Institutional report - Arrhythmia

Biatrial reduction plasty with reef imbricate technique as an adjunct to maze procedure for permanent atrial fibrillation associated with giant left atria

William Wang, L. Ray Guo, Anne Marie Martland, Xiao-Dong Feng, Jie Ma, Xi Qing Feng

1 Scripps Memorial Hospital, San Diego, USA
2 The 2nd Teaching Hospital of Shanxi Medical University, China
3 Shanghai 1st People’s Hospital, China
4 Asia Pacific Heart Center, China

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Abstract

Success of the modified maze procedure after valvular operation with giant atria and permanent atrial fibrillation (AF) remains suboptimal. We report an aggressive approach for these patients utilizing biatrial reduction plasty with a reef imbricate suture technique concomitantly with valvular and maze procedure for AF. From January 1999 to December 2006, 122 consecutive Chinese patients with permanent AF and biatrial enlargement who required mitral valve + tricuspid valve (TV) surgery underwent aggressive left atrial reduction combined with radiofrequency bipolar full maze procedure. Left atrial dimensions were measured by TTE or TEE. There were 71 women (58.1%) and 51 men (41.9%) and their mean age was 45±9.5 years. Mean duration of AF was 48.4±21.4 months. All patients underwent left atrial reduction plasty with reef imbricate suture technique and full maze procedure. Their preoperative left atria measured 64±12 mm in the enlarged left atria (ELA) group and 86±17 mm in the giant left atria (GLA). Mitral valve replacement (MVR) combined with TV repair was performed in 102 patients (83%) while 21 patients underwent MVRs combined with aortic valve replacements (17%). Sixty-six (54%) patients required additional procedures and 61 (50%) of the patients also underwent left atrial appendage clot evacuation. Postoperative left atrial size was reduced to 49±8 mm (ELA) and 51±11 mm (GLA), respectively (P<0.05). Ninety-three of 122 (76%) patients were restored in normal sinus rhythm after one year clinical follow-up. Aggressive biatrial reduction plasty combined with full maze procedure is an effective treatment for patients with permanent AF undergoing concomitant valvular surgery. Further studies utilizing the reef imbricate suture technique for atrial reduction need to subsequently be evaluated.

Keywords: Atrial fibrillation; Maze; Biatrial reduction plasty; Giant left atria

1. Introduction

The surgical treatment of permanent atrial fibrillation (AF) in patients with concomitant mitral valve (MV) disease continues to be a clinical challenge particularly with significant left atrium (LA) enlargement. MV surgery alone often does not result in restoration of sinus rhythm. Moreover, AF surgical treatment with the maze procedure may recur weeks or months after the procedure.

The traditional cut-and-sew Cox maze III operation serves as the benchmark in AF surgical treatment, providing 90–97% freedom from AF [1]. However, concerns about procedural complexity have limited the acceptance [2]. Recent modifications in the operation including the use of ablative therapies and different approaches to atrial reduction have increased the application of the maze procedure with concomitant MV surgery. However, the rate of conversion to sinus rhythm following these surgical approaches is suboptimal [3], particularly in patients with long-standing AF and a giant left atrium (GLA) [4].

Recently, many have argued whether the maze procedure should be performed on all patients with GLA [5]. Marui and Mishina have reported LA reduction with continuous horizontal mattress sutures along with pulmonary vein isolation during MV surgery and proved its safety and efficacy [6]. However, no reports have focused on reduction of GLA with the aggressive reef imbricate suture technique following different LA geometry pattern during concomitant maze and MV surgery.

In this study, we describe an approach to treating these complicated patients who otherwise might be left in AF or even not operated on owing to their predisposing predicates of failure. We propose that significantly enlarged atria should be reduced by utilizing biatrial reduction concomitantly with a full-modified Cox maze procedure for AF.
2. Patients and methods

2.1. Patient group

Between January 1999 and December 2006, 122 consecutive drug resistant patients with permanent AF and LA enlargement who required MV surgery were included in the present study. Large LA in this report was defined as two groups: 1) enlarged left atrium (ELA) is a left atrial diameter (LAD) between 55 and 74 mm, 2) GLA is a LAD ≥ 75 mm (Fig. 1).

The study comprised of 51 men (41.9%) and 71 women (58.1%) with mean age of 45 ± 9.5 years. Mean duration of AF in the series was 48.4 ± 21.4 months. LAD was measured at time of aortic valve closure on the M-mode echocardiogram in the parasternal long-axis view. The preoperative mean atrial size was 64 ± 12 mm in ELA group and 86 ± 17 mm in GLA group. All patients underwent a modified full Cox maze III procedure using radiofrequency (RF) ablation and biatrial reduction with the reef imbricate technique concomitantly with MV±tricuspid valve (TV) surgery (Table 1). Severity of tricuspid regurgitation was classified as 0 (none), 1 (trivial), 2 (mild), 3 (moderate), 3.5 (moderate-severe), and 4 (severe) by two-dimensional echocardiographic evaluation before surgery and postoperative follow-up at discharge, six months and one year.

### Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ELA</th>
<th>GLA</th>
<th>Total value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient (n)</td>
<td>83</td>
<td>39</td>
<td>122</td>
</tr>
<tr>
<td>M/F</td>
<td>34/49</td>
<td>17/22</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>38±10.4</td>
<td>54±7.3</td>
<td></td>
</tr>
<tr>
<td>NYHA class</td>
<td>2.1±0.7</td>
<td>2.9±0.9</td>
<td></td>
</tr>
<tr>
<td>Hx of stroke, n (%)</td>
<td>4 (4.8%)</td>
<td>6 (15%)</td>
<td></td>
</tr>
<tr>
<td>Atrial appendage clot</td>
<td>26</td>
<td>35</td>
<td>61</td>
</tr>
<tr>
<td>Mitral stenosis and Insufficiency</td>
<td>65</td>
<td>37</td>
<td>102</td>
</tr>
<tr>
<td>Mitral Insufficiency</td>
<td>6</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Aortic stenosis and Insufficiency</td>
<td>10</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>Tricuspid Insufficiency</td>
<td>68</td>
<td>34</td>
<td>102</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>48±8</td>
<td>36±11</td>
<td></td>
</tr>
<tr>
<td>Duration of AF (months)</td>
<td>45±87</td>
<td>56±67</td>
<td></td>
</tr>
<tr>
<td>Left atrial diameter (mm)</td>
<td>64±12</td>
<td>86±17</td>
<td></td>
</tr>
</tbody>
</table>

ELA, enlarged left atrium; GLA, giant left atrium; AF, atrial fibrillation; Hx, history.

2.2. Operative procedure

A transesophageal or transthoracic echocardiogram was performed on all patients. Operations were performed via a median sternotomy and standard cardiopulmonary bypass with bicaval cannulation and mild hypothermia (32 °C). A left atriotomy incision was made through the Waterson’s groove and LA appendage thrombus was first evacuated if present. The left pulmonary veins were carefully dissected and isolated. The bipolar RF Atricure clamp (Atricure, Inc, Cincinnati, OH) was then placed on the left pulmonary vein which the rim of the atrial tissue surrounding the pulmonary veins was ablated. The left atrial appendage was amputated and bipolar RF ablation was performed between the LA appendage and the left superior pulmonary vein by placing one jaw on the endocardium and one jaw on the epicardium. Then, the dome of LA was ablated with RF clamp through amputated left atrial appendage and transverse sinus. Then, the standard left atriotomy was extended into the dome of LA and inferiorly around the orifice of the right inferior pulmonary vein. The bipolar RF Atricure clamp was placed on the rim of right pulmonary vein for ablation. A connecting ablation lesion was performed from the inferior aspect of the LA into the left inferior pulmonary vein. In the GLA group, a second connecting ablation was placed from the middle inferior wall of LA into left superior pulmonary vein. Finally, a bipolar RF ablation line was performed by placing one jaw of clamp from the inferior end of incision down to the mitral annulus at a point of P3 area and another jaw at a point which was marked as left isthmus ablation in-between the circumflex artery and right coronary sinus. The ELA and GLA are plicated mainly between the left and right pulmonary vein down to the...
inferior end of left atrial incision on the half-moon shape (Fig. 2). The reef imbricated suture was placed at least 2 cm away from the mitral annulus and circumflex artery. After aggressive closure of the redundant free wall of LA, the right atrial appendage was excised and an incision was carried from the right atrial stump parallel to right atrioventricular groove extending toward the inferior vena cava. Standard RF ablation lesions were then placed to isolate the tricuspid annulus and continue across the atrial septum. The redundant right atrial wall and incision were reef imbricated closure with 4-0 running prolene sutures (Fig. 3). Additional procedures performed in this study include mitral valve replacement (MVR), MV repair, TV repair, aortic valve replacement (AVR) and patent foramen ovale closure (PFOC) (Table 2).

### 2.3. Postoperative care and patient follow-up

All patients received anti-arrhythmic medication amiodarone in the perioperative period. Electrical cardioversion was performed prior to hospital discharge in any patient not in sinus rhythm. Anticoagulation therapy was determined by the valve surgery performed and postoperative diameter of LA. For patients with a postoperative LAD > 50 mm, anticoagulation with Coumadin was used for the first three postoperative months.

Follow-up was obtained through a combination of outpatient clinic visits and phone interviews with local doctors. Postoperative follow-ups were scheduled at 3, 6, 12 months and then annually thereafter. At all visits, a history and physical examination and electrocardiogram and echocardiogram were obtained. In patients with symptoms, such as palpitations and other evidence of atrial arrhythmias, a 48-h Holter monitor recording was obtained.

### 2.4. Data analysis

All values are expressed as the mean ± standard deviation (S.D.). Statistical analysis comparing the data between two groups was performed with the Fisher exact probability test for categorical variables. Continuous variables were compared using a two-sample t-test or Wilcoxon rank-sum test where appropriate. Data collected were analyzed using the number cruncher statistical systems software (NCSS, Kaysville, UT). A significant difference between measurements was defined as $P \leq 0.05$.

### 3. Results

All 122 patients underwent MV surgery and concomitant modified Cox maze III RF ablations. An aggressive LA resection with reef implication technique was carried out as an adjunct to the maze procedure in all patients. Other concomitant procedures included AVR in 21 (17%) patients, TV repair in 102 patients, left atrial thrombus evacuation (LATE) in 61 (50%) patients and coronary artery bypass grafting (CABG) in five patients. The distribution of operative procedures is summarized in Table 2.

Mortality was defined as death occurring within 30 days following initial surgery or during the same admission. The mortality was 0 in ELA group and 3 (2%) in the GLA group. One patient died of congestive heart failure and two patients were due to severe pneumonia and respiratory failure. Hospital morbidity included reoperation for bleeding in 13 (10%) patients and requirement for permanent pacemaker insertion in four (3%) patients. There were no transient ischemic attacks, stroke, or perioperative myocardial infarctions.

Intraoperative sinus rhythm recovery or junctional rhythm was observed in 112 (91%) patients, 80 (96%) patients in the ELA group and 32 (89%) patients in the GLA group, respectively. At time of discharge, 69 (83%) patients in the ELA group and 22 (56%) patients in the GLA group remained in sinus rhythm. There were no atrial flutter observed in two groups.

Long-term follow-up was 96% complete. Median follow-up was 19 ± 16 months (range 1–58 months), 72 of the 80 patients (90%) in ELA group and 21 of 36 patients (58%) in the GLA group were in sinus rhythm. Patients in the ELA group maintained a higher sinus rhythm recovery rate than those in the GLA group at the 12-month follow-up period ($P < 0.05$). Of 122 patients, 46 (37%) underwent electrical cardioversions, all of which occurred within the first three months.

Transthoracic echocardiographic examinations were performed perioperatively and at the 12-month follow-up after surgery. Among the patients in the ELA group, the LAD at discharge was much smaller than the preoperative LAD ($49 ± 8$ vs. $64 ± 12$ $P = 0.01$). LAD in patients in the GLA group at discharge was significantly ($P < 0.05$) reduced compared with preoperative diameter ($51 ± 11$ vs. $86 ± 17$.)
4. Discussion

This report demonstrates that utilizing aggressive biatrial reduction with the reef imbricated technique as an adjunct to the Cox maze procedure for patients with ELA (LAD ≥ 75 mm), prolonged history of AF and MV disease can have a successful outcome. In this study, we found that 83% of patients in the ELA group with preoperative LAD 55–74 mm regained sinus rhythm after surgical treatment and 90% of patients in this group also remained in sinus rhythm at one year follow-up. However, only 56% of patients in the GLA group regained sinus rhythm and 58% of these patients remained in sinus rhythm after one year follow-up.

It is generally agreed that patients with ELA or GLA require some supplementary procedure as an adjunct to maze procedure at the time of MV surgery for effective treatment of AF. The greater the LAD, the lower is the sinus conversion rate [7]. AF is rare when LADs are < 40 mm [8]. Cox and associates [9, 10] suggested LA size (diameter > 60 mm) was an important factor in the development persistence and recurrence of AF. Yuda et al. [11] reported that maze procedure was able to restore a sinus rhythm in 50% AF patients with GLA. Scherer et al. [12] reported a sinus conversion rate of 66% with sole atrial reduction in patients having valvular disease. This study suggests that AF associated with severely enlarged atria can be successfully treated with the maze procedure and concomitant atrial reduction. Although the type of maze procedure depends on the lesion set [13], the full Cox maze procedure was still the first surgical choice for patients with GLA.

In this report, we evaluated the impact of using the reef imbricated suture technique on the sinus rhythm recovery as well as the maintenance of sinus rhythm. The cut-and-sew surgical technique for atrial reduction is considered by many surgeons to be difficult, time-consuming, technically demanding and with an increased postoperative bleeding particularly in patients with giant atria. Badhwar [14] and Romano et al. [15] reported that LA reduction via traditional cut-and-sew technique to remove excess atrial wall tissue was 92% effective in sinus rhythm recovery up to one year freedom from AF. Our findings suggest three significant points. First, LA reduction procedures using only continuous horizontal mattress suture plications are not sufficient in reducing the LA. Our reef imbricated suture technique was first pulling up the LA excess wall tissue then rolling over with continuous running suture. It was very effective in reducing LAD and more importantly the over sewn ridge seemed to serve as an artificial barrier disrupting LA wall chaotic wavelets and macro-re-entry circuit. In addition, it significantly improved LA hemostasis and reduced the opportunity of thrombus formation. We have found this technique to be technically simple and quick to accomplish and most importantly, effective in relieving AF without adding any complications.

Second, ELA or GLA geometry with rheumatic MV disease presented unique characteristics that stretched the LA wall usually located between the left and right pulmonary veins, left atrial posterior wall and free wall. The reef imbricated suture line on the half-moon shape distal to the posterior mitral annulus was effective in eliminating redundant LA wall tissue and preventing injury to the circumflex coronary artery.

Third, rheumatic MV disease not only contributed to GLA and AF but also to tricuspid valvular regurgitation, pulmonary hypertension and giant right atria in advanced stages. We found the high prevalence of significant late AF recurrence was related to late postoperative tricuspid regurgitation. The correction of tricuspid regurgitation with anuloplasty ring, right atrial reduction plasty and right side maze procedure could be important in long-term outcomes.

5. Conclusion

Aggressive biatrial reduction plasty with the reef imbricated technique combined as an adjunct to RF full maze procedure is an effective modality for treating permanent AF in patients with giant atrial undergoing concomitant mitral surgery. Surgical therapy to restore normal atrial geometry may render a long-term benefit to maintain the normal sinus rhythm. Further prospective randomized studies with a long-term follow-up are required to assess the effectiveness of novel surgical technique.

References

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reduction, only the running suture, just decrease probably one-third of the atrium reduction. Actually, the left atrium free wall reductions, you have geometry on the size doesn’t improve at all. But after two years, but is not the left atrium size. Unfortunately, after one year, the left atrium, the up before the surgery and postoperative surgery and even with six months due only to rate of surgery.

comment on your paper, which is, I fully agree with the third conclusion you of sinus rhythm and afterwards in those patients with very large atria? patients. Did you look at transport function echographically during the time the sinus rhythm remains in the large atria shorter than in the other patients.

Dr. Y. Louagie (Louvain, Belgium): In my opinion, this work is remarkable for two reasons. First, the authors were able to treat successfully patients with extreme enlargement of the atria due to rheumatic mitral valve disease and needing left atrial thrombus evacuation in 50% of the cases. Many of us would consider such patients as unsuitable for arrhythmia surgery. And the second reason, the reef imbricate technique you described is original. Indeed, it differs from the triangular excision of the left atrial posterior wall published by Romano. And it contrasts with the plication technique between the mitral annulus and the left pulmonary veins as described by Marui.

So I have two questions. First, your technique is based on a longitudinal mattress suture of the left atrial posterior wall in between the pulmonary veins. How do you avoid stitching the esophagus, particularly in the presence of a transeosophageal echo device?

Dr. Wang: The geometry of the left atrium for the rheumatic heart disease and the redundant, you can see redundant the left atrial posterior wall, the most is between the left and the right pulmonary vein and the free wall of the left atrium. What we do, first, we just pull the redundant tissue up. And that’s called reef imbricated. We pull up with the 4-0 Prolene suture line running. So two things: (1) we reduce enough the left atrium; (2) we don’t damage the posterior wall of the adjacent organs.

Dr. Louagie: Second question. Despite your aggressive approach, only 56% of GLA patients regained sinus arrhythmia after 19 months follow-up time. To enhance the volume-reduction effect, could it be possible to associate the plication technique described by Marui, I mean the plication between the mitral annulus and the left pulmonary veins, and your reef imbricate technique?

Dr. Wang: That part of the reduction is not the main purpose for the left atrium reduction. Actually, the left atrium free wall reductions, you have to do a very aggressive reduction from there. And the posterior wall reduction, only the running suture, just decrease probably one-third of the left atrium reduction.

Dr. C. Kik (Rotterdam, Netherlands): You showed us that the time after the sinus rhythm remains in the large atria shorter than in the other patients. Did you look at transport function echographically during the time of sinus rhythm and afterwards in those patients with very large atria?

Dr. Wang: Yes. We still follow-up these patients’ giant atrium. We follow-up before the surgery and postoperative surgery and even with six months and at one year. Even right now, two years, we still continue to follow-up the left atrium size. Unfortunately, after one year, the left atrium, the geometry on the size doesn’t improve at all. But after two years, but is not a significant decrease, in some patients you can see reduced a little bit the left atrium.

Dr. Kik: And what happens if after the period the sinus rhythm disappears?

Dr. Wang: You can see, we continue follow-up like this. The EKG follow-up is not very accurate and we usually put the patient on the Holter for 3–6 days, 1 year – and after that we probably do not follow-up too much.

Dr. M. Mariani (Groningen, Netherlands): I just had a methodological comment on your paper, which is, I fully agree with the third conclusion you do, because it will be more convincing in your series if you could add a randomized group in which you just do the maze procedure without reducing the left atrial appendage, because we don’t know if those good results are due only to rate of surgery.

Dr. Wang: We did have the control group. We’re going to present at the AATS next year. We have the 322 patients, we have a control group, yes.