Mitral insufficiency with persistent foramen ovale | mitral valve reconstruction and direct closure of the persistent foramen ovale | 1 | 2.3 |
| Tricuspid insufficiency | tricuspid valve reconstruction | 1 | 2.3 |

The most frequent procedure was CABG (18 patients, 41.9%), performed as an isolated operation in 8 patients (18.6%) and as a combined operation in 10 (23.3%). The mean number of peripheral anastomoses was 2.6 ± 1.1. The left internal thoracic artery was used as a bypass graft in 16 patients (88.9%).

**Table 3. Implanted heart valve prostheses and annuloplasty systems**

| | Number of implanted prostheses | Size of the implanted prostheses (mm) |
|---|---|---|
| Mitral annuloplasty ring | 11 | 31.6 ± 1.9 |
| Biological aortic valve | 9 | 23.2 ± 1.8 |
| Mechanical aortic valve | 6 | 24.0 ± 1.9 |
| Mechanical mitral valve | 6 | 30.2 ± 1.7 |
| Biological mitral valve | 1 | 31 |
| Tricuspid annuloplasty system | 1 | 32 |

The most frequently performed valve procedures were ring annuloplasty of the mitral valve (11 patients, 25.6%) and biological AVR (9, 21.0%). Commonly, we are using Carpentier-Edwards Physio- or Cosgrove-Edwards (Edwards Lifescience) rings for mitral valve reconstruction, the Carpentier-Edwards Perimount Plus bioprostheses (Edwards Lifescience) for biological aortic valve replacement, and the SJM Regent prostheses (St. Jude Medical) for mechanical mitral or aortic valve replacement.

**Table 4. Urgency of operation and kinds of surgery**

| | Patients | Percentage |
|---|---|---|
| Elective surgery | 41 | 95.4 |
| Urgent surgery | 1 | 2.3 |
| Emergent surgery | 1 | 2.3 |
| Conventional operation | 38 | 88.4 |
| Minimally-invasive operation | 5 | 11.6 |
| Epicardial cryoablation | 23 | 53.5 |
| Endocardial cryoablation | 20 | 46.5 |

This table demonstrates that the predominant number of operations were performed electively, and that there were only 5 minimal-invasive procedures (mitral valve surgery via a right anterolateral thoracotomy in the fourth intercostal space with implantation of the cannulas for cardiopulmonary bypass via the groin vessels). The conventional procedures were performed via a complete median sternotomy. The number of endocardial and epicardial cryoablations were nearly equally distributed.

**Table 5. Operative and postoperative data**

| | |
|---|---|
| Duration of operation (minutes) | 273.5 ± 84.6 |
| Duration of cardiopulmonary bypass (minutes) | 160.4 ± 59.6 |
| Cross-clamp time (minutes) | 84.0 ± 28.3 |
| Duration of postoperative mechanical ventilation (hours) | 16.1 ± 15.6 |
| Stay on the intenisve care unit (days) | 8.0 ± 13.7 |
| Stay on the normal ward (days) | 10.8 ± 11.5 |
| Drainage loss (mL) | 921.3 ± 428.9 |
| Applied packed red blood cells | 4.5 ± 2.7 |
| Applied fresh frozen plasma | 3.5 ± 2.7 |
| Applied platelet concentrates | 0.5 ± 0.5 |

These data do not include data of deceased patients because they had a very long stay in the intensive care unit with prolonged mechanical ventilation. Including them would falsify data of the surviving patients.

**Table 6. Postoperative complications**

| | Patients | Percentage |
|---|---|---|
| Postoperative confusion | 10 | 23.3 |
| Temporary renal insufficiency | 2 | 4.7 |
| Revision for bleeding | 2 | 4.7 |
| Revision for superficial wound healing disturbance | 2 | 4.7 |
| Need for permanent pacemaker insertion | 1 | 2.3 |
| Revision for mediastinitis | 1 | 2.3 |
| Need for dialysis | 1 | 2.3 |

This table reveals that postoperative confusion was the most frequent complication, which was treated successfully by drugs in all patients.

necessary because of other reasons (for example: implantation of a mechanical heart valve prostheses). Follow-up data were collected 26 ± 15 months after surgery. The number of patients with sinus rhythm had increased to 26 (66.7%), whereas 13 still suffered from atrial fibrillation.

## Discussion

In general, it is expected that a conversion of atrial fibrillation to sinus rhythm improves atrial contractility and enhances both left and right ventricular fillings, optimizing cardiac output.[10] These effects can lead to an improved quality of life and survival. Furthermore, the rate of cerebral infarctions and the need for antiarrhythmic and anticoagulative drugs may be reduced. Therefore great efforts are justified to improve the treatment results for atrial fibrillation.

Cryoablation is one of several energy sources used for surgical ablation of atrial fibrillation. Reported conversion rates to sinus rhythm range from 59% to 84%.[11–16] This rate appears to be dependent on the type of atrial fibrillation (permanent versus paroxysmal) and the type of surgery (surgery for atrial fibrillation alone versus combined procedures).[10] Furthermore, it seems to be also dependent on the length of follow-up. Ahmadzade et al.[17] reported a conversion rate of 33.3% within two months postoperatively, but a one-year follow-up revealed that 73.3% of all patients had sinus rhythm. Our data seem to confirm this finding (56.4% of patients had sinus rhythm on discharge, but 66.7% demonstrated a sinus rhythm at follow-up). Altogether, the results for cryoablation appear to be comparable to the results achieved with the "cut-and-sew" technique when it is considered that the patients undergoing this technique were younger, were more-often treated for paroxysmal atrial fibrillation, and more-often underwent surgery for atrial fibrillation alone.[10]

In contrast to other energy sources, especially radiofrequency, no complications related to the use of cryoenergy

are reported.[18] Nevertheless, the need for postoperative pacemaker implantation is described with 0%–21%.[11–16] This wide range can be explained by the time-dependant indication for pacemaker implantation and its different indications given by various authors: AV junctional arrhythmia, atypical bradycardic arrhythmia, and lack of an adequate exercise-induced increase of the heart rate.[10] These varying clinical strategies still need generalization for an evaluation of the true need for pacemaker insertion after cryoablation.

## Conclusions

Cryoablation seems to be an effective tool in the treatment of atrial fibrillation. The results appear to be comparable even to the results of the "cut-and-sew" technique when it is considered that the patients undergoing this technique are younger, more often treated for paroxysmal atrial fibrillation, and more often undergo surgery for only atrial fibrillation.

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