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ORIGINAL ARTICLE

Maze surgery normalizes left ventricular function in patients with persistent lone atrial fibrillation†

Alberto Pozzoli[a,*], Maurizio Taramasso[a], Giuditta Coppola[a], Mikel Kamami[a], Giovanni La Canna[a], Paolo Della Bella[b], Ottavio Alfieri[a] and Stefano Benussi[a]

[a] Department of Cardiothoracic Surgery, San Raffaele University Hospital, Milan, Italy
[b] Arrhythmia Unit and Electrophysiology Laboratories, San Raffaele University Hospital, Milan, Italy

* Corresponding author. Department of Cardiothoracic Surgery, San Raffaele University Hospital, Via Olgettina 60, 20132 Milan, Italy. Tel: +39-02-26435316; fax: +39-02-26437125; e-mail: albertopozzoli@gmail.com (A. Pozzoli).

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Abstract

OBJECTIVES: The aim of this study is to evaluate the mid-term clinical and functional outcomes of maze surgery in symptomatic refractory lone atrial fibrillation (AF) patients.

METHODS: Between March 2008 and January 2013, 39 highly symptomatic patients [mean age 51 ± 10 (mean ± standard deviation); 95% CI, European Heart Rhythm Association class III–IV] underwent maze surgery for lone AF. Biatrial ablations were performed with bipolar radiofrequency and cryoenergy, according to a maze III lesion set (modified by omitting the intercaval line in 5 of 39 patients). Mean ejection fraction was 51 ± 9% (range 17–60), <45% in 10 patients (26%). Seventeen of 39 patients (44%) had persistent, 22 of 39 patients (56%) long-standing persistent AF, and 35 of 39 patients (90%) had previous transvenous ablations (median = 2; range 0–8). No patient had concomitant structural heart disease.

RESULTS: A minimally invasive approach was adopted in 22 patients (56%). Major complications were 1 mediastinitis, 1 re-exploration for bleeding and 2 pacemaker (5%) implantation. At a mean follow-up of 29.4 ± 14.2 months, freedom from arrhythmias was 92 and 93% at 24 and 36 months, respectively. Freedom without antiarrhythmic drugs was 75 and 85% at 24 and 36 months, respectively. Ejection fraction normalized in all cases, from 51.3 ± 9% to 61.1 ± 3% ($P < 0.001$) overall, and from 37.0 ± 10% to 60.3 ± 3% ($P < 0.001$) when ≤45% preoperatively. AF-related symptoms score decreased to class I in 36 patients (93%). No early or late stroke occurred.

CONCLUSIONS: Within a dedicated AF centre, maze surgery grants excellent outcomes, with symptoms relief and negligible risk. It provides a complete reversal of arrhythmia-related myocardial dysfunction and is therefore a convenient alternative to His bundle ablation and lifelong pacemaker dependency in symptomatic refractory patients.

Keywords: Electrophysiology • Arrhythmias • Minimally invasive surgery • Congestive heart failure • Maze surgery • Atrial fibrillation ablation • Transcatheter ablation

INTRODUCTION

The reported prevalence of idiopathic or 'lone' atrial fibrillation (AF) is ∼5% [1–2]. Irregular heart rhythm and rapid heart rate caused by this arrhythmia can lead to symptoms of palpitation of different severity and heart failure. The latter are due to cardiomyopathy and left ventricular (LV) dysfunction caused by high ventricular rate, also named tachycardiomyopathy, and can be totally reversed only by conversion to sinus rhythm [3–4]. In the era of catheter ablation, we face in our clinical practice very highly symptomatic AF patients, who are either refractory to multiple percutaneous ablations or very unlikely to benefit from it. One of the more troubling aspects following ineffective transcatheter ablations, particularly the extensive atrial ablations for persistent AF, is the appearance of persistent atrial tachycardias [5]. Since the results of aggressive percutaneous treatment in persistent AF forms are disappointing, ablative surgery is generally the only treatment alternative to ablation of the atrioventricular (AV) node and permanent pacemaker implantation in young symptomatic patients [6–8]. The maze procedure proved to treat AF with still unequalled excellent long-term results (up to 20 years) and is today easier and safer thanks to the latest generation ablation devices [9–10]. Thus, the purpose of this study is to report the clinical and functional outcomes achievable with maze surgery in patients with persistent and long-standing persistent lone AF, even if affected by LV dysfunction.

PATIENTS AND METHODS

Patient population

Between July 2007 and February 2013, 260 patients underwent biatrial maze surgery at our institution. Among them 43 patients

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received stand-alone maze procedure for persistent lone AF. Four of 43 patients who underwent stand-alone maze surgery were also excluded from the analysis, because they were affected by concomitant hypertrophic non-obstructive cardiomyopathies (3 patients) and previous correction of atrial septal defect (1 patient). This was done in order to obtain a cohort of 39 patients affected by true 'lone' persistent AF. All patients were operated on by the same surgeon (S.B.), according to a maze III lesion set [9] and 10 (26%) were operated on with left ventricular impairment defined by preoperative left ventricular ejection fraction (LVEF ≤ 0.45) [11].

One patient documented severe stenosis of the left pulmonary veins at admission (cardiac magnetic resonance), final result of three ineffective and extensive percutaneous ablation for persistent AF. Baseline data are listed in detail below (Table 1). Preoperative symptoms were evaluated according to the European Heart Rhythm Association (EHRA) score of AF-related symptoms [12] and the New York Heart Association (NYHA) functional classification for congestive Heart Failure.

Surgical technique

All patients had intraoperative transoesophageal echocardiography. They underwent stand-alone maze procedures either conventionally via mid-sternotomy or in a minimally invasive fashion via right minithoracotomy. Once the heart was exposed and cardiopulmonary bypass with bicaval cannulation instituted, soft tissues around the right pulmonary veins were gently dissected and the AtriCure Isolator bipolar radiofrequency (RF) clamp (AtriCure, Inc., Cincinnati, OH, USA) was used to achieve the isolation of the right and of the left pulmonary veins by epicardial clamping of the antral portion of the left atrium. After cross clamping, usually during crystalloid cardioplegia administration, a right atriotomy was performed perpendicular to the AV groove. The epicardium was entered through a small incision parallel to the groove, and the outer part of the AV groove was dissected following the plane between the sulcus fat and the atrial myocardium, to mobilize the right coronary artery from the target area on the right atrial wall to prevent inadvertent coronary injury during tricuspid ablation. The bipolar clamp was then set in place in an endo-epicardial fashion, from the atriotomy to the tricuspid annulus [13]. The same atriotomy was then connected with the inferior vena cava and (when a complete right set of lines was performed) with the postero-superior aspect of the superior vena cava in an endo-epicardial fashion during a brief period of release of the caval snare and partial occlusion of the venous cannula. After stab incision of the tip of the right appendage, the same type of dissection was carried out on the medial aspect of the right atrium, facing the ascending aorta and the anterior tricuspid ablation was performed. If deemed necessary, the distal parts of these annular lines were reinforced endocardially with a linear nitrous oxide cryoprobe (AtriCure, Inc.). An additional endo-epicardial ablation was performed from the appendage incision towards the main atriotomy. The left atrial lesion set was performed under complete cardioplegic arrest. Coronary anatomy guided the ablation strategy. In patients with right dominance or a codominant system, the coronary-free spot of the AV groove was identified and marked before ablation [14]. Then, the atrium was opened with an extended incision parallel to the Waterston groove. A mitral ablation line was then carried out by clamping the left atrial wall in an endo-epicardial fashion with bipolar RF, doubled thereafter with crioenergy. Cryoablation of the AV groove is adopted to adhere to the original maze technique, as described by Cox *et al.* [9]. It is in fact a mainstay of all known iterations of the maze operation, adopted to have a better penetration of the ablations in the thickest and fattiest area of the left atrium—namely, the AV groove—where RF might not penetrate adequately. Then, two endo-epicardial inter-pulmonary lines were performed to connect the two encirclings. One last left atrial appendage (LAA) connecting endocardial ablation was performed by clamping the device with one jaw in the appendage and one in a left PV [15]. The LAA was oversewn from inside with a watertight double-layer running suture at its base. Instead, for patients undergoing minimally invasive surgery, a 5–7 cm right minithoracotomy was performed and cardiopulmonary bypass instituted via jugulo-femoral cannulation. It was adopted a more suitable bipolar radiofrequency device, characterized by an articulated deflectable active distal element and by the possibility of deploying the device atraumatically through a glide-path (Synergy EMT1, AtriCure, Inc., Cincinnati, OH, USA). The right ablations were performed as previously described using the Synergy EMT1 and a N_2O cryoprobe. On the left, after an extended left atriotomy, the left side of the PV box ablation was completed by ablating endo-epicardially between the left PV and the left appendage with the loosened articulated head of the bipolar device set in place atraumatically on the guide of a glide-path. Such box ablation was connected to the LAA, which was then excluded, with bipolar radiofrequency. Finally, the posterior mitral annulus was electrically interrupted with linear cryoablation as previously described.

Table 1: Preoperative demographics

	Stand-alone maze (*n* = 39)
Age (years)	51 ± 10
Sex (male)	36 (92%)
Previous MI (*n*, %)	0 (0%)
COPD (*n*, %)	0 (0%)
Chronic renal failure (*n*, %)	0 (0%)
Logistic EuroSCORE	1.1 ± 0.4
AF duration months, median (IQR)	70 (44;120)
Persistent AF	17 (44%)
Long-standing persistent AF	22 (56%)
Failed AADs class I and III (*n*, %)	39 (100%)
Flutter history (*n*, %)	7 (18%)
Oral anticoagulants baseline (*n*, %)	32 (82%)
Previous transvenous ablation (median, range)	2 (range 0–8)
Severe PV stenosis after transvenous ablation	1 (2%)
CVA history (*n*, %)	4 (10%)
NYHA class III or IV (*n*, %)	5 (13%)
EHRA score III or IV (*n*, %)	30 (77%)
LVEF (%)	51.3 ± 9
LVEF ≤45 (*n*, %)	10 (26%)
LAV (ml)	80 ± 27.5
RAV (ml)	65.3 ± 17.7
IST (mm)	11.1 ± 1.28
PWT (mm)	10 ± 1

COPD: chronic obstructive pulmonary disease; AF: atrial fibrillation; IQR: interquartile range; AADs: antiarrhythmic drugs; PV: pulmonary vein. CVA: cerebrovascular accident; NYHA: New York Heart Association; EHRA: European Heart Rhythm Association; LVEF: left ventricular function; LAV: left atrial volume; RAV: right atrial volume; IST: interventricular septum thickness; PWT: posterior left ventricular wall thickness.

Postoperative care, follow-up and end points

After surgery, oral anticoagulation treatment was determined based on the CHA_2DS_2VASC score for stroke and maintained for

the first 3 months. Antiarrhythmic drugs (AADs) were continued during the first 3–6 months. All patients visited the outpatient clinic according to standard protocol of care after surgical ablation and underwent 24- or 96-h Holter Monitoring at 3, 6 and 12 months. After the first year, the follow-up was conducted annually or on indication, by 24-h Holter monitor and physical examination during outpatient visits.

Success was considered the freedom from atrial arrhythmias with a duration of >30 s, off-class I and III AADs, according to the 2012 Expert Consensus Statement on AF ablation [12].

Data analysis

Baseline descriptive statistics are presented as mean ± standard deviation or median (range) for continuous variables, if appropriate, and counts with percentages for categorical variables. Univariable comparisons were performed with Student's paired *t*-test for continuous normally distributed data, which was tested with the Shapiro–Wilk normality test. Follow-up data were censored for patients who had a first recurrence of AF or had been followed through 15th August 2013. The observation time was calculated as the time from ablation until either the occurrence of AF or the moment of censoring. The statistical software package SPSS 20 (SAS Institute, Inc., NC, USA) was used for analysis.

RESULTS

Perioperative data

A total of 39 patients underwent biatrial maze surgery using bipolar radiofrequency and crioenergy for lone refractory AF. Mean age was 51 ± 10, and 36 (92%) patients were male. There were 17 (44%) patients with persistent and 22 (56%) with long-standing persistent AF. Further, the majority of them (35 patients, 90%) had previous transvenous ablations (median = 2; range 0–8). By definition, no patient had concomitant structural heart disease. A minimally invasive maze operation via right minithoracotomy and right groin cannulation was preferred in younger patients whenever anatomically suitable, and it was adopted in 22 patients (56%). Preoperatively, no patients had a pacemaker or implantable cardioverter defibrillator implanted. Biatrial ablations were performed according to a maze III lesion set (modified by omitting the intercaval line in 5 of 39 patients). The intercaval line was omitted in patients with early persistent form as opposed to long-standing persistent AF and in patients with normal right atrial volumes. The mean extracorporeal time was 110 ± 24 min, and the mean cross-clamping time was 76 ± 23 min. LAA was excluded from systemic circulation in 36 of 39 patients (92%). Mean post-operative hospitalization was 10.6 (range 5–32) days (Table 2).

Adverse events

Neither early nor late death and stroke was registered. In 9 (23%) patients periprocedural adverse events occurred. One patient required early permanent pacemaker implantation due to sick sinus syndrome. The other was implanted 2 years after maze for primary prevention, due to asymptomatic bradycardia while on antiarrhythmic drugs. One patient had deep sternal infection and developed mediastinitis requiring surgical revision, healed thereafter without sequelae. Finally, 1 patient was re-explored for bleeding. All individual adverse events are listed below (Table 2).

Efficacy end points

After a mean follow-up of 29.4 ± 14.2 (range 5–60), freedom from arrhythmia off-AADs I and III was 80% (Fig. 1). Overall, freedom from atrial arrhythmias was obtained in 37 patients (94.8%) (Fig. 2). Over time, the percentage of patients free from atrial arrhythmias without AADs use was 80, 75 and 85% at 12 (34 patients), 24 (24 patients) and 36 (13 patients) months, respectively. With the use of AADs, freedom from atrial arrhythmias was 94, 92 and 93% at 12, 24 and 36 months, respectively. Freedom from oral anticoagulants was achieved in 30 patients (77%). Oral anticoagulants were stopped after documented stable sinus rhythm at 24-h electrocardiogram Holter and documented left atrial contractility at echo study. AF-related symptoms score decreased to class I in 36 patients (92%). AF-related symptoms score (EHRA

Table 2: Perioperative data and adverse events

	Stand-alone maze (*n* = 39)
Extracorporeal circulation time (min)	110 ± 24
Cross-clamp time (min)	76 ± 23
Minimally invasive approach (*n*, %)	22 (56%)
Left atrial appendage exclusion	36 (92%)
Concomitant procedures (*n*, %)	0 (0%)
Inotropic drugs (*n*, %)	12 (31%)
Intra-aortic balloon pump (*n*, %)	0 (0%)
Early atrial tachyarrhythmias (*n*, %)	13 (33%)
Hospitalization (days, range)	10.6 ± 5.9 (range 5–32)
Early stroke < 30 days (*n*, %)	0 (0%)
Death (*n*, %)	0 (0%)
Red blood cell transfusions (*n*, %)	3 (7%)
Pacemaker implantation <90 days (*n*, %)	2 (5%)
Mediastinitis (*n*, %)	1 (2%)
Rethoracotomy for bleeding (*n*, %)	1 (2%)
Pneumothorax (*n*, %)	2 (5%)
Renal failure (*n*, %)	0 (0%)
Total (%)	23%

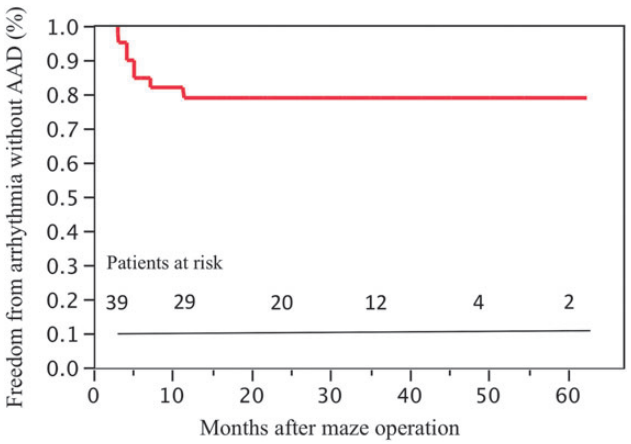

Figure 1: Success without antiarrhythmic drugs.

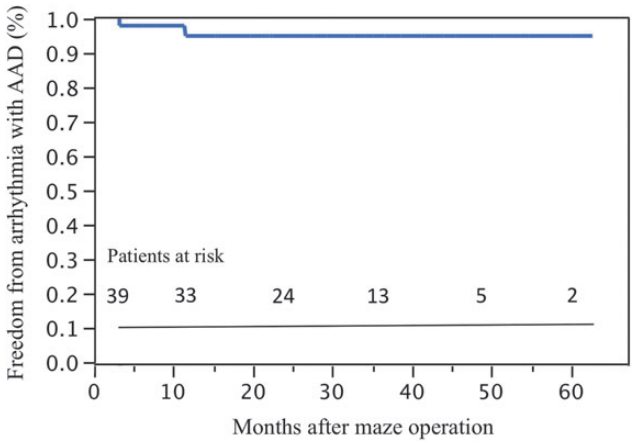

Figure 2: Success with antiarrhythmic drugs.

Table 3: Follow-up data

	Stand-alone maze (n = 39)
Mean follow-up, months (range)	29.4 ± 14.2 (range 5–60)
FFAs off-antiarrhythmics class I and III (%)	80%
FFAs with antiarrhythmics class I and III (%)	94.78%
Freedom from oral anticoagulants	32 (82%)
Mortality at follow-up (n, %)	0 (0%)
Late stroke (>30 days) (n, %)	0 (0%)
NYHA class ≤2 (n, %)	39 (100%)
EHRA score ≤2 (n, %)	39 (100%)

FFA: freedom from atrial arrhythmias; NYHA: New York Heart Association; EHRA: European Heart Rhythm Association.

score) decreased to class I and II in 39 patients (100%) and NYHA functional classification was also between class I and II in all patients 6 months after operation. There were 2 failures, both occurring during the first year (Table 3). One of these 2 patients underwent electrophysiological study immediately after recurrence, 1 year later, documenting an electrical conduction gap between the superior inter-pulmonary line and the left PV encircling (where the left atrium is very thick), successfully treated by applying a pulse of transcatheter RF. The other patients were free from postoperative DC-Shock.

Echo findings

At 1-year follow-up, compared with baseline, LVEF (%) recovered and normalized completely after conversion to sinus rhythm, passing from a mean of 51.3 ± 9 to 61.1 ± 3 (P < 0.001, Fig. 3A). When the comparison was focused on patients with preoperative LVEF ≤45%, ventricular dysfunction was normalized in all cases, passing from 37.0 ± 10 to 60.3 ± 4 (P < 0.001, Fig. 3B). All patients recovered atrial contractility during the first 3 months. Left atrial diameters and volumes significantly reduced 1 year after, passing from 42.5 ± 7.5 to 41.1 ± 6.7 (P = 0.005) and from 80.2 ± 27.5 to 73.1 ± 19 (P = 0.002), respectively (Table 4).

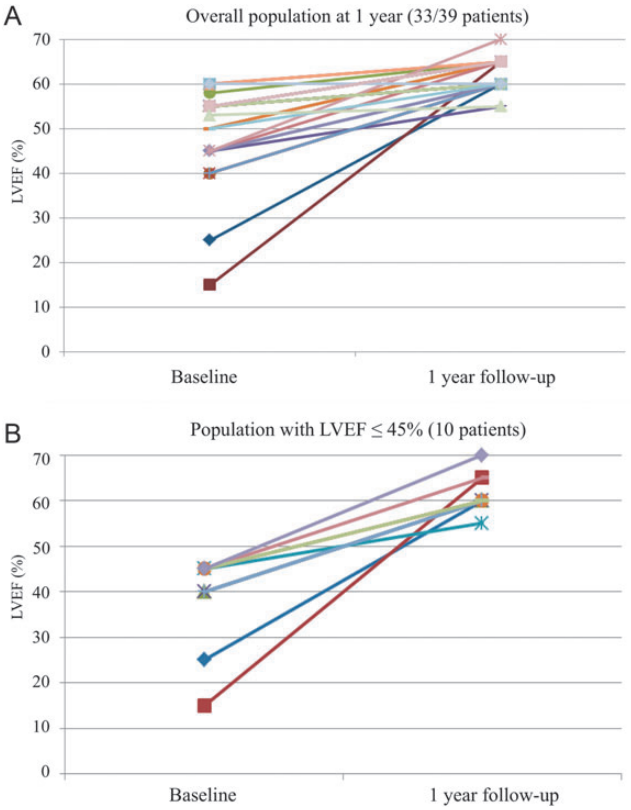

Figure 3: (**A**) Normalization of LV function at 1 year after maze surgery in overall populations (33 of 39 patients). (**B**) Normalization of LV function at 1 year after maze surgery in patients with LVEF less than 45% (10 patients).

Table 4: Echo findings and comparison baseline versus 1-year follow-up (33 patients)

	Baseline	1 year	P-value[a]
LVEF (%)	51.3 ± 9	61.1 ± 3	<0.001
LVEF ≤45 (%)	37.0 ± 10	60.3 ± 4	<0.001
LVEDD (mm)	51.1 ± 6	50.7 ± 4.8	0.029
LVESD (mm)	33.5 ± 6	33.1 ± 5.2	0.080
LAD (mm)	42.5 ± 7.5	41.1 ± 6.7	0.005
LAV (ml)	80.2 ± 27.5	73.1 ± 19	0.001
sPAP (mmHg)	29.2 ± 4.8	31.6 ± 3.5	0.002

[a]Student's paired t-test.
LVEF: left ventricle ejection fraction; LVEDD: left ventricle end-diastolic diameter; LVESD: left ventricle end systolic diameter; LAD: left atrial diameter (parasternal and end-systole measurement); LAV: left atrial volume; sPAP: systolic pulmonary artery pressure at rest.

DISCUSSION

The main outcome of our study is that maze surgery yields excellent outcomes in the very challenging context of symptomatic refractory persistent lone AF. Overall, freedom from atrial arrhythmias was obtained in 37 patients (95%), while the overall success off antiarrhythmic drugs was 80%. Interestingly, after maze surgery LVEF recovered significantly in the overall group (P < 0.001) and this improvement was particularly evident in those patients with

significant impairment of LVEF due to tachycardiomyopathy (26% in our series). Basically LV function normalized in all cases, with no exceptions. Most patients became asymptomatic after maze surgery, with a consistent improvement in quality-of-life and AF-related symptoms [16, 17]. Previously, Stulak *et al.* [18] reported improvements in ejection fraction in patients following the classic cut-and-sew maze, although it was carried out in a series of patients mostly undergoing concomitant cardiac procedures. Also, Ad *et al.* [16] from the Inova Heart Center reported on a similar series, with low-ejection fraction and long-standing persistent AF, undergoing surgery for structural heart diseases and concomitant AF ablation. They both showed that the ablative maze could be performed safely and with a high success rate.

The 2006 American College of Cardiology/American Heart Association/European Society of Cardiology Guidelines for the Management of patients with AF postulated that drug-refractory, symptomatic recurrent AF should be given catheter ablation, the maze operation or AV nodal ablation and pacing [19]. Although this last strategy might be effective in controlling palpitations in elderly patients, ablation of the AV node and pacemaker implantation does not restore LV function and exercise capacity as effectively as ablation-mediated sinus rhythm recovery. Our group previously showed that recovering sinus rhythm (successful AF ablation) was one of the predictors of effective reverse LV remodelling in patients with advanced dilated cardiomyopathy undergoing mitral valve repair [20]. This notwithstanding, the 'ablate and pace' strategy includes other important drawbacks like lifelong pacemaker dependency (infection risk or need of multiple implant procedures) and the persistent need for anticoagulation, with the related risk of haemorrhage [21].

Actually, maze surgery compares favourably also with catheter ablation. A retrospective analysis of AF ablation experience at the Mayo Clinic revealed that freedom from recurrent AF after maze surgery was three times more effective, without increasing procedural risks, when compared with catheter ablation (87% success at 5 years after maze and 28% after catheter ablation, off-antiarrhythmic drugs) [22]. Maze surgery results in a greater freedom from AF and less medical treatment with antiarrhythmic drugs and oral anticoagulation (~80% free from warfarin in our series). The value of our finding is particularly relevant, since the results of transcatheter ablations in patients with refractory persistent AF are particularly disappointing. Recent series demonstrate 5-year outcomes in the range of 45% with antiarrhythmic drugs, even in highly specialized centres and despite an aggressive strategy with multiple repeated transcatheter ablations [6, 7]. For these reasons, long-standing persistent AF has been recently termed the 'Metastatic Cancer of Electrophysiology' by the arrhythmological community [23]. Although there are the usual expectations about technological advance, possibly prompting some degree of improvement in the clinical results of catheter ablation of persistent AF, at present, at least 50–60% of the patients are likely not to benefit from it. A quite paradigmatic case is represented in our series by a 35-year-old patient affected by refractory long-standing persistent AF. He had received 4 catheter ablations (!) only to develop during months severe tachycardiomyopathy (preoperative LVEF 26%), becoming eligible for heart transplantation. He underwent maze surgery and is now in sinus rhythm with no drugs and a normal LV function.

The maze, performed at any stage of the disease should be considered the first alternative to transcatheter ablation for young refractory symptomatic AF patients.

A state-of-the-art competence in maze surgery should definitely be available within a dedicated Arrhythmia Team, to manage persistent refractory AF patients appropriately, according to a patient-centred treatment strategy.

Limitations

This study has several limitations. Surgery was performed in an AF-dedicated center and the results may not be reproducible in a low-volume centers. This is a small retrospective study and patients were carefully selected.

CONCLUSION

Within a dedicated AF centre, ablative maze surgery grants excellent outcomes, with symptoms relief and negligible risk. It provides a complete reversal of AF-related myocardial dysfunction and is therefore a convenient alternative to His bundle ablation and lifelong pacemaker dependency in symptomatic refractory patients.

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Conflict of interest: Stefano Benussi has a financial relationship with St Jude Medical Inc., AtriCure Inc., Medtronic Inc., CryoCath Inc. and Edwards Lifesciences Inc. The other authors report no conflicts.

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APPENDIX. CONFERENCE DISCUSSION

Dr T. Folliguet *(Nancy, France)*: Obviously, this is very nice result, but it is a very selected population. The left atrium mean is around 42 mm, and this may explain in part the excellent results that you had. Also, 50% were minimally invasive. I have a couple questions.

Number one: How did you select the minimally invasive versus sternotomy, and was there any difference between the two groups in terms of result? Number two: Did you look at a wave in the echo? Because we know sometimes you can have a sinus rhythm, but the atrium is not really functioning. And that's a very important question. And also, I'm surprised that you have no left atrial flutter, because after this procedure, in about 10% of the cases, you do have some kind of left atrial flutter. And finally, even though the results are good, you still have nine complications, which is about 23%. Some of them are not important, but you still have a mediastinitis.

My recommendation would be, if you really want to increase the number of patients that the cardiologist can send us, to try to do them off-pump, because there are other techniques where you don't have to open the left atrium and where you can do most of this totally off-pump.

Dr Pozzoli: In terms of outcome, there were no differences between the minimally invasive patients and those undergoing mid-sternotomy. We had one failures for each group. Regarding the indication, normally a minimally invasive approach is preferred for patients with only persistent AF if they have suitable anatomical confirmation. Concerning the absence of left atrial atypical flutter at follow-up, I think it depends on how the mitral ablation line is reinforced with cryoenergy. Dr Benussi does this very meticulously; he always uses the cryoenergy to complete this line till the mitral ring, both endocardially and epicardially, after the RF ablation. In this way you should literally close all the electrical gaps. The last question was concerning the left atrium.

Dr Folliguet: In any way, did you have an echo? Were the atria functional?

Dr Pozzoli: We had some transient dysfunctions at discharge echos, but no more detectable lately at follow-up. So they recovered.

Dr N. Ad *(Falls Church, VA, USA)*: I think for those of us who are not dealing with these types of patients, their complexity is significant. Some of the questions that were asked are completely appropriate for normal LV function patients with AF, but may not be applicable for this type of patient and procedure.

We presented at this meeting, I think, three or four years ago, a large series of low EF patients who had surgical ablation for AF, which were very challenging. Let me ask you one question.

We know that patients coming to the operating room with 15% or 20% ejection fraction due to tachycardia-induced cardiomyopathy should have a maze procedure, which in this case can be completely justified. A full maze procedure is the only way to cure them and have a shot at improving their EF. What type of discussion do you have with them prior to surgery about the potential for LVAD at the end of the procedure? Because sometimes, as we know, tachycardia induced cardiomyopathy can be malignant and may not be cured immediately. So I think from that perspective, I would be interested in how you deal with those patients preoperatively.

Dr Pozzoli: How we deal with them when we are considering these complex patients?

Dr Ad: You take someone with 15% ejection fraction to the operating room, which is a challenging procedure, and you know that there is a possibility they may not come off bypass. So what do you discuss with them with regard to the other options? Do you tell them that they may come out of the operating room with LVAD?

Dr Pozzoli: That counterpulsation is an option, but I'm not sure I understand your question.

Dr Ad: I find it challenging. I have a large group of patients that I operate on with this particular problem. And you know that you may have significant problems when you come off bypass. So the question is: What did you discuss with them, with the family, with the cardiologists, about the options?

Dr Pozzoli: Actually, the discussion with the family of these patients was done by Dr Benussi.

Dr S. Benussi *(Milan, Italy)*: The two worst cases I remember were two very young patients, which might serve as examples to also answer Dr Folliguet's question about selection: sternotomy versus thoracotomy. I would never operate on a 15% ejection fraction patient via thoracotomy, for instance, even if he is young because even if thoracotomy implied only 10 minutes of prolongation of cross-clamp time, that can be the difference between life and death. And considering these patients, we were, however, very optimistic about the possibility of recovering a good function after the acute phase.

The first one that Alberto Pozzoli showed you in detail had come to the hospital with a very severe tachycardiomyopathy after three ablations, and left ventricular ejection fraction was 10% when we first observed him. We put him under rate control with a heavy beta blocker regimen, and he recovered some 17% ejection fraction in a few days. So we had good reasons to think that he had a good chance of recovering his heart function.

And the other was another male patient about the same age, in his 40s, with 25% ejection fraction. Likewise, he was referred for open ablation after three failed percutaneous ablations, he recovered acutely with inotropes and an intra-aortic balloon. They both recovered pretty soon after surgery. Actually, in the ICU with a normal rate, the function was already much better. At three months their ventricular function normalized.

If I were to deal with even worse patients than these, I would probably be skeptical about open ablation surgery, and would consider other options, or discuss, as you suggest, further increase of the invasiveness with the patient before surgery.