Excellent results for atrial fibrillation surgery in the presence of giant left atrium and mitral valve disease

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Abstract

Objective: The incidence of sinus conversion in the enlarged left atrium after atrial fibrillation surgery is reported to be low. The purpose of the current study was to investigate the effects of atrial fibrillation surgery on mitral valve disease associated with a giant left atrium (GLA).

Method: From July of 1997 to February of 2002, 188 patients received mitral valve and atrial fibrillation surgery. The patients were placed in either GLA group (n = 94), or NGLA group (n = 94), based on LA size. The presence and onset of sinus rhythm and the incidence and velocity of transmitral A waves were monitored during the early postoperative period and throughout the follow up period of 42 months.

Results: The onset of postoperative sinus rhythm was slightly earlier in the NGLA group than in the GLA group at 1.3 ± 0.4 days versus 3.1 ± 1.2 days, respectively, (P = 0.008). The sinus conversion rates in the GLA and the NGLA groups were 91.5 and 97.9% in the early postoperative period and 94.7 and 95.7% at 6 months after surgery, respectively. A wave appearance rates in the early postoperative period in the GLA and the NGLA groups were 62.2 and 71.7%, and continued to improve over time to 94 and 95% by 36 months, respectively. Peak A wave velocities in the early postoperative period in GLA and NGLA groups were 67.4 ± 34.0 and 61.1 ± 29.5 cm/s without significant change during the follow up. Conclusion: The results suggest that atrial fibrillation surgery is effective at inducing sinus rhythm and restoring left atrial contractile function after concomitant mitral valve surgery regardless of LA size.

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Keywords: Maze procedure; Mitral valve surgery; Atrial fibrillation

1. Introduction

The maze procedure is currently the standard against which the effectiveness of all other modifications or methods of atrial fibrillation (AF) surgery are measured. Surgical indications have gradually expanded over the years to include more and more situations requiring surgical treatment for atrial fibrillation, and the results have been satisfactory in terms of sinus rhythm conversion and restoration of mechanical atrial contractile function [1].

The incidence of chronic AF at the time of mitral valve surgery is approximately 30–50% [2]. Moreover, the persistence of AF after mitral valve surgery increases the postoperative morbidity and mortality rates [3]. As spontaneous sinus conversion after mitral surgery alone is rare, additional intervention, such as the maze procedure, is required to terminate the atrial fibrillation, thereby enhancing long-term quality of life [4]. However, sinus conversion is not always assured as factors such as advanced age, low atrial fibrillation wave (f-wave) voltage, long-standing AF, and increased cardiothoracic ratio (CTR) may lead to maze procedure failure [5]. The presence of a giant left atrium (GLA) is also a strong independent risk factor for maze procedure failure. Consequently, there has been a tendency to perform the maze procedure selectively to avoid
these and other risk factors [5–7]. On the other hand, our experience has produced good results with atrial fibrillation surgery regardless of LA size. The aim of the current study was to compare and assess the effectiveness of AF surgery for the restoration of electro-mechanical sinus rhythm in patients with or without ‘giant’ LA.

2. Patients and methods

From July 1997 to February of 2002, 188 patients undergoing mitral valve and AF surgery were case matched for age, sex, and duration of AF. There was no isolated AF and the AF duration was determined by counting from the first time the patient was aware of any irregular heart beat or from when the diagnosis of atrial fibrillation was documented in the medical records, which ever was first. The patients were divided into two groups based on left atrial (LA) size. GLA group (n = 94) patients had ‘giant’ left atria where-as NGLA group (n = 94) patients had normal sized or enlarged LA, in which the enlargement did not reach proportions to meet the criteria of a giant left atrium. The only notable difference in the patient demographics of the two groups was in the LA dimensions (Table 1). The left atrium was diagnosed as giant if its antero-posterior diameter on parasternal long axis view was greater than or equal to 60 mm at end systole, the left atrial posterobasal segment exceeded 30 mm in the long axis view [8,9] or if the LA was dilated and excessively thin walled. In the GLA group, the left atrium was greater than 70 mm in 35 patients and greater than 105 mm in one patient.

The procedures performed concomitantly with AF surgery in the GLA group were mitral valvuloplasty (MVP, n = 61) and mitral valve replacement (MVR, n = 33). Additional procedures consisted of either isolated or combined procedures associated with the aortic or tricuspid valves (n = 46), CABG with or without aortic or tricuspid valvular procedures (n = 4), combined redo mitral valve and tricuspid valve surgery (n = 10), or other procedures (n = 10).

Echocardiography was performed early and 6 months postoperatively, and then annually. Patients were monitored for the presence of transmural A waves and the magnitude of peak A wave velocity.

2.1. Surgical technique

Prior to January 1999 the ‘conventional’ Cox Maze III procedure [3] was performed for atrial fibrillation (AF) and after this period a ‘modification’ of the maze procedure was adopted, the details of which have been described earlier [10]. In brief, the modification, which was designed to enhance left atrial function after the maze procedure, attempted to minimize the obligatory left atrial tissue mass incorporated in the area of the pulmonary vein isolation by tightly encircling the pulmonary venous orifices, replacing sharp incisions with cryothermia wherever possible, and reducing the left atrial size with generous resections of redundant atrial tissue in the posterior left atrial wall parallel to the posterior mitral anulus. The result was superior preservation of left atrial functional integrity, - and structural contiguity, and a better preservation of the arterial blood supply to both the left atrium and the sinus node. Cryoablation of the right atrial isthmus was thoroughly performed to prevent postoperative atrial flutter. To ensure transmurality of the cryoablation, the duration of cryoablation was adjusted according to the thickness of the atrial wall, so that thicker areas received longer cryoaulation. Specifically, the cryoaulation at −60 °C was timed for 2 min only after transmural freezing was noted by visually observing stiffening and a whitish color change in the atrial tissue.

2.2. Postoperative management and OPD follow up

All patients were placed on DDD pacing until a normal sinus rhythm was restored. The onset of sinus restoration was confirmed by standard 12 lead EKG taken every 12 h. However, EKG monitoring was continued for several days even after sinus conversion was confirmed, as the transient arrhythmogenic tendencies of the operated atrial tissue tended to persist for some time after surgery.

Indications for amiodarone included; failure of postoperative sinus conversion, persistent atrial fibrillation, atrial tachycardia, frequent atrial premature beats, and recurrent atrial arrhythmia. Once amiodarone was initiated, it was continued for 6 months. MVP patients were routinely anticoagulated with coumadine for 3 to 6 months postoperatively. The INR was targeted at 1.5–2.0 at the discretion of the attending surgeon.

Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>GLA (n = 94)</th>
<th>NGLA (n = 94)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>45.7 ± 13.0</td>
<td>49.8 ± 11.5</td>
<td>NS</td>
</tr>
<tr>
<td>Female (%)</td>
<td>54(57)</td>
<td>63(67)</td>
<td>NS</td>
</tr>
<tr>
<td>Rheumatic (%)</td>
<td>65(69)</td>
<td>61(65)</td>
<td>NS</td>
</tr>
<tr>
<td>AF duration yrs.</td>
<td>5.0 ± 4.9</td>
<td>4.2 ± 5.5</td>
<td>NS</td>
</tr>
<tr>
<td>F-wave type (fine,%)</td>
<td>48</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Preop LAD (mm)</td>
<td>67.8 ± 7.1</td>
<td>54.1 ± 4.9</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(61–105)</td>
<td>(40–60)</td>
<td></td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; GLA, giant left atrium; NGLA, non-giant left atrium; NS, not significant; Preop LAD, preoperative left atrium dimension.
2.3. Statistical analysis

Data were expressed as the means ± standard deviation, and SPSS version 10.0 (SPSS Inc, Chicago, IL) was used for the analysis. The χ² test was used for categorical variables, the Student’s t test for the assessment of continuous variables, and the paired t test and repeated measured ANOVA to compare repeated data within a group. A P value of 0.05 or less was considered significant.

3. Results

Mean follow up duration was 42 ± 14 months. The onset of sinus conversion was significantly earlier in the NGLA group (P = 0.008), but the differences between the two groups at discharge and 6 months postoperatively in terms of sinus conversion rate were insignificant (Table 2).

Preoperatively, the LA was enlarged in both groups, but it was significantly larger in the GLA group (67.83 ± 7.14 mm) versus NGLA group (54.07 ± 4.95 mm), as shown in Fig. 1. However, the LA was reduced to near normal dimensions in the early postoperative period in both groups to 46.2 ± 5.57 mm in the GLA group and 42 ± 5.9 mm in the NGLA group, at which point no significant differences were observed between the two groups (P = 0.615). Furthermore, the initial decrease in the LA dimension seen in the early postoperative period showed no further increase thereafter, in both groups (P > 0.05 in both groups).

Complications observed in the GLA group included; bleeding (n = 5), pneumonia (n = 2), wound infection (n = 2), cerebral vascular accident (n = 1), pericardial effusion (n = 1), and permanent pacemaker implantation (n = 1). Complications observed in the NGLA group included; bleeding (n = 1), acute renal failure (n = 1), pneumonia (n = 1), CVA (n = 1), pericardial effusion (n = 3), wound infection (n = 1), vocal chord palsy (n = 2), and permanent pacemaker (n = 1). In both groups, permanent pacemaker implantation was due to sick sinus syndrome. Although ARF, pneumonia, and CVA were the most serious complications, there was just one death, which occurred in a CVA case, in the GLA group, due to massive cerebral hemorrhage. Notwithstanding, freedom from CVA was 97.8%. All other complications resolved without significant problems.

Nine patients in the GLA and six in the NGLA group remained on antiarrythmic medications (amiodarone) for more than 6 months after surgery due to recurrent AF on

Table 2
Sinus conversion comparison by group

<table>
<thead>
<tr>
<th>Variables</th>
<th>GLA</th>
<th>NGLA</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus conversion date (POD)</td>
<td>3.1 ± 1.2</td>
<td>1.3 ± 0.4</td>
<td>0.008</td>
</tr>
<tr>
<td>Sinus conversion rate (%)</td>
<td>91.5</td>
<td>97.9</td>
<td>NS</td>
</tr>
<tr>
<td>Sinus conversion rate (%)</td>
<td>94.5</td>
<td>95.7</td>
<td>NS</td>
</tr>
</tbody>
</table>

GLA, giant left atrium; NGLA, non-giant left atrium; NS, not significant; POD, postoperative day.
long term follow up. Among them, five in the GLA and one in the NGLA group returned to sinus rhythm. The overall incidence free of surgical failure, defined as the presence of medically refractory permanent AF at 6 or more months postoperatively [18] were 95.7% (90/94) and 94.7% (89/94) in the GLA and NGLA groups, respectively. There were 3 deaths in all; two in the GLA group and one in the NGLA group. In the GLA group, one patient died of intracerebral hemorrhage after hospital discharge, and another of suicide. In the NGLA group, there was one death caused by sudden tracheal bleeding in a patient undergoing prolonged ICU care for persistent atrial fibrillation post maze procedure combined with CABG, MVP, and LA aneurysmectomy.

4. Discussion

Dilatation and structural changes in the left atrium secondary to persistent LA pressure or volume overload in mitral valve disease may result in atrial fibrillation. Although the electrophysiological effects of chronic volume and pressure overloads are incompletely understood, mechanoelectrical feedback may play an important role in the development of cardiac arrhythmias [11]. Histological and electrophysiological changes in the atrial myocardium such as fibrosis, necrosis, inhomogeneous depolarization potentials, refractory periods, and unidirectional conduction block may all produce reentrant circuits leading to the eventual development of AF in these patients.

Giant LA, which is invariably associated with atrial fibrillation, is a frequent occurrence in mitral valve disease, especially in rheumatics. Its presence is usually indicative of long standing mitral valve disease with secondary changes in the atrial myocardium, such as wall thinning, which may lead to poor contractility and outcome after cardioversion or the maze procedure [5–7]. However, in the current study, no significant differences were observed between the two groups in terms of sinus conversion rate and atrial transport function. We believe that the following factors may have contributed to producing the good results in the present series, even in those with giant LA: (1) effective elimination of LA pressure or volume overloads (2) completeness of surgical ablation, and (3) aggressive left atrial size reduction.

Because an atrial-stretch mechanism is considered a primary cause of AF in mitral valve disease, the elimination of pressure and volume overloads on the LA is mandatory to prevent further atrial myocardial damage. Atrial dilatation from increased atrial pressure has been shown to greatly increase vulnerability to AF [12]. Therefore, the presence of a significant postoperative mitral valve lesion should probably not be left untreated as the mitral valve lesion may increase the likelihood of AF recurrence. Spontaneous sinus rhythm conversion has been reported with mitral valve surgery alone, but it is unlikely unless the duration of AF was short or the mitral regurgitation was purely degenerative. Studies such as those by Kalil et al. have shown mitral valve surgery alone to be inadequate to induce spontaneous sinus rhythm conversion, as most such patients remained in AF [14]. These findings point to the irreversible nature of the electroanatomical changes which result from atrial remodeling of the atrial myocardium in secondary chronic AF. Therefore, in addition to atrial fibrillation surgery, further measures to remove stressors such as mitral valve disease which may lead to pathologic changes causing atrial fibrillation should be performed.

The completeness of surgical ablation is another important consideration, which may affect AF surgery outcome. Cox noted that the maze procedure, when performed properly, cured AF in nearly 100% of cases with or without mitral valve disease, irrespective of LA size, and type of AF [15]. Therefore, lesions must be transmural and atrial lesion sets complete. Transmural lesions can be ensured either with the cut and sew technique or with 2 min of cryothermia at −60 °C on the arrested heart [15]. The lesion sets must include encircling and isolation of the pulmonary veins, excising the left atrial appendage, and isolating the RA isthmus. In an effort to further ensure transmurality, we adjusted the duration of cryoablation according to the atrial wall thickness, which was easily determined intraoperatively. Our technique involved modifications aimed at enhancing atrial transport and simplification of surgery. However, in this study, no significant differences were observed in outcome between those receiving the conventional maze procedure versus those receiving the described modified technique, probably as the degree of transmurality and completeness of atrial lesion sets were equal in both groups. The presence of preoperative sinus node dysfunction and the presence of micro-reentry circuits are conditions that may cause failure of sinus rhythm recovery, despite complete surgical ablation. These conditions, however, do not constitute AF surgical failure.

The importance of atrial size reduction during atrial fibrillation surgery and the maze procedure has been demonstrated in several series [8,16,17]. In particular, Scherer et al. showed that LA size reduction alone may be sufficient to induce sinus conversion in a high proportion of patients [16]. Similarly, others have shown AF reentrant wavelets to be inhibited by atrial size reduction [12,13]. Kobayashi et al. reported on the vulnerability to post-operatively persistent LA enlargement to AF or atrial tachycardia secondary to micro- and relatively smaller macro-reentry circuits resulting from a heightened state of automaticity and shorter refractory periods [5]. As the presence of a giant left atrium may have a contributory cause and effect relationship with atrial fibrillation, it is our contention that surgery should address not only the matter of correcting the atrial fibrillation but also reduction of the enlarged LA. Furthermore, LA size reduction may have a positive effect in restoring atrial contractile function. Yuda et al. suggested that reduction of atrial size by the maze procedure may reduce atrial wall stress and facilitate atrial contraction, as with the left ventricle after Batista’s
operation [8]. Accordingly, we adopted a policy of aggressively reducing LA size to include not only those patients meeting the criteria of a giant LA but also those patients in whom the anteroposterior diameter as measured on the parasternal long axis view and or the left atrial postero basal segment appeared greater than normal or where the LA wall simply appeared dilated and thinned during surgery.

Although the current data produced favorable results, it is insufficient to address the issue of whether the maze procedure should be extended to all giant LA patients as the current study was inclusive but not limited to those patients having severely dilated left atria. Isobe et al. suggested a higher risk of persistent AF after the maze procedure in patients having a greater than 70% CTR ratio on chest X-ray and an LA greater than 80 mm preoperatively [6]. We feel that a severely dilated and paper-like thin-walled left atrium or severely degenerated and calcified atrial tissue may be poor indications for the maze procedure, as contractility seems almost absent. In such patients, without the restoration of both electrical and mechanical functioning of the left atrium, the key objectives of atrial fibrillation surgery may not be achieved. Although we did not observe any permanent thromboembolism related stroke, we can only speculate that this favorable outcome was attributable to AF surgery, as approximately one third of all patients were on permanent anticoagulation after valve replacement.

In conclusion, the current data show no significant differences in surgical outcome between the two groups throughout the postoperative follow-up period. A notable observation was that, not only was there a progressive improvement in the sinus conversion rate, but also an improvement in the appearance of left atrial contractility over time.

Acknowledgements

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References


Appendix A. Conference discussion

Dr K. Bando (Osaka, Japan): I have two questions. One is you mentioned about the sinus restoration rate only showed six months after surgery, and what happened after six months? The reason I am asking it, in our experience of over 600 patients with the maze procedure, some of the patients with a giant left atrium, over 70 mm, still converted to A-fib after one year or a year and a half, and if you could share your experience with that.

Dr Choo: With regards to the presence of sinus rhythm after six months, is that your question?

Dr Bando: Yes.

Dr Choo: My understanding is, so far the presence of A wave appearance and sinus rhythm restoration is over 90%. However, we did have permanent pacemakers implanted in patients with giant LA, four, as a matter
of fact, and one in the nongiant LA group. However, according to the definition by Gillinov and colleagues in their recent publication in the Annals of Thoracic Surgery, we did not consider these patients with permanent pacemaker implantation as surgical failures.

**Dr J. Melo (Carnaxide, Portugal):** Those are outstanding results, which are really much better than the results reported by Dr. Cox. So I have a few questions to try to understand why you are getting such good results. Number one, your patient population; they are 45 years old on average in both groups. So this is a very young population. I believe they are mostly rheumatics, which makes the group even more difficult to treat.

I am surprised also of serving more patients with supraventricular arrhythmias like we see in those rheumatic patients, and I would like to know how you are defining sinus rhythm to be able to stop anticoagulants after surgery, because we know that after the maze operation the posterior flap of the left atrium remains 99% of the times in atrial fibrillation. So it is very dangerous to stop anticoagulants on those patients where 40% of the left atrium is in atrial fibrillation. So could you share with us a bit more your experience.

**Dr Choo:** Sorry, could you please repeat the last question?

**Dr Melo:** How do you assess after surgery that your left atrium is in sinus rhythm, because the posterior flap is always fibrillating after the maze operation, or most of the times?

**Dr Choo:** With regards to how we were able to achieve such good results, probably three factors were important. One is, by making sure no residual MR was left behind by intraoperative TEE, a driving factor for A-fib, mitral valve lesions were eliminated. Second, efforts were made to ensure transmurality of all of our ablative lesions. Accordingly, the duration of cryoablution varied with varying wall thickness of the left atrial wall. Third, by aggressively reducing the LA size, the size differences between the giant and non giant LA’s throughout the postoperative period were minimal, and this, by decreasing LA wall tension, may probably have been important in maintaining good LA contractility.