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Institutional report - Arrhythmia

Mid-term results of a closed biatrial procedure using bipolar radiofrequency ablation concomitantly performed with non-mitral cardiac operations

Takeshi Miyairi[a,*], Sumio Miura[a], Ikutaro Kigawa[a], Haruo Yamauchi[a], Sachito Fukuda[a], Sen Yachi[b], Kazuhiro Hara[b]

[a]*Department of Cardiovascular Surgery, Mitsui Memorial Hospital, Japan*
[b]*Department of Cardiology, Mitsui Memorial Hospital, Japan*

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Institutional Report

Abstract

The long-term success rate of the Cox maze III procedure is excellent, although it has not been widely adopted because of the need for extensive incisions of the atria. In this study, we report our experience with a closed biatrial procedure using bipolar radiofrequency (RF) ablation for treating atrial fibrillation (AF) during non-mitral cardiac operations. Beginning in December 2004, a total of 19 patients underwent a closed biatrial procedure with bipolar RF energy. All the patients had a maze procedure plus a concomitant non-mitral operation. Except for several stabs to introduce the bipolar device, no incisions were made in either atrium. The first six patients were investigated with 64-slice multidetector computed tomography (MDCT), six months after the operation. Patients were followed-up monthly with a clinical examination and electrocardiography. There were no operative deaths. MDCT showed no evidence of coronary sinus stenosis. At one year of follow-up, 93% of the patients (14/15) were in sinus rhythm. The closed biatrial procedure using bipolar RF ablation is safe and effective in treating AF during open-heart surgery. This could be particularly beneficial for patients with AF who are undergoing a cardiac surgical procedure without opening the left atrium.

Keywords: Arrhythmia surgery; Atrial fibrillation; Ablative therapy; Surgical instruments; Computed tomography

1. Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and is identified as a major source of stroke and other thromboembolic disease in elderly patients [1–3]. The maze procedure abolishes macro-reentrant circuits with lines of conduction block created by surgical incisions, and has been established as the gold standard of surgical intervention for AF [4]. However, the maze procedure has been rarely applied to patients without mitral valve disease, because of its invasiveness and the time required to create complicated incisions in the left atrium.

Recently, bipolar radiofrequency (RF) ablation has been used to replace surgical incisions [5]. The use of RF ablation to create lines of block in lieu of surgical incisions is faster and does not require long cut-and-sew lines, thus decreasing operation time and postoperative bleeding.

We used this device to replace cut-and-sew lesions in patients with AF, who were undergoing a cardiac surgical procedure that did not require an incision of the left atrium [6].

*Corresponding author. Mitsui Memorial Hospital, Kandaizumi-cho 1, Tokyo, 101-8643, Japan. Tel.: +81-3-3862-9111; fax: +81-3-5687-9765.
E-mail address: tmiyairi-tky@umin.ac.jp (T. Miyairi).

2. Patients and methods

From December 2004 to August 2008, a total of 19 patients with AF undergoing non-mitral heart surgery on cardiopulmonary bypass underwent the biatrial procedure using bipolar RF ablation (Atricure Inc, Cincinnati, Ohio) concomitantly. The majority of incisions of the Cox maze III procedure were replaced with RF ablation lines, and the device was used to individually isolate the right and the left pulmonary veins (PVs). No incisions were made in either atrium. Approval for this study was granted by the institutional review board at Mitsui Memorial Hospital in Tokyo. Informed consent and approval for release of information was received from each patient.

2.1. Technique of the biatrial procedure using bipolar RF ablation

After induction of anesthesia, the heart was exposed through a median sternotomy. The right atrial lesions and isolation of the right PVs were performed before establishment of cardiopulmonary bypass, while the left atrial lesions and isolation of the left PVs were performed during cardiopulmonary bypass. To isolate the PVs, the rim of atrial tissue around the PVs was clamped and ablated as the device was passed around the PVs. To create other lesions, the device was introduced through purse-string sutures in the atrial wall and was manipulated such that the interposing tissue between the inner and outer jaws was ablated. Each time the clamp and RF energy was applied twice. Pacing to document transmural conduction block in the ablated lesions was not performed. The lesions were created in the following order (Fig. 1). 1) Lesions in the superior vena cava (SVC), the inferior vena cava (IVC), and the right atrial free wall were created through a purse-string suture placed midway between the confluence of the superior and inferior vena cavae. The right coronary artery was dissected and snared with a tape to avoid heart injury. 2) The right atrial free wall was ablated both medially and laterally through the right atrial appendage. 3) Isolation of the right and the left PVs was performed. 4) A connecting lesion with the left PV isolation was created through the left atrial appendage. The left atrial appendage was circumferentially over-sewn. 5) The roof of the left atrium below the SVC and the ascending aorta was ablated through the right upper PV. 6) The roof of the left atrium was ablated through the left upper PV, thus creating the connecting lesion between the right and left PVs isolation line. 7) The lines toward the right and left inferior PVs were ablated through the lower part of the left atrial wall. 8) Finally, in the last twelve cases, ablation crossing the atrioventricular groove was added. The line toward the mitral annulus across the coronary sinus was ablated through a purse-string suture in the lower part of the left atrial wall (Fig. 2). The rest of the operative procedure was performed as indicated.

Perioperative AF was treated with either intravenous or oral bepridil hydrochloride. If the drug was not tolerated, patients were managed with rate control medication and elective cardioversion at 2–4 weeks. Six months after discharge from the hospital, the first six patients underwent 64-slice multidetector computed tomography (MDCT) to assess coronary sinus stenosis. Follow-up electrocardiograms were obtained at one, three, and six months in all patients. All patients reporting palpitations or with atrial arrhythmias documented by electrocardiography underwent two-week telemetry monitoring (Cardiomobi EV-50, Fukudadenshi, Tokyo, Japan).

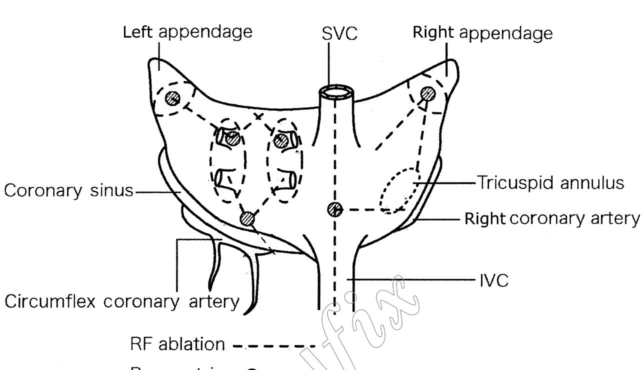

Fig. 1. Diagram of all the ablations. SVC, superior vena cava; IVC, inferior vena cava; RF, radiofrequency.

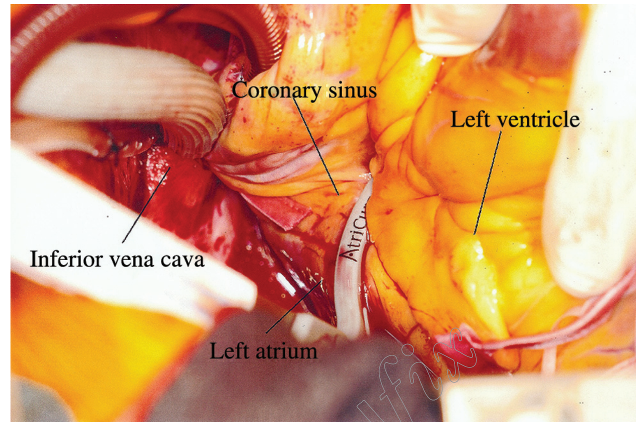

Fig. 2. Bipolar RF clamp through a hole in the posterior wall of the left atrium across the coronary sinus. RF, radiofrequency.

2.2. 64-Slice MDCT scan protocol and image reconstruction

MDCT scans were performed on a 64-slice scanner (SOMATOM Sensation Cardiac 64, Siemens Medical Solutions, Forchheim, Germany) with a gantry rotation time of 330 ms. A total of 100 ml of iopamidol (Iopamiron 370 mg/ml, Schering, Osaka, Japan) was injected into an antecubital vein with an infusion rate of 4.5 ml/s, followed by a 30 ml saline chasing bolus. Electrocardiographically gated data sets were reconstructed at 320–420 ms before R waves, adjusted individually so that the end of the reconstruction period was positioned at the peak of the P wave on the electrocardiogram. Additional images were constructed in different phases after examination of data sets if motion artifacts were present. After reconstruction, CT data were transferred to a workstation (Wizard, Siemens Medical Solutions).

2.3. Statistical analysis

Values are expressed as mean±S.D. The McNemar test was applied to analyze the difference of the antiarrythmic drugs free rates of the patients during follow-up. *P*-value is expressed two-tailed.

3. Results

3.1. Operative results

The male/female ratio was 14:5. The mean age was 63.3±6.0 years. Patient characteristics and underlying diseases are detailed in Table 1. The mean diameter of the left atrium was 51.3±7.3 mm (range, 35–69 mm). The mean ejection fraction of the left ventricle was 56±6% (range, 42–74%). The mean duration of AF was 3.9±2.2 years. The median duration was 3.1 years (0.6–12 years). Preoperatively, five patients had paroxysmal AF, three patients had persistent AF, and 11 patients had permanent AF. All the patients underwent the maze procedure with other concomitant cardiac operations (Table 2).

Table 1
Patient characteristics

Characteristic	Results
Age (years)	63.3±6.0 (range, 52–78)
Sex	74% male (14/19)
CAD	32% (6/19)
Mitral valve disease	16% (3/19)
Congestive heart failure	11% (2/19)
Prior stroke–TIA	11% (2/19)
Previous MI	5% (1/19)
Prior catheter ablations	11% (2/19)
Preoperative cardioversion	21% (4/19)
Preoperative AADs	
None	16% (3/19)
1	63% (12/19)
2	11% (2/19)

CAD, coronary artery disease; TIA, transient ischemic attack; MI, myocardial infarction; AADs, antiarrhythmic drugs.

Table 2
Concomitant surgical procedures

Procedure	Patients, *n* (%)
AVR	12 (63%)
CABG	2 (11%)
AVR+CABG	2 (11%)
Aortic root replacement	1 (5%)
Total arch replacement	2 (11%)

AVR, aortic valve replacement; CABG, coronary artery bypass grafting.

3.2. Perioperative results

The mean duration of the entire process using the bipolar RF device was 35±7 min. The mean cross-clamp time was 91±33 min. Patient outcomes are summarized in Table 3. The median intensive care unit stay was three days. The median postoperative hospital stay was 12 days.

3.3. Postoperative complications

There were no operative deaths. There were no perioperative myocardial infarctions (MI), strokes or sternal infections. Postoperative AF was present in nine patients (47%), but this was usually transient. Seventeen patients (89%) were discharged from the hospital in normal sinus rhythm. One patient (5%) required postoperative permanent pacemaker placement for sick sinus syndrome. There were no complications attributable to the bipolar device in terms of collateral tissue injury. Sixty-four-slice MDCT was conducted on the first six patients six months after the operation. There was no evidence of coronary sinus stenosis in any patient (Fig. 3).

Table 3
Patient outcomes

Outcome	Results
Perioperative mortality	0%
Ablation time (min)*	35±7
Aortic cross-clamp time (min)	91.2±33.2
Cardiopulmonary bypass time (min)	165.3±45.1
Postoperative stay (d)	13.9±6.3
Late mortality	0%
Reintervention	0%
Free of AF at 1 year	94% (14/15)
Off AADs at 1 year	60% (9/15)

AF, Atrial fibrillation; AADs, antiarrhythmic drugs.
*Data recorded on six patients.

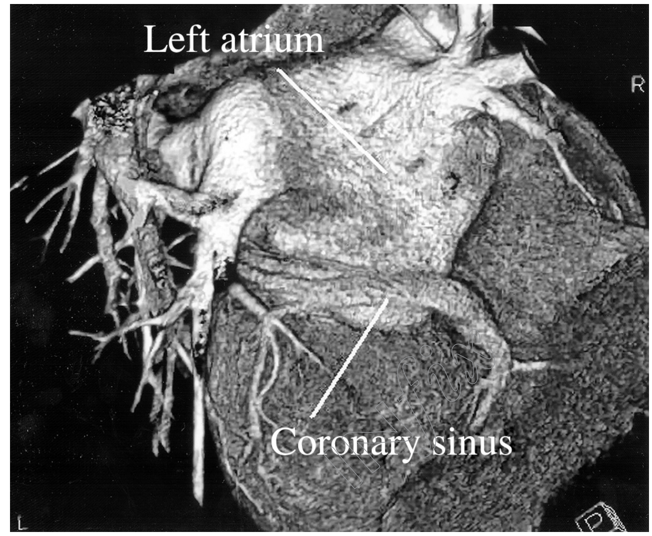

Fig. 3. Three-dimensional reconstruction image of heart with 64-slice MDCT (multidetector computed tomography) six months after the closed biatrial procedure.

3.4. Arrhythmia control

The mean follow-up time was 21.4±9.5 months. The median follow-up was 17 months. At one month after the operation, 17 of 19 patients (89%) were free from AF. At six months and one year, 16 of 18 patients (88%) and 14 of 15 patients (93%) were free from AF, respectively. At the last follow-up, 18 of 19 patients (95%) were free from AF. In the outpatient clinic, the patients were weaned off antiarrhythmic drugs (AADs) as tolerated. A significant decline in the number of patients requiring AADs was observed during a 1-year period ($P<0.001$); 19 of 19 patients (100%) required therapy at discharge, 11 of 18 patients (61%) at six months, and six of 15 patients (40%) at 1 year of follow-up.

4. Discussion

In the past decade, the Cox maze procedure has proven to be an extremely effective, non-pharmacological approach for treating AF. The success rate is 95% in patients undergoing the Cox maze III procedure [4]. Although there have been a number of reports of maze procedures done concomitantly with mitral operations [7], many surgeons hesitate to open the left atrium in patients who are undergoing cardiac operations in which left atrial incisions are not needed. Our biatrial procedure using a bipolar RF ablation system requires no incisions in either atrium, except for several stabs to introduce the bipolar device.

There was no bleeding or tissue injury attributable to the bipolar device. In comparison with unipolar surgical or catheter-based ablation, bipolar ablation appears to be safer in that it limits lateral thermal spread of the lesion, decreasing the possibility of collateral tissue injury [8, 9]. As for injury to the coronary artery, a suitable site for the device to cross the atrioventricular groove may be distal to the last circumflex marginal coronary artery, because there was neither perioperative MI nor ischemic changes of the left lateral wall in the postoperative electrocardiograms. Naturally, however, the bipolar device should not be applied across the atrioventricular groove if there is a dominant circumflex coronary artery. The question of late coronary sinus stenosis remains a concern. We applied the bipolar device to obliquely cross the coronary sinus at its most enlarged part to minimize the constrictive effects of ablation. In this study, the first six patients were evaluated with high-resolution 64-slice MDCT scans at six months. At that interval, there was no evidence of coronary sinus or PV stenosis in any patient.

There is concern that incomplete ablation around the coronary sinus can potentially lead to postablation atrial flutter. Atrial tachyarrhythmias after ablation procedures are most commonly caused by incomplete and non-transmural ablation lines [10, 11]. Bipolar ablation reduces these risks by ensuring transmural lesions. Although we did see the entire width of the coronary sinus to be clamped between the jaws in every patient in whom the bipolar device was applied to the coronary sinus, it is uncertain whether the conductive tissue around the coronary sinus was ablated completely. Ishii and colleagues reported that, in a canine model, conduction was blocked in an extremely narrow isthmus <5 mm between surgical atrial incisions four weeks after surgery, because the atrial myocardium in the isthmus was replaced by fibrous tissue [12]. It might be possible that a small amount of viable myocardium around the coronary sinus after ablation loses conductivity by scarring. Only one patient in this study, in whom the ablative device was not applied across the atrioventricular groove, had atrial flutter. Fifteen of the 19 patients treated had either persistent or permanent AF, and success was achieved in all of these patients. Further follow-up is necessary to determine the long-term cure rate.

Although some reports have suggested that PV isolation alone may be curative for selected patients with paroxysmal AF [13], it remains unclear whether this simple procedure will be effective in surgical cases, particularly those patients with valvular heart disease. The biatrial procedure using a bipolar RF device allows PV isolation as well as atrial ablation to be performed quickly, without the need for any atrial incisions.

This study has some limitations. It represents a relatively small number of patients with a short follow-up. Coronary sinus stenosis was evaluated at six months, which may be too short an interval for this complication to develop. Careful long-term observation will be needed to demonstrate the late safety and efficacy of this procedure. The strength of this study is that it is the only study to date to examine postoperative coronary sinus stenosis using 64-slice MDCT after bipolar RF ablation.

In summary, this study suggests that the biatrial procedure using a bipolar RF ablation system is safe and can effectively replace almost all of the surgical incisions in the Cox maze III procedure. This procedure could be particularly beneficial for patients with AF who are undergoing a cardiac surgical procedure in which incision of the left atrium is not required, such as aortic valve replacement (AVR) or coronary artery bypass grafting (CABG).

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