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Experience with Various Surgical Options for the Treatment of Atrial Fibrillation

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ABSTRACT

Background: New alternatives exist using various energy sources and lesion lines for the surgical treatment of atrial fibrillation (AF). The efficacy of these options compared to the cut-and-sew maze III procedure is unknown.

Methods: From August 1996 to August 2003, 79 patients have undergone a procedure for AF, with 70 patients currently more than 3 months postsurgery. The patients (58 continuous, 12 paroxysmal) underwent a surgical procedure for AF, lone AF (12) and with concomitant procedures (58). Techniques included cut and sew (23), bipolar radiofrequency (RF) (28) and unipolar-RF (10), and cryothermy (9). Lesions included maze III (46), pulmonary vein isolation (16), and pulmonary vein isolation plus mitral annular connecting line only (8).

Results: Follow-up was complete in 58 (83%) of 70 patients at a mean time of 595 ± 750 days (range, 24-2530 days). The operative mortality was 0% in lone AF patients and 7.1% (5/70) in patients undergoing concomitant procedures. Need for perioperative pacemaker was 22.9%. Overall, normal sinus rhythm (NSR) was restored in 82.7% of patients, with success in 83.3% (10/12) lone procedures and 82.6% (38/46) concomitant procedures (*P* = NS); the rate of continuous AF was 85.1% (40/47) and SR with paroxysmal fibrillation was 72.7% (8/11) (*P* = NS). Traditional maze was successful in 80.6% (29/36) patients, pulmonary vein isolation was successful 93.3% (14/15), and left-sided maze in 71.4% (5/7) (*P* = NS). Cut and sew procedures were successful in 88.2% (15/17), RF-bipolar in 84.0% (21/25), RF-unipolar in 77.8% (7/9), and cryothermy in 71.4% (5/7) (*P* = NS). Energy source, lesion set, AF duration, and lone/concomitant procedure were the factors subjected to logistic regression analysis. No factors were predictive of achieving postoperative NSR.

Conclusions: Our early experience with newer surgical techniques employing different energy sources and fewer incision lines suggests that the success rate may approach the results obtained with traditional cut-and-sew Cox-maze III procedures.

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INTRODUCTION

The operative management of atrial fibrillation (AF) is evolving. Currently, multiple operative strategies exist for treating paroxysmal and continuous AF, with the most effective surgical approach being the Cox-maze III procedure [Cox 1995]. This operation has excellent long-term results [Damiano 2003] but can be technically demanding. As a result, newer, less time-consuming technologies for the intraoperative treatment of AF have been developed.

Four surgeons in our group have used a combination of techniques and energy sources (cut and sew, cryothermy, unipolar radiofrequency [RF] ablation, bipolar RF ablation) to treat AF, using a variety of lesion sets (traditional maze, left-sided maze, pulmonary vein isolation). The objective of this study was to compare our early experience with the alternative energy sources and lesion sets for the intraoperative treatment of AF with our results using the traditional cut-and-sew Cox-maze III procedure as performed by these same surgeons.

MATERIALS AND METHODS

After the study received Institutional Review Board approval, the medical records of patients who underwent an operative procedure for AF between August 1996 and October 2003 were reviewed for this study. Follow-up was obtained from medical records, telephone calls to the patients, or records from cardiology offices.

A total of 79 patients were identified as having had an ablation procedure for atrial fibrillation; 70 of these patients (58 continuous, 12 paroxysmal) were more than 3 months postoperative. Twelve patients received surgical therapy for AF as a lone procedure, and 58 patients underwent surgical ablation as part of a concomitant procedure. Patients undergoing concomitant procedures included 9 with coronary artery bypass graft (CABG), 16 with CABG + valve

Table 1. Atrial Fibrillation (AF) Data Summary

	N	No AF	Still in AF	*P*
Energy source				NS
Cryothermy	7	5 (71.4%)	2 (28.6%)	
Cut/sew	17	15 (88.2%)	2 (11.8%)	
Radiofrequency-bipolar	25	21 (84%)	4 (16%)	
Radiofrequency-unipolar	9	7 (77.8%)	2 (22.2%)	
Type				NS
Continuous	47	40 (85.1%)	7 (14.9%)	
Paroxysmal	11	8 (72.7%)	3 (27.3%)	
Procedure done				NS
Concomitant	46	38 (82.6%)	8 (17.4%)	
Maze alone	12	10 (83.3%)	2 (16.7%)	
Type of ablation				NS
Left maze	7	5 (71.4%)	2 (28.6%)	
Pulmonary vein isolation	15	14 (93.3%)	1 (6.7%)	
Traditional maze	36	29 (80.6%)	7 (19.4%)	
Continuous only				NS
Cryothermy	7	5 (71.4%)	2 (28.6%)	
Cut/sew	15	13 (86.7%)	2 (13.3%)	
Radiofrequency-bipolar	20	17 (85%)	3 (15%)	
Radiofrequency-unipolar	5	5 (100%)	0	
Paroxysmal only				NS
Cryothermy	0	0	0	
Cut/sew	2	2 (100%)	0	
Radiofrequency-bipolar	5	4 (80%)	1 (20%)	
Radiofrequency-unipolar	4	2 (50%)	2 (50%)	

repair/replacement, 31 with valve repair/replacement, and 2 with miscellaneous procedures.

Several techniques were used by the surgeons to perform an ablation procedure, with 23 patients treated with a cut-and-sew maze III procedure, 28 patients with bipolar RF ablation, 10 patients with unipolar RF ablation, and 9 patients with cryothermy ablation. Of the 58 patients who received an ablation procedure as part of a concomitant procedure, 47 had continuous AF and 11 had paroxysmal AF.

The cut-and-sew maze III procedure was performed as previously described by Cox [1995]. Pulmonary vein isolation was performed as if it were part of the Cox-maze III, and left atrial maze was performed by adding a line from the pulmonary vein isolation lines to the mitral annulus.

RESULTS

Outcomes data were available for analysis on 58 (83%) of 70 patients, and no information was available on 12 patients, 3 who could not be contacted and 9 whose outcomes were still unknown after chart review and telephone contact. The mean follow-up in this group was 595 ± 750 days (range, 24-2530 days).

The operative mortality was 5/70 (7.1%), with all deaths occurring in patients having concomitant procedures. Forty-eight of the 58 patients (82.7%) were treated successfully, being in normal sinus rhythm at follow-up, with 24/48 (50%) requiring no adjunctive therapy, 4/48 (8.3%) having the need for a perioperative pacemaker, 11/48 (22.9%) requiring medication, and 9/48 (18.8%) requiring both medication and a pacemaker. In the remaining 10 patients (17.3%) sinus rhythm had not been achieved at follow-up.

Table 1 shows the results of the ablative therapy.

The patients were separated into groups of those in continuous and those with paroxysmal AF so that the efficacy of the different energy sources and cut-and-sew maze was compared. The data are presented in Table 2.

Data were further analyzed to assess the outcome of using the various energy sources with the different lesion sets created. Table 3 presents the success rate of the therapy according to the energy source used and lesion set created.

Energy source, lesion set, AF duration, and lone/concomitant procedure data were subjected to logistic regression analysis. No factors were predictive of achieving postoperative normal sinus rhythm.

DISCUSSION

Atrial fibrillation is the most common sustained cardiac arrhythmia encountered in clinical practice. With the rising incidence of AF in the general population, there has been an associated increase in annual hospital admissions for AF [Friberg 2003, Wattigney 2003]. The effects of AF on cardiovascular morbidity and mortality are significant, and include a 5-fold increase in the incidence of embolic stroke [Tsang 2003].

Table 2. Comparison of Procedure Efficacy in Patients with Continuous and Paroxysmal Atrial Fibrillation (AF)

Type of AF	Procedure Done	Energy Source	No. of Patients	No AF	Still in AF
Continuous	Concomitant	Cryothermy	7	5 (71.4%)	2 (28.6%)
		Cut/Sew	5	5 (100%)	0
		Radiofrequency-bipolar	18	15 (83.3%)	3 (16.7%)
		Radiofrequency-unipolar	5	5 (100%)	0
	Maze alone	Cut/sew	10	8 (80%)	2 (20%)
		Radiofrequency-bipolar	2	2 (100%)	0
Paroxysmal	Concomitant	Cut/sew	2	2 (100%)	0
		Radiofrequency-bipolar	5	4 (80%)	1 (20%)
		Radiofrequency-unipolar	4	2 (50%)	2 (50%)

Table 3. Success Rate of Atrial Fibrillation (AF) Therapy according to the Energy Source Used and Lesion Set Created

Energy Source	Type of Procedure	No. of Patients	Current AF Status	
			No AF	Still in AF
Cryothermy	Left maze	2	2 (100%)	0
	Pulmonary vein isolation	1	0	1 (100%)
	Traditional maze	4	3 (75%)	1 (25%)
Cut/sew	Traditional maze	17	15 (88.2%)	2 (11.8%)
Radiofrequency-bipolar	Left maze	3	3 (100%)	0
	Pulmonary vein isolation	10	10 (100%)	0
	Traditional maze	12	8 (66.7%)	4 (33.3%)
Radiofrequency-unipolar	Left maze	2	0	2 (100%)
	Pulmonary vein isolation	4	4 (100%)	0
	Traditional maze	3	3 (100%)	0
Totals		58	48	10

The cut-and-sew maze III procedure successfully eliminates AF in 90% of patients with lone AF, AF associated with valvular disease, and in selected patients with AF and ischemic heart disease [Cox 1993, Damiano 2003, Prasad 2003]. Morbidity and mortality rates were comparable to those occurring in patients undergoing equivalent procedures performed without concomitant maze. Despite these superb results, widespread acceptance is limited by additional cross-clamp time, perceived increase in morbidity and mortality, and by surgical selection limited to better-risk patients.

New alternatives for creating the maze III lesion sets and new empiric data reducing the number of lesions required to cure earlier AF can be expected to reduce morbidity and mortality and make both stand-alone and concomitant maze procedures more widely accepted [Cox 2003a].

It has been shown that RF can be used to create atrial lesion lines similar to those created with maze III. The early results using RF ablation to treat AF are comparable to those obtained with the cut-and-sew maze procedure [Raman 2002]. Other energy sources, such as cryothermy, have been introduced to create intraoperative lesion lines, which interrupt the circuits required to propagate the AF [Doll 2003].

Our retrospective review looked at the experience of 4 surgeons with the cut-and-sew maze and compared it to their experience employing newer lesion-creating technology. Although logistic regression analysis failed to identity factors predictive of achieving postoperative normal sinus rhythm, review of the failures in each subset may offer guidelines to the proper choice of lesion sets and ablative technology.

The cut-and-sew maze III was successful in 13 of 15 patients with continuous AF. The 2 unsuccessful procedures were performed by a surgeon with no prior or subsequent maze experience. Three other surgeons had no unsuccessful cut-and-sew maze procedures. When the maze III was performed with RF assist, however, 4 of 15 patients remained in AF. These 4 patients underwent surgery performed with the first-generation bipolar RF clamp with lower energy levels, shorter lesion times, and only one lesion "burn." Subsequent patients fared better.

Pulmonary vein isolation alone was successful in 14 of 15 patients with either paroxysmal or continuous AF. The isolated failure occurred in an elderly female patient with long-standing continuous AF who underwent cryoablation of pulmonary veins only. Both RF unipolar and bipolar pulmonary vein isolation were effective in abolishing AF.

This study has several limitations. It is a retrospective review of selected patients. Many patients were high risk and died, thus being eliminated from follow-up (mortality rate, 7.1%). Follow-up was available in 83% of the patients, and electrocardiogram documentation of normal sinus rhythm was not available for all patients who stated they were in normal sinus rhythm.

The procedures investigated in this study employ new technology. Despite the surgeon's familiarity with the maze III, there is a learning curve with any new technology that becomes available, likely leading to an underestimation of the efficacy of second-generation devices. In this study the use of these devices was not standardized and varied by surgeon.

The terms continuous and paroxysmal AF used in this paper were adopted prior to Cox's newer suggested classification of AF as either continuous or intermittent [Cox 2003b]. It is possible that some patient arrhythmias classified as continuous were, in fact, intermittent or paroxysmal in this case.

Our study, however, reflects the same philosophy that standardized lesion sets specific to each type of AF are highly effective in curing AF. Cure rates of >80% in most of these subsets of patients suggest that newer technology, when standardized and applied to the correct subset of AF, offers cure rates approaching the traditional cut-and-sew maze III. Use of this newer lesion-creating technology and adoption of minimally invasive techniques can be expected to broaden the surgical attack on AF. Earlier referral of patients should increase the efficacy of surgical treatment of AF.

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REVIEW AND COMMENTARY

1. Editorial Board Member HR142 writes:

As the authors note, this investigation has all the problems of a small, retrospective, and highly selected study. At this stage in development of these techniques, even a small retrospective study has a certain amount of descriptive value, but the complications need to be more specifically dealt with. An increasing number of referring physicians are citing complications as a reason to resist widespread application of the maze procedure. The main two culprits have been (1) need for a permanent pacemaker and (2) appearance of refractory, rapid atrial flutter. The authors should address these complications, if they have any experience with them, and must clarify what they mean by "perioperative pacemaker." Permanent or not?

Authors' Response:

As Editorial Board Member HR142 points out, there is currently hesitation among referring physicians to refer patients for the surgical treatment of AF as a sole therapy. However, most of this concern relates to the "maximally" invasive nature of the surgical approach compared to catheter-based therapy. Once a minimally invasive approach, through small port-type thoracotomy incisions, has been shown to be as efficacious, or better, than catheter-based interventions, then patients will be increasingly referred for lone surgical therapy for AF.

Complications from the surgical therapy of AF are a concern. However, these complications depend in part on the type of energy source used to create the atrial lesion set and on the type of atrial lesion set used. As our experience with different energy sources grows, we can minimize the technology-based complications by choosing the "safest" modality. In addition, the appropriate and best lesion pattern has yet to be determined, and additional studies are needed to determine the most efficacious lesion set.

In our experience, "perioperative pacemaker" use was defined as the need for a permanent pacemaker. Only 8.3% of patients not in AF postoperatively required a permanent pacemaker alone, and 18.8% of patients not in AF required both a permanent pacemaker and medical therapy. It is often difficult to determine preoperatively based on their preoperative rhythm which patients will require a pacemaker postoperatively. Some patients in preoperative atrial flutter will have underlying sinus node dysfunction, and after the flutter is eliminated with the maze procedure, they will need a permanent pacemaker postoperatively.

Postoperative atrial flutter can occur in approximately 8% to 10% of patients undergoing surgical therapy for AF. Additional studies are necessary to determine the appropriate lesion set to treat AF and prevent atrial flutter, but through additional surgical experience with different lesion sets, we have found that adding a right-sided atrial lesion along the septum from the inferior vena cava to the coronary sinus and tricuspid valve will minimize the incidence of postoperative atrial flutter.

2. Editorial Board Member AN153 writes:

A lower conversion with left atrial maze (which inherently has pulmonary vein isolation) compared to plain pulmonary vein isolation: these results seem to be contradictory. The sample sizes seem to be too small and the group is so heterogeneous—different methods, techniques, and lesions have all been grouped together, and an attempt is made to draw conclusions using this heterogeneous group, which seems to be not predefined.

Authors' Response:

We agree that patients receiving pulmonary vein isolation alone would be expected to have a lower success rate than patients who received a left atrial maze procedure. Our study showed the opposite. Although this finding is unexpected, a number of factors may be involved. First, these data are at 3 months postoperatively. Most studies have shown that it can take 6 months, or even 12 months, for the full effects of the maze procedure to be realized. As we follow this cohort of patients, this difference may disappear. Extended tissue manipulation is inherently required with a left atrial maze procedure, and therefore it may take a longer time for the full effects of the procedure to be realized. Additional factors that potentially could affect the success of one approach over another are type of energy source and the etiology of AF. Additional studies are warranted to address this issue. Although our study suggests trends of different modalities and approaches for the surgical management of AF, additional studies are necessary to better understand this important subject. It will be important to conduct studies on a larger series of patients with well-defined lesion sets and energy sources.