

Surgery for Atrial Fibrillation: Selecting the Procedure for the Patient

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Abstract

This manuscript aims to review the current knowledge in the field of surgical ablation of atrial fibrillation (AF), including a brief discussion regarding the standard Maze procedure, its variants, minimally invasive thoracoscopic procedures and hybrid treatments, which briefly summarizes the advantages and differences between each technique. The rationale for the surgical approach of the left atrial appendage, its different techniques and complications will also be briefly covered. To conclude, the current Expert Consensus recommendations will be reviewed and an algorithm for the surgical management of the patient with AF, suggesting which technique applies better to which patient, under specific settings, will also be proposed.

Introduction

Atrial Fibrillation (AF) is the most frequent sustained arrhythmia and a major public health issue in terms of increased morbidity and mortality.¹ Antiarrhythmic drugs have been widely used to prevent recurrences of AF and mitigate symptoms, but their efficacy is limited. Furthermore, the effect of these drugs on mortality and other clinically relevant outcomes (such as stroke, embolism or heart failure) is clearly unsatisfactory. Therefore, surgical and percutaneous ablation techniques have grown significantly in the last decades. Surgical treatment has undergone significant advances over the past years and the number of recent publications and surgical techniques is overwhelming, leading to an ill-defined "state of the art". This manuscript aims to review the current knowledge in the

field of surgical ablation of AF, including a brief discussion regarding the standard Maze procedure, its variants, minimally invasive thoracoscopic procedures and hybrid treatments which briefly summarizes the advantages and differences between each technique. The rationale for the surgical approach of the left atrial appendage (LAA), its different techniques and complications will also be briefly covered. It is not our aim to provide an extensive and detailed review of the different surgical techniques. An additional purpose will be to summarize the current Expert Consensus recommendations and propose an algorithm for the surgical management of the patient with AF, suggesting which technique applies better to which patient, under specific settings.

Techniques For Surgical Ablation Of Atrial Fibrillation

The Maze Procedure

Cardiac surgeons were the pioneers of curative ablation of AF. Their interest began in the 1980's when Cox and associates introduced the left atrial isolation procedure, a technique that allowed restoration of regular rhythm and confining AF to the left atrium in dogs.² Later, in 1985, Guidaron introduced "the corridor procedure", an open-heart technique that divided the atrium in 3 compartments: right atrium, left atrium and a corridor from the sinus to the atrioventricular node.³ In this procedure sinus rhythm in the corridor was preserved while atrial synchrony was lost. Some of the disadvantages that were pointed to these procedures were the absence of atrioventricular synchronism and the remaining vulnerability to systemic thromboembolism.

Key Words:

Atrial Fibrillation, Surgical Ablation, Cox-Maze Procedure, Pulmonary vein isolation, Minimaze, Minimally invasive ablation, Hybrid procedures

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None.

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The Maze procedure was introduced in humans in 1987 as the first surgical treatment for AF by Cox and colleagues.⁴ The procedure consisted in interrupting all macro re-entry circuits associated with the development of atrial flutter or AF. The surgical strategy consisted in creating multiple incisions that could block all possible macroreentrant circuits and direct the propagation of the sinus impulse throughout both atria. Lesions were created by a “cut and sew” method (used in the Cox-Maze I to III procedures), performed under direct vision, which had the advantage of increasing the probability of achieving transmural. Excision of the LAA was also performed alongside. One of the main advantages of this surgery when compared to its previous counterparts was the freedom from stroke.⁵

Unfortunately, this procedure (the Cox-Maze I) resulted in occasional left atrial dysfunction and the frequent inability to generate adequate sinus tachycardia in response to exercise. In order to overcome these limitations, the Cox-Maze II procedure was developed. It excluded the sinus node incision and relocated the left atrium dome transverse atriotomy to a more posterior location. Later, the necessity of complete transection of the superior vena cava to complete the treatment was confirmed and the initial method was perfected giving birth to the Cox-Maze III. The septal incision posterior to the superior vena cava orifice allowed the long-term preservation of atrial transport and sinus node function, decreasing the need for a pacemaker and the recurrence of arrhythmia, while improving the speed of the procedure.⁶ In 1999, Cox et al modified the Cox-Maze III to a minimally invasive approach using a 7 cm right submammary incision.⁷

Despite the proven efficacy of the Cox-Maze III, the procedure was not widely accepted. The reasons for that were its technical complexity and risks for the patient due to the number of atrial incisions. The reported 30-day mortality rates varied from 0-7.2%⁸ and complications such as iatrogenic injury of the sinus node requiring postoperative atrial pacemaker implantation (6% reported by Cox JL et al.⁵ and 3.2% in Mayo Clinic experience⁹), stroke and bleeding were something to be taken into account.

Many attempts were made to improve the simplicity of the treatment. The most obvious change was to replace lines of incision by lines of transmural necrosis using other energy sources. The Maze IV procedure was initially tested in a series of 40 patients from January 2002 to October 2003.¹⁰ It preserved the entire lesion set of the Cox-Maze III procedure, but used bipolar radiofrequency instead of the cut-and-sew technique. Unipolar technology (cryoablation) was used for the valve annuli. There were only two small atriotomies and the LAA could be excised or ligated. It was performed by median sternotomy or a small right thoracotomy and despite the fact that the pulmonary veins could be isolated in the beating heart, it still required a cardiopulmonary bypass for the remaining lesions.

A systematic review from 2005 comprising 3832 patients compared the classical Cox-Maze III with procedures that used alternative sources of energy (cryo and radiofrequency ablation) but found no significant differences as far as postoperative sinus rhythm conversion rates were concerned.¹¹

Simplified (pulmonary vein encircling with connecting lesions) or complete modified Cox-Maze III using a diode-pump laser has also been tried. This was initially described as a single-center experience in a small set of 28 patients with concomitant mitral valve surgery

performed in 75%. Results were favorable with > 95% freedom of AF and 76% freedom of all atrial tachycardia after 6 months.¹²

Minor variations of the Cox-Maze procedure have been proposed over time, namely concerning the extension of the lesion-set. Although full-thickness incisions through the walls of both atria are usually required, Shaff HV et al. reported that incisions could be limited to the right atrium in patients with primary tricuspid valve disease.⁹ However more recent data suggested that biatrial ablation surgical procedures were more effective in controlling AF than procedures confined to one atrium (mostly the left one).^{13,14}

The presence of left ventricular dysfunction, a feature that initially raised some concerns, is not anymore considered a contraindication for the procedure and restoration of sinus rhythm can improve left ventricular ejection fraction in most patients.⁹

Pulmonary Vein Isolation, the Minimaze and other Thoracoscopic Procedures

The documentation of spontaneous initiation of AF by ectopic beats originating in the pulmonary veins¹⁵ has redirected the focus of interest to the pulmonary veins as the main target. Some years before the development of the Maze IV procedure, Queirós and colleagues developed a strategy aiming to surgically isolate only the pulmonary veins by means of radiofrequency energy. The first procedures were performed through endocardial ablation^{16,17} and subsequently epicardial ablation was used.¹⁸

Some investigators have also proposed a bilateral isolation of the pulmonary veins instead of one box lesion encircling all pulmonary veins.^{19,20} Nevertheless, a more extensive reduction of substrate mass under the critical level necessary to perpetrate AF may be necessary for AF elimination, especially in dilated atria and, therefore, additional lines between the isolated pulmonary veins and the mitral valve annulus may be considered.^{19, 20} This approach has also been shown to decrease the risk of postoperative atypical atrial flutter.

Ablation of AF through surgical pulmonary vein isolation (PVI) has some advantages compared to the standard Maze procedure.²¹ Firstly, an atriotomy can be avoided and transmural may be achieved without significant damage to the endocardium, thus lowering risk of thrombus formation (mainly when linear lesions are made in the left heart, such as during the catheter maze procedure and ventricular tachycardia ablation) and stroke (one of the most feared complications of AF ablation).²²

Secondly, ablation performed from the epicardial site limits damage to surrounding tissues (including, but not limited to, the oesophagus), since the energy vector is directed towards the atrial cavum and not away from it. Thirdly, measurements of conduction block are possible during an epicardial beating heart procedure, which may eventually help guide ablation. Additional potential benefits may arise from targeting parasympathetic innervations of the heart (through ablation of epicardial fat pads). Decreasing parasympathetic tone may shorten the atrial effective refractory period, which decreases susceptibility to AF, although the long-term efficacy of this approach is not known, as restoration of autonomic activity may occur early following ablation.

Possible lack of transmural is one of the main issues in epicardial beating heart ablation. In a histological investigation of microwave epicardial lesions in 3 non-ablation related deaths, only 3 out of 13 samples (23%) showed transmural necrosis.²³ This incomplete transmural of lesions may partly explain the existing difference in success rates between the original Maze operation and other

epicardial strategies.^{24,25}

In 2004, Cox defined the minimaze procedure as the minimal set of lesions (“pulmonary vein encircling incision, left atrial isthmus lesion with its attendant coronary sinus lesion, and the right atrial isthmus lesion”) that had to be performed to cure most patients with AF.²⁶ Moreover, he reinforced that in order to achieve this goal, energy had to be applied in the endocardium in order to overcome the presence of the left circumflex artery in the posterior mitral annulus and reach the atrial wall, something that could not be done using neither cryotherapy, unipolar, bipolar or irrigated radiofrequency, microwave or laser energy.

However, in 2002, Saltman had already developed a method for performing epicardial ablation of AF endoscopically in the beating heart, without cardiopulmonary bypass or median sternotomy.²⁷ This method used microwave energy and became known as the microwave minimaze (or micromaze) procedure. Not long after, Wolf and colleagues developed a similar procedure using radiofrequency energy instead that became known as the Wolf minimaze procedure.²⁸ In these procedures, the LAA was also frequently removed. The high intensity focused ultrasound minimaze used an ultrasonic device that was positioned epicardially.²⁹ Still, it was performed in conjunction with other cardiac surgical procedures, not being minimally invasive in those cases. These procedures have been almost restricted to paroxysmal AF and long-term results are only based on preliminary reports. Still, short-term and long-term success may range from 67 to 91%.²⁷⁻²⁹

Thoracoscopic techniques have evolved and became more sophisticated being able to track more severe substrates and severely diseased AF patients. One of the most well-known developments was the “Dallas lesion set”,³⁰ that included a more extensive set of lesions, alongside with partial ganglionated plexi de-ervation. Sirak J and colleagues introduced a true port-access procedure that was able to address both autonomic and anatomic sources of AF, incorporating PVI, mapping of epicardial autonomies, extended linear ablations and ligation of the LAA.³¹ This technique proved to be a highly effective and safe approach in patients with advanced forms of AF. The same authors also proposed a variant of the thoracoscopic technique, entitled “five-box thoracoscopic maze procedure”, in which a complete dissection of the transverse sinus and exposure of the left atrial floor enabled the creation of contiguous compartments connecting to the anterior mitral trigone and isolating the posterior left atrium, replicating the Cox Maze left atrial pattern.³² This procedure was as effective as the Cox Maze benchmark.

As these are minimally invasive procedures, comparison with other minimally invasive techniques like percutaneous catheter ablation has been performed. The atrial fibrillation catheter ablation versus surgical ablation treatment (FAST) trial was a two-center randomized clinical trial of 124 patients comparing the efficacy and safety of minimally invasive thoracoscopic procedures (Saltman and the Dallas lesion set) with percutaneous catheter ablation in a population comprising either patients with left atrial dilatation and hypertension (33%) or prior failed catheter ablation (67%).³³ The surgical treatment group yielded higher efficacy (freedom from left atrial arrhythmia >30 seconds without antiarrhythmic drugs after 12 months 65.6% vs 36.5%; $p=0.0022$) at expense of a higher adverse event rate (34.4% vs 15.9%; $p=0.027$).

The Catheter Versus Thoracoscopic Surgical Ablation Strategy

in Persistent Atrial Fibrillation (CASA-AF) atrial is currently investigating the safety and efficacy of a thoroscopically assisted surgical ablation (including PVI, ganglionated plexi ablation and LAA exclusion), while comparing it with catheter ablation. Results of this trial are expected to be available by the end of 2013.³⁴

At present, there is small amount of consistent and reproducible data on the thoracoscopic surgical techniques when compared to the standard Maze ablation, but further research may eventually provide robust data supporting its non-inferiority, allowing these less invasive procedures to become the first line approach in surgical AF ablation.

Hybrid Procedures

Hybrid procedures combining minimally invasive epicardial left atrial ablation with the endocardial percutaneous approach have been tried in difficult cases of AF.³⁵ Despite being more time consuming, some theoretical advantages that have been pointed are: maximization of the efficacy of the ablation, avoiding lesion gaps and confirming the conduction block and minimizing potential complications, such as tamponade and thrombus formation

Krul et al. have added the localization and ablation of the ganglionated plexi to this procedure and observed a high success rate of 86%, with no recurrences of AF, atrial flutter or tachycardia, out of antiarrhythmic treatment.³⁶

Pison L et al. have recently demonstrated that in 23% of patients undergoing thoracoscopic procedures the epicardial lesions were not transmural and endocardial percutaneous “touch-up” was necessary.³⁷ The one year success of this hybrid approach was reported to be 90% for persistent and to 93% for paroxysmal AF.

Excision Of The Left Atrial Appendage

In patients with AF, 90% of emboli responsible for strokes arise from the LAA.³⁸ Some investigators proposed that ligation of the LAA could reduce the risk of stroke in cardiac surgical patients with and without preexisting AF.³⁹

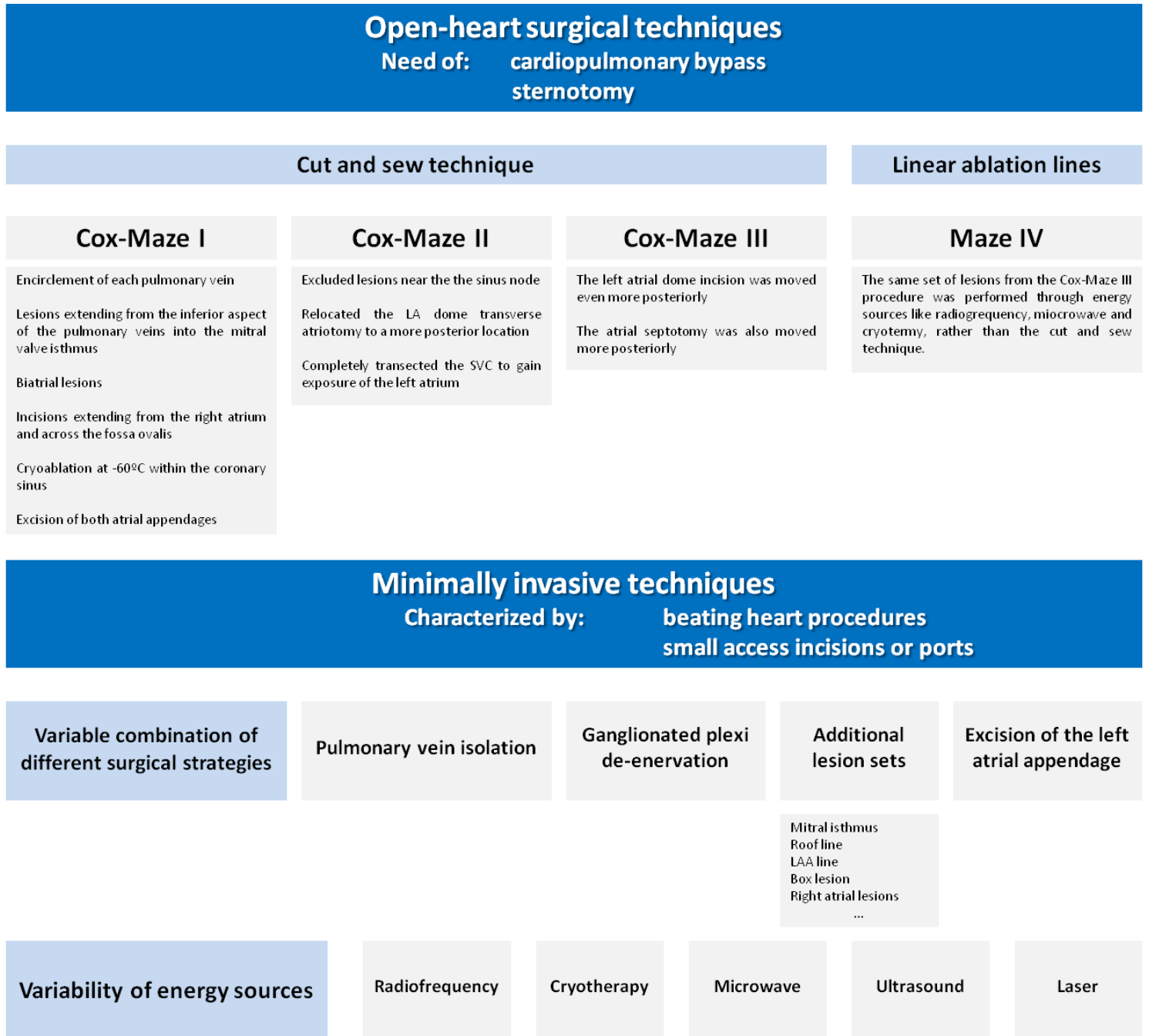
Several surgical techniques of LAA closure are used in an attempt to reduce the stroke risk, with varying and controversial success rates. The most frequent are either excision or exclusion by sutures or stapling. Kanderian AS et al. compared these techniques and reported that successful LAA closure occurred more often with excision (73%) than with suture exclusion (23%) or stapler exclusion (0%), when assessed on transesophageal echocardiogram performed 8.1±12 months after surgery. Also, LAA thrombosis was found in 41% of patients with unsuccessful LAA exclusion vs. none with excision. However, at the time of transesophageal echocardiogram, stroke or transient ischemic attack had occurred in 11% of the patients with successful LAA closure (vs. 15% in those with unsuccessful closure; $p=n.s.$).⁴⁰ In fact, incomplete suture ligation was shown to increase the risk of thromboembolism, initially in case reports⁴¹ and, years after, in a case-control study with a median follow-up of 69.4 months.³⁹ None of the currently available surgical techniques consistently guarantees a high percentage of successful closure. Despite the seemingly advantages, excision of the LAA can also lead to risk of bleeding or the theoretical possibility of thrombus formation in the LAA, in case of incomplete resection.

Therefore, even though surgical closure of the LAA, in particular its excision, seems an attractive therapeutic option in patients with AF submitted to cardiac surgery, safer and more efficient surgical techniques are still warranted.

Recently, in the “Watchman Left Atrial Appendage System for

Figure 1: Diagram illustrating some of the surgical techniques described in this revision

Legend: LA – left atrium; LAA – left atrial appendage



Embolc Protection in Patients With AF” (PROTECT-AF) trial, percutaneous closure of the LAA has shown its noninferiority vs. warfarin in patients with high thromboembolic risk, but a concomitant high bleeding risk contraindicating anticoagulation.⁴²

To the best of our knowledge there are not yet many surgeons performing this technique, whose major technical difficulty may be the transeptal puncture. However, a new technique for suture ligation of the LAA through a combined percutaneous procedure targeting the epicardium through sub-xifoid puncture and transeptal

catheterization for accessing the endocardium has shown interesting initial results (high closure rate ≥ 95 to 98% and a favorable peri-procedural adverse event rate).⁴³

A diagram describing the previously described surgical techniques and the evolution and extension of lesion sets is provided in Figure 1.

Particular Sub-Groups Of Patients

Valvular Atrial Fibrillation

The addition of the Cox Maze procedure to mitral valve repair and replacement has been demonstrated to be safe and effective

for selected patients, with a possible decrease in stroke. In patients undergoing mitral valve replacement or repair, Bando K et al. proposed that freedom from AF and stroke at 5 years was significantly higher in those that had undergone Maze procedure.⁴⁴ Von Oppell et al. demonstrated that radiofrequency maze ablation added to mitral valve surgery resulted in a higher sinus rhythm conversion rate, leading to a normalization of atrial function in 63% of the patients converted to sinus rhythm.⁴⁵ Maze outcomes are considered acceptable regardless of the type of mitral surgery (repair or replacement).⁴⁶ Preoperative left atrial size and duration of AF are the primary predictors of sinus conversion by the radiofrequency Maze procedure in patients with persistent AF and mitral valve disease.⁴⁷ In addition, AF recurrence was mainly affected by age, unfavorable electrocardiographic characteristics of AF, and larger preoperative left atrial size.⁴⁶ Even patients with chronic AF undergoing mitral valve replacement can potentially derive benefit from intra-operative radiofrequency left atrial ablation, with significant improvement of sinus rhythm restoration rate. In these patients, advanced heart failure and a significantly dilated left atrium were negative predictive factors for sinus rhythm maintenance.⁴⁸

The effectiveness of surgical ablation of AF during mitral valve procedures due to rheumatic etiology has also been studied. Canale LS et al. reported that bipolar radiofrequency ablation in patients submitted to mitral valve surgery of rheumatic etiology was effective in converting AF (including cases with the permanent form) to sinus rhythm in 68% of patients after 14 months.⁴⁹ Sternik L et al. corroborated these findings, suggesting that there was no significant difference in the efficacy of AF surgical ablation between rheumatic and nonrheumatic patients, provided that the AF was of similar type and duration before ablation. Interestingly, enlarged left atria in the rheumatic group of patients did not influence results, probably due to the author's policy of not performing ablation in patients with an extremely enlarged left atrium. Permanent AF or AF for at least 10 years before surgery were risk factors for ablation failure at early and midterm follow-up.⁵⁰

Jeanmart H et al. have demonstrated that this combined approach could be beneficial even in the minimally invasive setting. They used unipolar radiofrequency ablation to perform a mini-maze (pulmonary vein isolation) during minimally invasive mitral valve surgery with good efficacy and safety profile.⁵¹

Current evidence therefore indicates that the Cox-Maze procedure and its variants in patients undergoing mitral valve surgery (either repair or replacement) appears to be safe and effective in treating AF, even in the setting of rheumatic heart disease.

Patients Without Structural Heart Disease

Currently, there is no role for surgical ablation of AF as first-line treatment in patients without structural heart disease. However, extremely symptomatic patients in which antiarrhythmic treatment and catheter ablation fails to control symptoms may be candidates for minimally invasive thoracoscopic mini-maze procedures. This has not been addressed by previous studies, however this option may be considered before referring the highly symptomatic patient with previously failed percutaneous pulmonary vein isolation for catheter ablation of the atrioventricular node and implantation of a pacemaker. Moreover, some centers are currently using this approach rather than percutaneous ablation, under specific settings.

Patients with Recurrent Stroke

Besides data from the original patients undergoing the Maze procedure,⁵ a multicentre registry also suggests that maintenance of sinus rhythm using a catheter ablation strategy may confer a reduction in stroke and death when compared to an AF population from the Euro Heart Survey treated medically.⁵²

The ongoing Catheter Ablation Versus Anti-arrhythmic Drug Therapy for Atrial Fibrillation (CABANA) Trial is prospectively testing this hypothesis, comparing left atrial ablation vs drug (rate or rhythm control) strategy⁵³ and will probably provide definitive evidence. Meanwhile and based on these preliminary results, it is still early to refer patients for ablation in order to reduce the risk of stroke. Nonetheless, if the patient has already had previous TIA/Stroke while under oral anticoagulation and it is the patients' preference to try this approach, we believe that a minimally invasive procedure may be seriously considered.

Surgical Ablation of Atrial Fibrillation - Which Technique for Which Patient?

Current Recommendations and Practice in High-Volume Centers

The recent 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of AF⁵⁴ recommends that in symptomatic patients with AF undergoing cardiac surgery it is reasonable to perform surgical ablation of paroxysmal or persistent AF independently of treatment with anti-arrhythmic agents (IIa class of recommendation). In a patient with symptomatic and longstanding persistent AF, despite antiarrhythmic treatment, surgical ablation is considered a reasonable option (IIa class of recommendation). For this particular setting, surgical ablation may be considered even prior to initiation of antiarrhythmic medication (IIb class of recommendation).⁵⁴

A lower class of recommendation (IIb) has been attributed to stand alone surgical ablation of AF (paroxysmal, persistent and longstanding persistent) in symptomatic patients already treated with antiarrhythmic drugs: either for those who already have undergone failed percutaneous procedure or for those who chose surgery as the first approach. As a stand-alone procedure prior to initiation of antiarrhythmic drug therapy (i.e. as first line treatment), surgical ablation is not recommended (III class recommendation).

All these recommendations assume that both the patient and surgery meet the necessary requirements for procedural success: suitable atrial anatomy (LA size and fibrosis), AF time of evolution, favorable risk/benefit relation and operator experience.

It is proposed that if a PVI procedure is chosen, PVI should be achieved and ideally a connecting lesion to the mitral valve annulus should be performed. If the AF is persistent or longstanding persistent, a biatrial procedure should be considered. Moreover, complete occlusion of the LA appendage should also be considered if it can be safely performed (no class of recommendation or level of evidence for this indication).

Furthermore, no clear indications are provided in this consensus concerning which surgical technique should be used in each particular patient or setting. It is of note that the level of evidence for all the aforementioned recommendations regarding surgical ablation (either stand alone or concomitant) in the 2012 HRS/EHRA/ECAS expert consensus statement⁵⁴ results merely from expert consensus (level C), claiming for more research in this field.

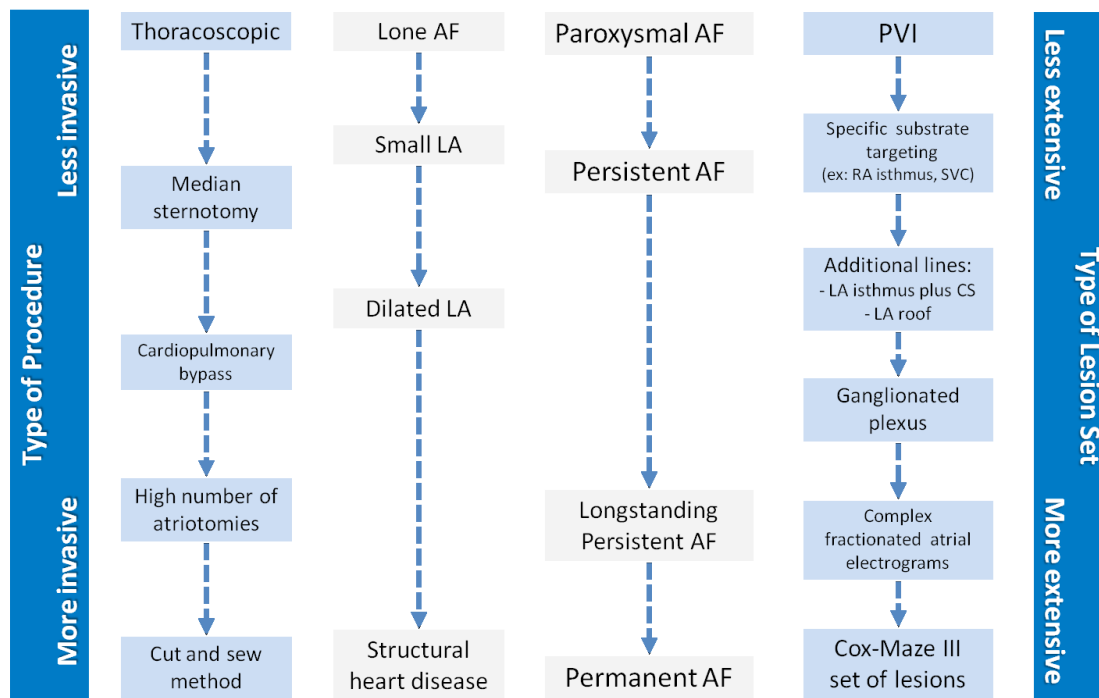


Figure 2: Schematic representation on how the type of AF and the extension of structural disease may affect the type of chosen procedure and lesion set.

Note: The authors assume that not all AF will present this type of evolution, since the disease does not always progress as a continuum. Therefore, this is just an oversimplified schematic view and approach to the complex AF patient

Legend: AF – atrial fibrillation; LA – left atrium; RA – right atrium; SVC – superior vena cava; CS – coronary sinus

Studies comparing different types of surgical AF ablation are scarce and most frequently do not comprise large numbers of patients. Besides the previously mentioned systematic review,¹¹ a single-center study by McCarthy and coworkers, comprising 408 patients, compared 5 surgical types of AF ablation (the classic maze procedure, high-intensity focused ultrasound, the left atrial maze procedure, the biatrial maze procedure and PVI) and the classic Maze procedure had the best results, with 90% of patients free from recurrent AF or from requiring a second ablation procedure.⁵⁵ Nonetheless, we are currently lacking data from multicenter trials directly comparing highly experienced centers/operators in the different techniques in a head-to-head fashion, in order to truly understand how much the technique by itself, independently from the centre and operator experience, can affect treatment success.

In a survey of European centers performing surgical ablation of AF,⁵⁶ wide variations in the technique have been described. Concerning stand-alone surgical ablation procedures, only eleven out of the 24 centers (46%) had performed this type of treatment in 2011. The most frequent indication for this was failed catheter ablation. Among the other pointed reasons, by a descending order of frequency, primary intervention for longstanding AF, patient preference and thromboembolic advantage due to LAA exclusion, were named. Nine centers (81%) used exclusively radiofrequency for these procedures, while one used only cryo energy and the remaining a combination of microwave and radiofrequency.

Three centers applied the Cox-Maze on-pump technique using radiofrequency or cryoablation in 100% of cases. Seven performed totally thoracoscopic ablation procedures (in 21 to 100% of cases). Only three centers still used the original cut-and-sew Cox Maze-III

technique, reserving it for a minority of procedures (1 to 10%). The minimally invasive Cox Maze-IV was used in two hospitals and only one center used the hybrid thoracoscopic epicardial and percutaneous endocardial procedure. There was a big heterogeneity concerning the type of performed lesions sets. Still, the most commonly performed, in five centers, was PVI alone. The remaining centers used different combinations of lesions: PVI plus box lesion (roof and inferior line), PVI plus the Cox-Maze III lesion set (restricted to the left atrium or in both atria) or box lesion and ablation of complex fractionated atrial electrograms. Confirmation of conduction block of the pulmonary veins and bidirectional block across linear lesions was performed in eight centers (73%), epicardially and endocardially in three of them.⁵⁶ All this heterogeneity and differences between centers make the task of assessing if any of the techniques or lesion sets is more effective a real challenge.

Concerning the surgical procedures on the LAA, the 2012 focused update of the ESC guidelines⁵⁷ suggests that surgical excision of the LAA may be considered in patients undergoing open heart surgery (IIb class of recommendation and a C level of evidence). Still, the guidelines reinforce that there is no conclusive evidence that surgical LAA excision or exclusion reduces stroke risk in AF patients, due to the lack of trials providing systematic follow-up and favorable data. Moreover, they reinforce that not all strokes in patients with AF are cardioembolic and that not all thrombi originate from the LA appendage. Therefore, the guidelines state that there may be a need for oral anticoagulation even in patients undergoing this type of treatment.

The previously mentioned European survey also illustrates the heterogeneity as far as the approach of the LAA is concerned. In six

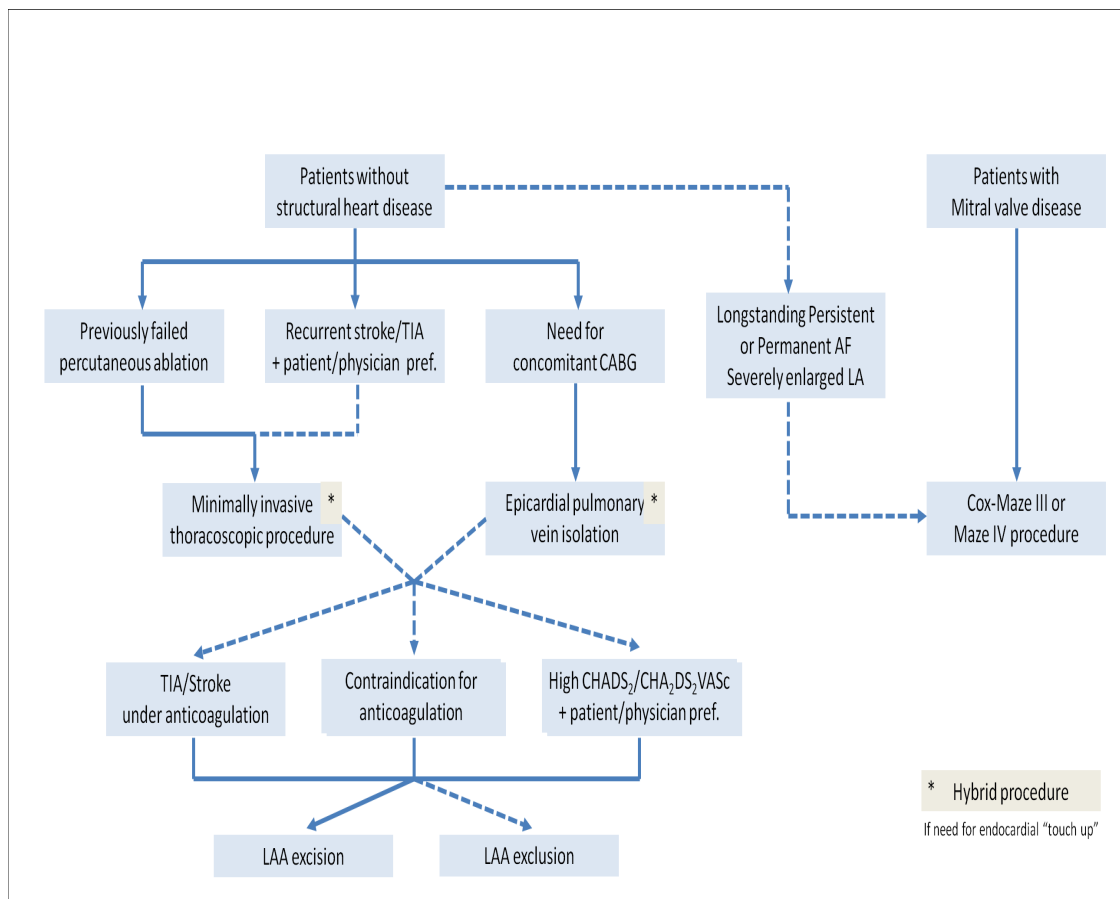


Figure 3: Framework suggesting a possible approach for patients with symptomatic recurrent atrial fibrillation despite optimal anti-arrhythmic therapy

Note: The use of epicardial PVI or a minimally invasive thoracoscopic procedure is based on the assumption that the AF is not permanent or longstanding persistent and the left atrium is not severely dilated. If this is the case a more complex lesion set should be performed. In the simpler procedures (PVI and minimally invasive thoracoscopy) LAA excision (preferably) or exclusion should be considered, namely in the presence of one of the three situations that are present in the framework. The Cox-Maze III or Maze IV procedures already routinely include this step.

Legend: Transient Ischaemic Attack; CABG - Coronary Artery Bypass Grafting; LAA - Left Atrial Appendage; LA - left atrium; Pref - preference

centers performing mostly off-pump stand-alone AF ablation, the LAA was removed or closed in all procedures in only three of them. One hospital never removed or closed the LAA and the remaining two only intervened on the LAA when the CHA₂DS₂-VASc score was ≥ 2 .⁵⁶

Algorithm for Patient Management

A simplified schematic representation on how the type of AF and the extension of structural disease may affect the type of chosen procedure and lesion set is present on Figure 2.

A possible approach for patients with symptomatic AF despite antiarrhythmic therapy and who may benefit from surgical ablation is suggested as a framework in Figure 3.

According to this, if the patient has mitral valve disease with need of surgical repair, maximum benefit may be derived from Cox-Maze III or Maze IV procedure. Patients with a severely dilated left atrium, longstanding persistent or permanent AF (i.e. those who have a higher probability of relapse) may also take advantage of this technique and its higher success rate.

Patients without structural heart disease may benefit from surgical ablation of AF in 3 circumstances: in the patient with need of coronary artery bypass grafting, the median sternotomy should be used for assessing and isolating the pulmonary veins. A minimally invasive thoracoscopic procedure should be preferred in patients

with previously failed catheter ablation or recurrent stroke despite oral anticoagulation. The indication for surgery in the latter group of patients still lacks a strong evidence support. Therefore, a strong patient preference after discussing all therapeutic alternatives and the physician's belief that treatment can be successful and safe for that specific case are two essential aspects when considering this option. In these three groups of patients, if no transmural lesions are attained during the epicardial approach, the need for endocardial "touch-up" (hybrid procedure) should be considered.

In all patients treated with Cox-Maze III or Maze IV the LAA will be either ligated or excised. However, in patients undergoing less invasive procedures, targeting the LAA should be reserved for specific settings: patients with TIA or stroke under oral anticoagulation, contraindication to oral anticoagulation or a high CHA₂DS₂-VASc, if after discussing the possible benefits and complications arising from the procedure the patient and physician consider that the overall risk/benefit ratio is advantageous. It is our opinion that in this context, LAA excision should be the preferred method.

Despite these suggestions, reflecting our personal view, we underline that the choice of the technique is highly dependent on the centre's expertise and experience. Moreover, as no contemporary trials directly compare the different surgical techniques in these

specific settings, these suggestions are not evidence based (like all the recommendations that are present on the 2012 Expert Consensus)⁵⁴ Further comparative trials are needed and should be encouraged in the future to solve this knowledge and evidence gap.

Conclusions:

Surgical ablation can offer a wide variety of techniques with considerable efficacy for the treatment of atrial fibrillation. Despite the fact that lesion set and energy modality varies widely from institution to institution, and there exists no consensus regarding the ideal lesion set or energy modality, there is common agreement that the standard Maze surgery, the mini-Maze or thoracoscopic procedures using energy sources such as ultrasound or radiofrequency are valid therapeutic approaches in symptomatic patients with AF submitted to cardiac surgery or in those with previously failed percutaneous ablation.

As a stand-alone procedure for other reasons, recommendations are not so strong, but there are specific subsets of patients that may derive a benefit from it.

Further studies are needed concerning new indications and also directly comparing the different surgical approaches, lesions sets and energy sources / cutting techniques in order to define and provide evidence support to the best treatment option for each specific type of AF patient.

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