

## Long-term Results of Left Surgical Monopolar Radiofrequency Ablation in the Treatment of Chronic Atrial Fibrillation during Mitral Valve Surgery

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### ABSTRACT

**Background:** The prevalence of atrial fibrillation is high in patients scheduled for mitral valve surgery and a conventional heart operation alone cannot be relied on for SR recovery. The maze procedure using radiofrequency ablation as an energy source seems to be a promising adjunct procedure. RF ablation can be applied on either both atria or the left atrium only.

**Aim of the work:** The aim of this work is to assess the long term efficacy of surgical RF ablation in the treatment of chronic atrial fibrillation using a left atrial maze procedure in patients undergoing mitral valve surgery.

**Patients and Methods:** The study was conducted on 40 patients with chronic atrial fibrillation that had cardiac surgery for valvular disease and a concomitant left modified Maze procedure using unipolar RF ablation. The procedures took place at the National Heart Institute and Dar El Salam hospital from 2014 to 2016 and follow-up was around  $5.06 \pm 0.22$  years later using a 12-lead ECG.

**Results:** The mean age was  $39.69 \pm 9.23$  years, female/male ratio was 55/45%, AF duration was  $58.3 \pm 42.57$  months, mean left atrial size was  $5.64 \pm 0.63$  cm, mean duration of by-pass time was  $106.93 \pm 12.25$  min. Mean duration of the radiofrequency procedure was  $15.8 \pm 3.6$  min. Follow-up by 12-lead ECG strip at  $5.06 \pm 0.22$  years showed that 52.5% of patients were in SR.. There was a negative correlation between left atrial size and preoperative AF duration and sinus rhythm restoration. Preoperative mean left atrial volumes were  $108.5 \pm 33.26$  ml in patients in SR and  $151.2 \pm 38.21$  ml in patients in AF. Preoperative AF duration was  $58.33 \pm 11.59$  months in the SR group and  $79.69 \pm 31.44$  months in the AF group.

**Conclusion:** The left atrial mono-polar RF maze procedure seems to be a safe and effective surgical treatment option in patients undergoing open heart surgery for the mitral valve with a success rate of 52.5 % at 5 year post-operative follow-up in this study. It is not time-consuming and was not associated with any major complications. Left atrial size and pre-operative AF duration are predictors of success. Better results were achieved in latter patients as more familiarity and experience with the procedure was attained.

**Key words:** AF: Atrial Fibrillation, SR: Sinus Rhythm, RF: Radiofrequency Ablation

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## Introduction:

AF is the most common arrhythmia seen in clinical practice, and is responsible for significant morbidity.<sup>[1]</sup> In addition to the increased thromboembolic risk and diminished cardiac output it causes, it significantly affects quality of life (QOL) in many patients<sup>[2,3]</sup>.

AF prevalence in patients undergoing mitral valve surgery ranges between 30 and 84 %<sup>[4-6]</sup>. If permanent AF is present, the conversion to SR after a conventional heart operation ranges from 4.5 to 36 % and is less likely than that in patients with left atrial enlargement<sup>[7]</sup>.

Treatments include anticoagulation, rate control medication, rhythm control medication, cardioversion, ablation, and other interventional cardiac procedures<sup>[8-10]</sup>.

Medical treatment has its shortcomings. The pharmaceutical armamentarium currently available aims at controlling signs/symptoms and reducing thromboembolic risk. Despite being first-line treatment, the advantage of rhythm vs. rate control remains hotly debated and efficacy/safety of antiarrhythmic drugs (AAD) is a matter of concern<sup>[11]</sup>. Antiarrhythmic drug therapy is associated with a failure rate of up to 84% at two years<sup>[12,13]</sup> and anticoagulation therapy exposes patients to significant hemorrhagic risk<sup>[14]</sup>. Surgical attempts to cure AF are hence, justified.

The Cox-Maze procedure is the most effective surgical treatment for patients with chronic atrial fibrillation<sup>[15-18]</sup>, managing to eliminate arrhythmia in more than 90% of patients<sup>[19,20]</sup>. Due to its complexity and invasiveness it has been of increasing interest to try and simplify this procedure, using new and different energy sources to create ablation lines. In the late 1990s, unipolar radiofrequency (RF) was introduced, obtaining rates of sinus rhythm (SR) restoration ranging from 69% to 76.9%<sup>[19-21]</sup>. Similar results were reported by other authors using monopolar RF ablation<sup>[22-25]</sup>.

## Aim of the Work:

The aim of this work is to determine the long-term efficacy of surgical monopolar radiofrequency ablation in the treatment of chronic atrial fibrillation using a left atrial maze procedure in patients undergoing mitral valve surgery.

## Patients and Methods:

***Patients:***

This prospective study was conducted on 40 patients at the National Heart Institute and Dar El Salam hospital between August 2014 and August 2016.

Patients included in the study were between the ages of 18 and 60 and had rheumatic mitral valve disease, with or without other valvular disease, and permanent atrial fibrillation. Permanent AF was defined as AF of more than 12 months duration that did not respond to electrical or medical cardioversion.

Patients excluded from the study were those with paroxysmal or persistent atrial fibrillation, chronic renal or liver failure, redo and emergency surgeries, ischemic heart disease, and those who have had previous catheter ablation.

All patients underwent mitral valve with or without other valvular surgery and a left sided radiofrequency Maze procedure. They received amiodarone therapy for 3 months post-operatively.

Follow-up was in the out-patient clinic using a 12-lead ECG at around 5 years post-operatively.

***Operative procedure:***

All patients had either isolated mitral valve replacements or mitral valve replacements combined with other valve surgeries.

A median sternotomy was employed in all cases.

After systemic heparinization and conventional aortic and bi-caval venous cannulation cardiopulmonary by-pass was established. Systemic cooling to around 28-30 degrees Celsius was done. The conventional longitudinal left atrial incision was used to gain access to the mitral valve. Intermittent antegrade cold crystalloid cardioplegia and topical cooling were employed. Mean time between cardioplegia doses was between 20 and 25 minutes (table (1)).

The mitral valve was replaced using a metallic prosthesis in all cases.

Tricuspid valve repair was done by a conventional Devega annuloplasty. Only 3 cases had an additional commissurotomy.

The aortic valve was replaced using a metallic prosthesis in all cases.

***Radiofrequency Maze procedure:***

Before Mitral surgery, a left atrial maze procedure (Fig. (3)), using radiofrequency ablation as an energy source, was performed on the endocardial surface of the heart. Monopolar saline-irrigated cooled tip RF ablation (SICTRA) was employed using the Medtronic Radiofrequency Generator Model 68000 as an energy source (Fig. (1)).

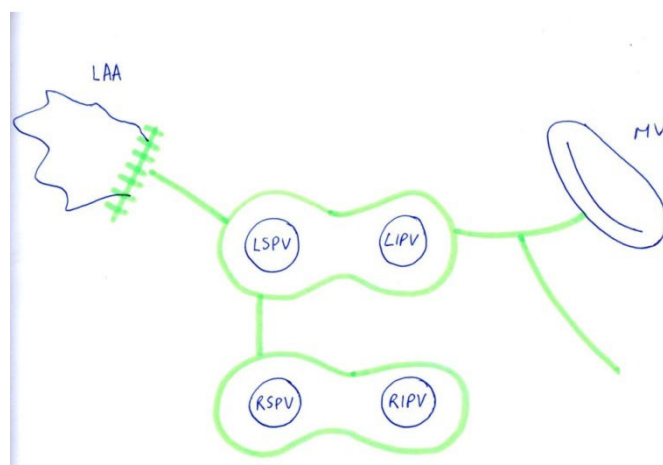


**Fig. (1): Medtronic Radiofrequency Generator Model 68000**

A voltage of 25-30 watts was adjusted according to effectiveness of ablation. Oscillatory and to-and-fro motions were employed on the atrial endocardium using the cardioblade pen (Fig. (2)) until proper blanching or whitening was achieved. Prolonged or repeated application was done when necessary in order to achieve a complete transmural scar.



**Fig. (2): Monopolar SICTRA Medtronic probe (Cardioblade pen)**



**Fig. (3): Diagram of the maze lines performed in the left atrium.** It included pulmonary vein isolation where both left pulmonary veins and both right pulmonary veins were isolated separately. A roofing line between the 2 superior pulmonary veins was done as well as two lines extending from the left pulmonary vein island, one going towards the base of the left atrial appendage and the other towards the annulus of the mitral valve at a point corresponding to the middle of the posterior

mitral leaflet. Another blind-ended line was drawn perpendicular to the line running from the left pulmonary vein island towards the mitral annulus. It ran across the isthmus and towards the area of the IVC and stopping just short of the atriotomy incision.

After the maze procedure was performed closure of the left atrial appendage was achieved using a 3-0 polypropylene purse string suture.

The maze procedure was performed by different surgeons but supervised by one surgeon.

### ***Post-operatively:***

Just after weaning from cardiopulmonary bypass I.V. cordarone therapy was administered in the operative theatre and in the ICU as follows:

-A loading dose of 300 mg over 1 hour.

-A maintenance dose of 900 mg over 24 hours.

DC cardioversion was employed once or twice to any patient that was discharged from the operative theatre in AF or that reverted to AF from SR in the ICU.

Oral amiodarone was started as soon as IV therapy ended if patient was extubated or through a ryle tube until extubation. The dose was 200 mg once daily for 3 months after surgery.

### ***Follow-up of patients:***

A 12-lead ECG Rhythm strip was done at  $5.06 \pm 0.22$  years post-operatively.

Preoperative trans-thoracic echocardiography was performed to assess left atrial size and volume.

The incidence of stroke was recorded as well as any need for pacemaker implantation.

**-12-lead ECG** was recorded on the specified timing using the SCHILLER CARDIOVIT AT-101 ECG.

-Preoperative **echocardiography** was performed by two experienced investigators using the GE VIVID 3 (General Electric) ultrasound device.

Values were obtained from a mean of 3-5 beats.

Left atrial volumes were measured by the prolate ellipsoid method using apical 4-chamber and parasternal long-axis views at ventricular end systole (maximum LA size) using the following formula:

Left atrial volume =  $0.523 \times (D1 \times D2 \times D3)$  where 0.523 is the value of  $\pi/6$ , D1 is the antero-posterior dimension, D2 is the short axis dimension and D3 is the long axis dimension.

Mitral and tricuspid flow patterns were measured in the apical view.

Time velocity integrals, E- waves and A-waves were recorded.

Atrial contraction was considered effective when an A-wave was present with an A/E ratio of 0.25 or more was present.

### ***Statistical analysis:***

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0. Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Paired sample t-test of significance was used when comparing between related sample.
- Chi-square ( $X^2$ ) test of significance was used in order to compare proportions between two qualitative parameters.
- Probability (P-value)
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant.

## Results:

**Table (1): Preoperative demographic and patient characteristics**

Parameter	Findings
Gender [F/M]	22/18 55/45%
Age (y)	39.69±9.23
BSA (m <sup>2</sup> )	1.81
AF duration (m)	58.3±42.57
NYHA Class:	
NYHA 2	14(35.0%)
NYHA 3	25(62.5%)
NYHA 4	1(2.5%)
EF%	59.38±7.66
Mean LA size (cm)	5.64±0.63
Associated TR	26 (65%)
Associated AV disease	11 (27.5%)
Hypertension	2 (5%)
History of stroke	2 (5%)
Medical therapy:	
Amiodarone	3 (7.5%)
B-Blocker	10 (25%)
Digoxin	18 (45%)
No	9 (22.5%)

t- Independent Sample t-test; \* $x^2$ -Chi-square test

**Table (2): Operative data:**

Mean duration of the radiofrequency procedure was  $15.8 \pm 3.6$  minutes.

Parameter	GROUP
MV replacement	40 (100%)
MV repair	0 (0%)
Other valve surgery	
TV surgery	26 (65%)
AV surgery	11 (27.5%)
LA thrombus removal	8 (20%)
Mean by-pass time	106.93±12.25
Mean cross-clamp time	78.13±12.84
Mean ICU stay (d)	2.69±0.96

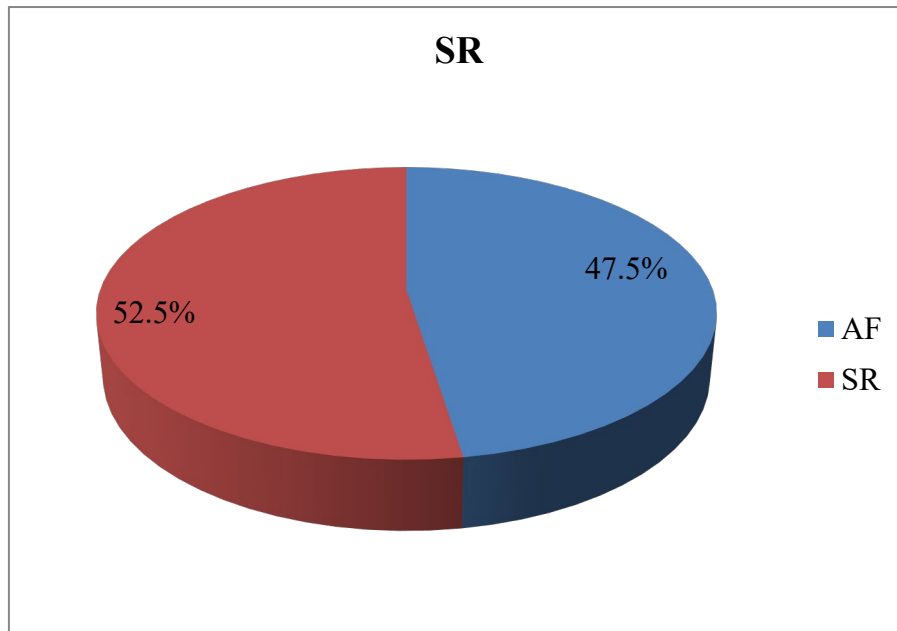
t- Independent Sample t-test; \* $\chi^2$ -Chi-square test

### Sinus rhythm restoration:

Cardiac rhythm was measured using a 12-lead ECG as previously described at the specified timing. (table (3) and chart (1)).

**Table (3): Proportion of patients in SR at specified timing:**

Parameter	SR (n=40)
<i>AF</i>	19 (47.5%)
<i>SR</i>	21 (52.5%)



**Chart (1): Pie chart Sinus rhythm restoration rate.**

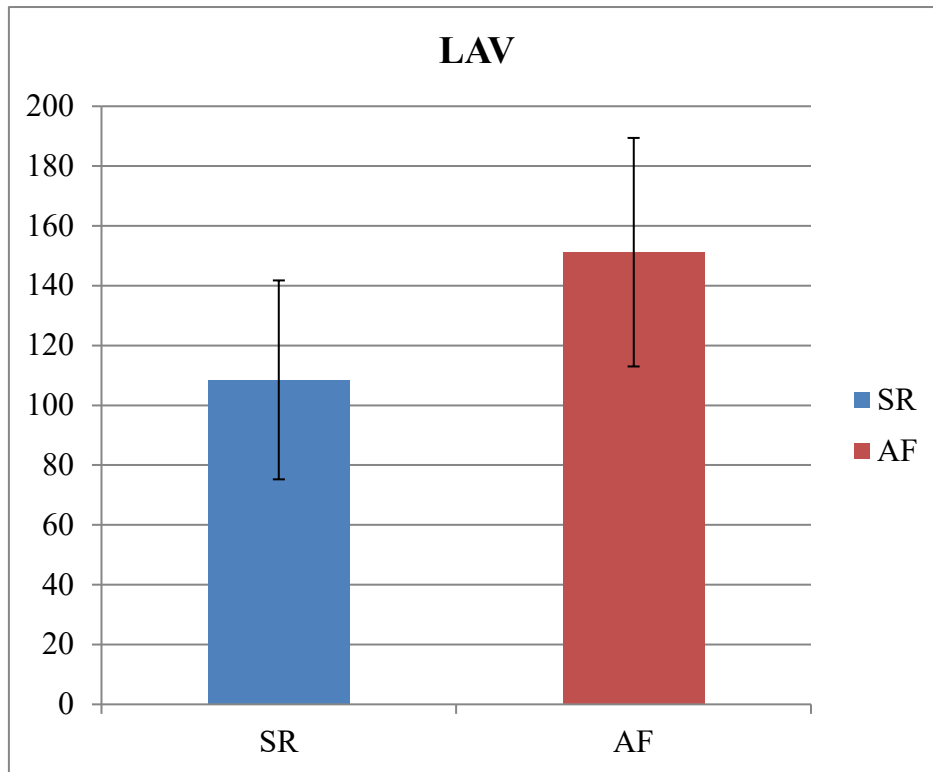
Of the patients not in sinus rhythm 1 patient presented with a supraventricular tachycardia and 2 patients with atrial flutter at around 6 months postoperatively.

**Bi-atrial contractility** was documented in all patients that regained sinus rhythm at 6 months. All patients in SR regained their atrial kick. The relation between pre-operative left atrial volume and sinus rhythm restoration was statistically significant.

**Table (4): The relation between pre-operative left atrial volume and sinus rhythm restoration**

	No.	LAV		t-test	
		Mean	±SD	t	p-value
SR	21	108.5	33.26	3.779	<0.001 (HS)
AF	19	151.2	38.21		



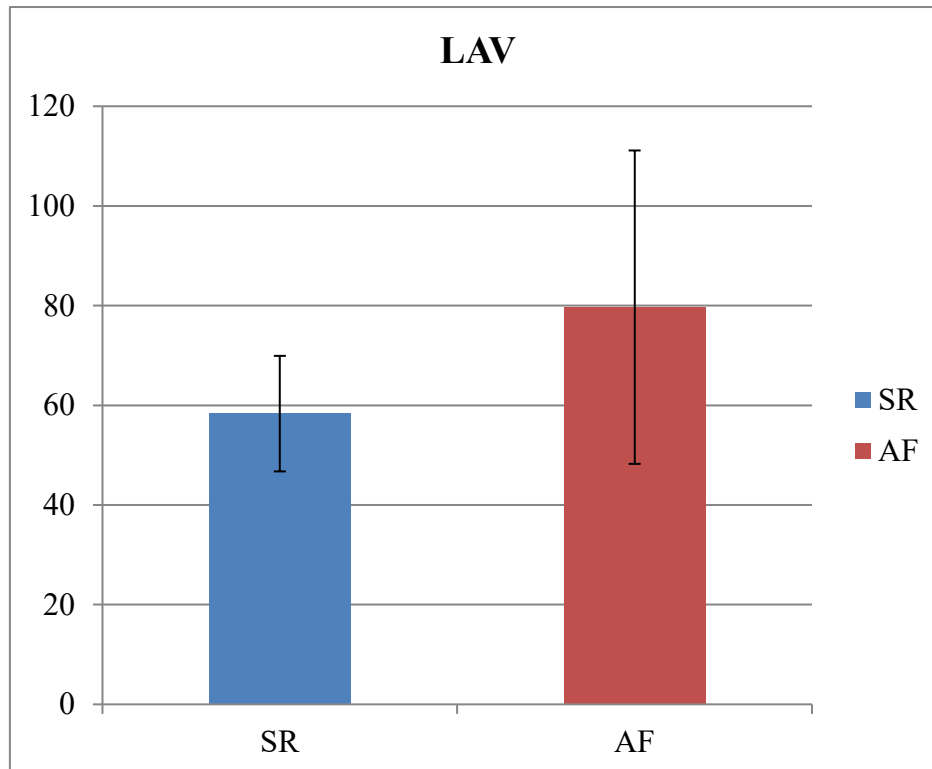


**Chart (2): The relation between pre-operative left atrial volume and sinus rhythm restoration.**

The relation between pre-operative AF duration and restoration of sinus rhythm was statistically significant.

**Table (5): The relation between pre-operative AF duration and restoration of sinus rhythm**

Group A	No.	AF Duration (months)		t	t-test p-value
		Mean	±SD		
SR	21	58.33	11.59	2.906	<b>0.006*</b>
AF	19	79.69	31.44		



**Chart (3): The relation between pre-operative AF duration and restoration of sinus rhythm in group A.**

There was no incidence of stroke however it must be noted that the patients were on anticoagulation.

No short or long-term major complications resulted from the radiofrequency procedure such as oesophageal injury, pulmonary vein stenosis or the need for permanent pacing.

One patient died 3 months after surgery due to multi-organ system failure from septic cholangitis. Another patient died suddenly 3 years post-operatively due to cardiac arrest from an undetermined cause.

## Discussion:

The left atrial maze procedure using monopolar radiofrequency ablation yields rates of sinus rhythm of higher than 50 % at 5 years, even in patients with permanent AF. We imagine these rates can be even higher as surgeons achieve more familiarity with and become more proficient at the procedure as what was seen with latter patients in this study. According to other studies, currently available ablation devices achieve an acceptable degree of sinus-rhythm conversion (45% to 95%) at mid- to long-term follow-up [25-27]. These results however, remain inferior to the results of the original cut-and-sew maze but, given the easy reproducibility and minor complications, it should not be overlooked as a treatment regimen for AF.

Predictors of failure were pre-operative left atrial volume, pre-operative AF duration provided the procedure was well-performed and that trans-mural ablation was achieved.

Longer-term follow-up could provide valuable insights into how patients' conditions unravel. Whether AF paroxysms occur during the long periods of post-procedural sinus rhythm is a question that needs to be answered. Such a finding requires long term ECG or pulse monitoring which, although challenging, can be of great benefit as it can relieve patients of anticoagulation therapy altogether, if not otherwise indicated. Also of interest is whether ablation induced sinus rhythm is different from normal sinus rhythm.

## Conclusion:

The left atrial maze procedure using monopolar radiofrequency ablation is a simple, undemanding and non-time consuming procedure that can be employed as an adjunct to mitral valve surgery. If it is more frequently employed by a larger number of surgeons more experience will be acquired in the field and this will contribute to diminishing the burden of AF.

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