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Society Guidelines

Canadian Cardiovascular Society Atrial Fibrillation Guidelines 2010: Surgical Therapy

Pierre Pagé, MD,[a] and the CCS Atrial Fibrillation Guidelines Committee[b]

[a] *From the Research Center, Hôpital du Sacré-Coeur de Montréal, Montreal, Québec, Canada*

[b] *For a complete listing of committee members, see Gillis AM, Skanes AC. Canadian Cardiovascular Society Atrial Fibrillation Guidelines 2010: Implementing GRADE and Achieving Consensus. Can J Cardiol 2011;27:27-30.*

ABSTRACT

Surgery for atrial fibrillation (AF) has been demonstrated as an effective treatment to restore and maintain sinus rhythm in patients for whom a rhythm control strategy is desired. It is usually offered to patients undergoing other types of cardiac surgery (eg, mitral valve repair or replacement, coronary artery bypass grafting, aortic valve surgery, intracardiac defects, ascending aortic surgery). It is also feasible as a stand-alone procedure, bearing a high success rate. In the past few years, less-invasive procedures have been described. AF is a triggered arrhythmia, resulting from ectopic activity most commonly located in and around the pulmonary veins of the left atrium. Therefore, electrical isolation of the pulmonary veins from the rest of the left atrium in order to prevent AF from being triggered is the rationale common to all surgical techniques. Further substrate modification may be required in patients with more persistent AF. This is done by adding ablation of the posterior left atrium with connecting lines of block between pulmonary veins, to the mitral valve annulus, as well as in specific sites in the right atrium. The left atrial appendage is resected or occluded at the same time. Despite patients' high rate of freedom from AF after surgery (70%–85% at 1 year), surgical ablation of AF has never been clearly shown to alter long-term mortality. The available literature supports the recommendation to stop oral anticoagulation therapy 6 months after surgery when sinus rhythm can be documented, because a very low rate of thromboembolic events is reported. However,

RÉSUMÉ

Il est démontré que la chirurgie de fibrillation auriculaire (FA) est un traitement efficace pour restaurer et maintenir le rythme sinusal chez les patients pour qui une stratégie de contrôle du rythme est indiquée. On l'offre habituellement aux patients qui doivent subir d'autres types de chirurgie cardiaque (par exemple réparation ou remplacement d'une valvule mitrale, pontage coronarien, chirurgie de la valvule aortique). Cette chirurgie est également possible en tant qu'intervention primaire et isolée et présente un taux de succès élevé. Au cours des dernières années, des interventions moins effractives ont été décrites. La FA étant une arythmie déclenchée par l'activité ectopique localisée le plus souvent dans les veines pulmonaires, l'isolation électrique des veines pulmonaires demeure le fondement habituel de toutes les techniques chirurgicales. D'autres modifications du substrat peuvent être nécessaires chez les patients présentant une FA plus persistante. Cela est fait par l'ajout de lignes d'ablation dans l'oreillette gauche postérieure entre les veines pulmonaires, vers l'anneau valvule mitrale, ainsi que dans des sites spécifiques dans l'oreillette droite. L'oblitération ou la résectionde concomitantel'appendice auriculaire gauche est fortement recommandée. Malgré le taux élevé de patients qui sont épargnés d'une FA après la chirurgie (70 %–85 % à 1 an), il n'a jamais été clairement démontré que l'ablation chirurgicale d'une FA pouvait modifier la mortalité à long terme. Selon la littérature chirurgicale, l'arrêt du traitement par anticoagulants

It appears essential to evaluate the surgical approaches to atrial fibrillation (AF) in view of the following clinical objectives: (1) to avoid symptoms associated with rapid and irregular heart beat; (2) to avoid blood stasis in the atrium and the attendant risk of thromboembolic events; and (3) to preserve atrial function, which ensures optimal cardiac performance. There is a need to balance the priority given to each of these objectives in relation to the clinical condition associated with the arrhythmia, as one objective may

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Corresponding author: Pierre Pagé, MD, Research Center, Hôpital du Sacré-Coeur de Montréal, 5400, Gouin B. West, Montreal, Québec, H4J 1C5, Canada.

E-mail: pierre.page@umontreal.ca

The disclosure information of the authors and reviewers is available from the CCS on the following Web sites: www.ccs.ca and www.ccsguidelineprograms.ca.

This statement was developed following a thorough consideration of medical literature and the best available evidence and clinical experience. It represents the consensus of a Canadian panel comprised of multidisciplinary experts on this topic with a mandate to formulate disease-specific recommendations. These recommendations are aimed to provide a reasonable and practical approach to care for specialists and allied health professionals obliged with the duty of bestowing optimal care to patients and families, and can be subject to change as scientific knowledge and technology advance and as practice patterns evolve. The statement is not intended to be a substitute for physicians using their individual judgment in managing clinical care in consultation with the patient, with appropriate regard to all the individual circumstances of the patient, diagnostic and treatment options available and available resources. Adherence to these recommendations will not necessarily produce successful outcomes in every case.

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there is no evidence-based data to support the safety of omitting long-term oral anticoagulation. Thus, surgery should be used primarily as a concomitant procedure during cardiac surgery for other diseased states or as a stand-alone procedure after failure of prior attempts of catheter ablation and antiarrhythmic drugs.

oraux 6 mois après la chirurgie est recommandé lorsque le rythme sinusal peut être documenté de façon certaine et puisqu'il y a un taux très faible de thromboembolies. Par ailleurs, peu de données probantes sont disponible pour appuyer l'innocuité de l'omission d'un traitement anticoagulant à prise orale à long terme. C'est donc dire que la chirurgie devra surtout être utilisée comme procédure concomitante pendant la chirurgie cardiaque pour d'autres maladies ou comme procédure distincte après l'échec de tentatives précédentes d'ablation par cathéter et de médicaments antiarythmiques.

dominate, depending on the clinical presentation of AF and the associated cardiac pathology. For instance, symptoms may be the main target in the case of occasional paroxysmal "lone" AF, prevention of thromboembolism may be the major motivation to terminate permanent or persistent AF, and improvement of cardiac performance may be the main objective in treating AF associated with congestive heart failure or valvular disease.

The maze procedure, designed and first reported by Cox et al,[1] was based on the assumption that many electrophysiological mechanisms coexist in the atrium, thus necessitating a standardized procedure that would address each of them. These assumptions were as follows:

1. According to the conceptual notion of Garrey,[2] fractionation of the atrial tissue into smaller segments would not allow multiple reentrant wavelets to be maintained.
2. To preserve atrial contraction, mandatory for the transport function and for eliminating the risk of thromboembolic events, all these segments should be linked to each other. Impulse propagation into dead-end pathways would not allow reentry to occur but would allow depolarization of sufficient atrial myocardium to ensure contraction.
3. The numerous atrial incisions required to address the first 2 assumptions would interrupt any possible macroreentrant pathway.

This procedure has been applied clinically since 1987 and has proven extremely effective.[3-12] However, despite this success, the maze procedure was perceived as difficult and associated with significant morbidity,[13] leading several authors to develop novel strategies aimed at simplifying the procedure without compromising the results. Less-invasive approaches have been designed to avoid sternotomy by accessing the left atrium through minimal incisions and to avoid cardiopulmonary bypass by accessing atrial tissue from the epicardium.[14-26] Furthermore, new information regarding the role of the pulmonary vein–left atrial junction, drivers and rotors occurring in the posterior left atrium, and the role of the intrinsic cardiac nervous system has been incorporated into the evolving surgical rationale.[27,28] In addition, it has been recognized that the underlying cardiac disorders might alter treatment outcomes. A number of factors, therefore, need to be considered when reengineering the surgical algorithm for AF management.[29,30]

Elimination of AF

A number of studies have shown that preoperative AF in patients undergoing cardiac surgical interventions is an independent factor for late major adverse cardiac events and poorer survival.[31-36] The literature also indicates that once AF appears in patients with mitral valve disease, it is uncommon for mitral valve surgery alone to restore sinus rhythm.[31,34,36,37] In this context, the duration of AF is a critical factor in predicting the return of sinus rhythm. When AF has been present for 3 months or less, sinus rhythm may resume in up to 80% of patients, but when the duration of preoperative AF exceeds 6 months, 70% to 80% of patients remain in AF if they do not undergo a specific AF procedure.[31,37] Therefore, ablation has been recommended concomitant with a mitral valve procedure in any patient who has had AF for more than 6 months.[29] Meta-analyses including prospective randomized trials have documented a high success rate of AF surgery (typically the Cox Maze procedure or several of its later modifications) in terms of restoration of sinus rhythm.[38-54] In the Mayo Clinic experience, there was a significant difference in freedom from AF 2 years after a concomitant maze operation (74% ± 8%) compared with 27% ± 7% for a control group with mitral valve surgery alone.[55] One of the largest series of patients undergoing the maze surgery associated with other primary cardiac operations was published by Beukema et al in 2008.[54] They performed surgery concomitant with a radiofrequency-modified maze procedure in 258 patients (updated to 700 in 2010)[56] with permanent AF. Sustained sinus rhythm, including an atrial rhythm or an atrial-based paced rhythm, was present in 69% of their patients at 1 year, in 56% at 3 years, and in 52% at 5 years.[54,56] In a recent study by Kim et al including 540 patients undergoing mitral valve repair or replacement, the maze procedure was also performed in 36% of this group.[57] After 5 years, the incidence of sinus rhythm was 86% in the patients who had undergone the maze procedure but only 24% in patients who did not undergo the procedure. Therefore, there is moderately high-quality evidence to demonstrate the 1-year efficacy of concomitant AF surgery to eliminate AF in patients undergoing cardiac surgical interventions.

Outcome Benefit: Cardiac Events and Survival

Whether AF surgery affords improved clinical outcome to patients with preoperative AF remains controversial.[13,52,54-58] Although it is generally accepted that preoperative AF is predictive of cardiac mortality and morbidity, it is unclear whether direct surgical correction of AF restores the survival curves of AF patients to the same level as those of patients without preoperative AF. Short-term and intermediate-term rates of sinus rhythm after classical maze or its variant procedures differ widely: between 44% and 95%.[4-13,38-61] However, none of the 6 randomized trials comparing outcomes in patients undergoing surgery with and without concomitant maze procedures has shown a clear benefit on mortality or stroke.[56] Nevertheless, many observational reports suggest that concomitant AF correction has the potential to improve long-term survival. In the study by Kim et al, a multivariate analysis indicated that the absence of a maze procedure in the presence of AF during mitral valve replacement or repair was an independent predictor of cardiac death and major adverse events.[57] Overall, the maze procedure was associated with better event-free survival. Bando et al also reported better survival in mitral valve patients who

underwent the maze procedure in the presence of preoperative AF, compared with patients who underwent mitral valve surgery alone.[58] On the other hand, there was no significant difference in survival data in the Mayo Clinic experience,[55] whereas Bando et al have, in a retrospective study, reported that patients with the adjunct of a maze procedure showed a similar high degree of freedom from cardiovascular-related death (96.9%) and stroke (98.2%), compared with a group of patients without preoperative AF.[58,59,62] Although these reports constitute low-quality evidence because of their retrospective design, they suggest that the maze procedure may improve survival when combined with mitral valve repair. In addition, other reports have failed to demonstrate a difference in mortality and morbidity early after surgery, whether the maze procedure is carried out concomitantly with mitral valve surgery or not.[41,54,58-61]

RECOMMENDATION

We recommend that a surgical AF ablation procedure be undertaken in association with mitral valve surgery in patients with AF when there is a strong desire to maintain sinus rhythm, the likelihood of success of the procedure is deemed to be high, and the additional risk is low (Strong Recommendation, Moderate-Quality Evidence).

Values and preferences. This recommendation recognizes that individual institutional experience and patient considerations best determine for whom the surgical procedure is performed.

RECOMMENDATION

We recommend that patients with asymptomatic lone AF, in whom AF is not expected to affect cardiac outcome, should not be considered for surgical therapy for AF (Strong Recommendation, Low-Quality Evidence).

Values and preferences. This recommendation recognizes that patients with lone AF are at low risk for stroke or other adverse cardiovascular outcomes. Thus, elimination of AF in the absence of a high number of symptoms is unlikely to result in an improvement in quality of life.

RECOMMENDATION

In patients with AF who are undergoing aortic valve surgery or coronary artery bypass surgery, we suggest that a surgical AF ablation procedure be undertaken when there is a strong desire to maintain sinus rhythm, the success of the procedure is deemed to be high, and the additional risk low (Conditional Recommendation, Low-Quality Evidence).

Values and preferences. This recommendation recognizes that left atrial endocardial access is not routinely required for aortic or coronary surgery. This limits ablation to newer epicardial approaches.

Stroke

The risk for late stroke after a maze procedure remains remarkably low throughout the surgical literature.[4-7,9,13,36,46,52,54-63] Recent data suggest that restoration of sinus rhythm not only improves survival in this group but also reduces the risks for stroke, other thromboembolism, and anticoagulant-related hemorrhage.[58,59,62,63] Furthermore, one study reported that the absence of a maze procedure was the only risk factor for late stroke in patients undergoing mechanical mitral valve replacement.[62] This high freedom from late stroke likely is attributable to excision or obliteration of the left atrial appendage—an integral component of the maze procedure—in addition to restoration of sinus rhythm in the majority of patients.

RECOMMENDATION

We recommend that closure (excision or obliteration) of the left atrial appendage be undertaken as part of the surgical ablation of AF associated with mitral valve surgery (Strong Recommendation, Low-Quality Evidence).

We suggest that closure of the left atrial appendage be undertaken as part of the surgical ablation of persistent AF in patients undergoing aortic valve surgery or coronary artery bypass surgery if this does not increase the risk of the surgery (Conditional Recommendation, Low-Quality Evidence).

Values and preferences. These recommendations place a high value on stroke reduction and a lower value on any concomitant loss of atrial transport with left atrial appendage closure.

Lesion Set

The original cut-and-sew Cox Maze III procedure has been modified in 2 main ways: (1) the use of ablative energy sources deployed with new devices and (2) the elimination of some lines of block. The latter changes consisted of limiting the lesions to electrically isolating the pulmonary veins (PVs) from the rest of the left atrium (Fig. 1), avoiding connecting lines to the base of the left atrial appendage and to the mitral isthmus, and also avoiding ablation in the right atrium. According to the Heart Rhythm Society recommendation document, the term *maze* should apply only to the lesion sets mimicking that of the Cox Maze III procedure.[30] Modifications allowed to this terminology include the replacement of most of the Cox Maze III incisions with bipolar radiofrequency (Fig. 2, often referred to as the "Cox Maze IV procedure")[13,41,44,45,47-50,54,64] or with cryothermic devices.[60] Less extensive lesion patterns should not be referred to as a *maze*. Although new technologies such as bipolar radiofrequency may reliably produce transmural lines of block and can be applied minimally invasively for PVs, they do not allow secure performance of connecting lines in the left atrial isthmus or inside the right atrium.[13,25,26] Thus, they cannot allow the complete performance of the original lesion pattern of the Cox Maze III procedure necessary for optimal results in cases of persistent or permanent AF. On the other hand, recent studies have begun to explore the role of isolation of the PVs for paroxysmal AF.[14-26] These studies usually report small sample sizes and limited follow-up. In a series of minimally invasive bilateral PVs, Edgerton et al reported that at 6-month follow-up, 86% of patients with paroxysmal AF were in normal sinus rhythm as evaluated by Holter monitor, pacemaker interrogation, or event monitor.[15] Unfortunately, the

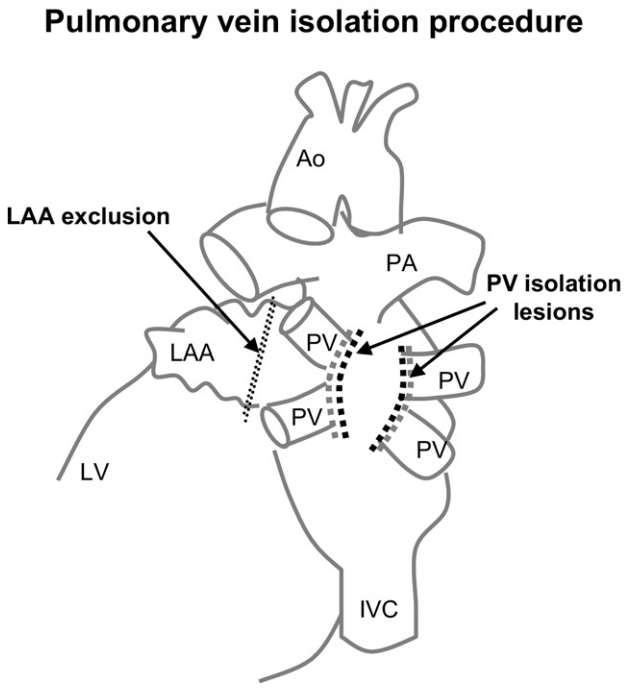

Figure 1. Isolation of the left- and right-sided pulmonary veins performed with the use of an irrigated bipolar radiofrequency probe (fat dotted lines). Pattern referred to the PVI procedure in Table 1. The site of exclusion of the left atrial appendage is indicated by the sharp dotted lines. Ao, ascending aorta; IVC, projection of the inferior vena cava; LAA, left atrial appendage; LV, left ventricle; PA, pulmonary artery; PV, pulmonary veins.

results of their PV approach have been disappointing in patients with persistent or longstanding AF because freedom from AF off drugs was achieved in only 32% at 6 months.[15] Thus, we propose the following algorithm of surgical ablation, which is based on the type of AF and the nature of underlying cardiac abnormalities (Table 1): The recommended lesion set ranges from PVs alone (as shown in Fig. 1) to a bi-atrial complete Cox Maze lesion pattern (as shown in Fig. 2). In between these extremes, PVs (in pairs or with a box lesion) may be associated with connecting lines to the left atrial appendage and the mitral valve annulus (PVI+ in Table 1, also termed *left atrial procedure* and Fig. 2, A). The full Cox Maze lesion set (CM in Table 1) should include the left atrial procedure (Fig. 2, A) plus right atrial lines along the sulcus terminalis and a line from the right atrial free wall to the annulus of the tricuspid valve (Fig. 2, B), plus right atrial isthmus ablation (Fig. 2, C). All procedures must include exclusion or resection of the left atrial appendage. Based on our review of the recent literature, we would recommend the full modified Cox Maze III pattern (as shown in Fig. 2, A to Fig. 2, C)[64] for patients with persistent or long-standing AF. Alternatively, the left atrial procedure (termed "PVI+" in Table 1 and also shown in Fig. 2, A) may be used in these patients on the surgeon's judgement to shorten the operative time. The PVI procedure (as shown in Fig. 1) should be confined to patients with lone paroxysmal AF and paroxysmal AF with nonmitral valve disease.

Postoperative Care and Anticoagulation After AF Surgery

Ad et al developed a strict follow-up program designed to adhere to the Heart Rhythm Society guidelines.[30,65] In brief, it consisted of a detailed AF registry that included a statistical platform that interacted with an institutional database. The AF registry tracked all patients' preoperative, operative, and postoperative characteristics, as well as patients' health-related quality of life. Clinical information and algorithm-driven protocols served as a basis for recommendations to the referring physicians. The clinical information collected included (1) patients' self-reported rhythm, (2) current medications, (3) any readmissions and cardiac intervention that had taken place during the interim, and (4) the date of the last visit to the cardiologist. Diagnostic (electrocardiography, Holter monitoring, 1-week monitoring, or pacemaker interrogation) rhythm information and echocardiography were obtained. Then the appropriateness of antiarrhythmic drugs and anticoagulation was decided on, depending on the clinical algorithm.[65] Incidentally, the authors recommended discontinuation of warfarin therapy whenever long-term monitoring confirmed rhythm status and atrial contraction assured the absence of intra-atrial stasis for a long period of time after surgery. However, Beukema and Sie recommend a more conservative approach with respect to anticoagulation.[54,56] Since reliable monitoring was not always available and a low flow state could not be ruled out in several patients, most of their patients were still on anticoagulant therapy at long-term follow-up, including patients with bioprosthetic mitral valve replacement. It should also be emphasized that the rate of recurrence of AF is not stable over time and that the moment of AF reappearance is uncertain.[54] Therefore, in the absence of strict continuous monitoring capabilities and the lack of a clinical program with algorithm-driven treatment protocols, it is probably best to maintain anticoagulation therapy despite its inherent inconveniences. This conservative approach constitutes the rationale for our recommendation on postoperative anticoagulation therapy. There are new and less troublesome options than warfarin for thromboembolism prophylaxis soon to be available for many of these patients.[66]

RECOMMENDATION

We recommend that oral anticoagulant therapy be continued following surgical AF ablation in patients with a $CHADS_2$ score ≥ 2 (Strong Recommendation, Moderate-Quality Evidence).

We suggest that oral anticoagulant therapy be continued following surgical AF ablation in patients who have undergone mechanical or bioprosthetic mitral valve replacement (Conditional Recommendation, Low-Quality Evidence).

Values and preferences. These recommendations place a high value on minimizing the risk of stroke and a lower value in the utility of long-term monitoring to document the absence of AF.

Conclusion

The Heart Rhythm Society Task Force on Catheter and Surgical Ablation of Atrial Fibrillation suggests the following

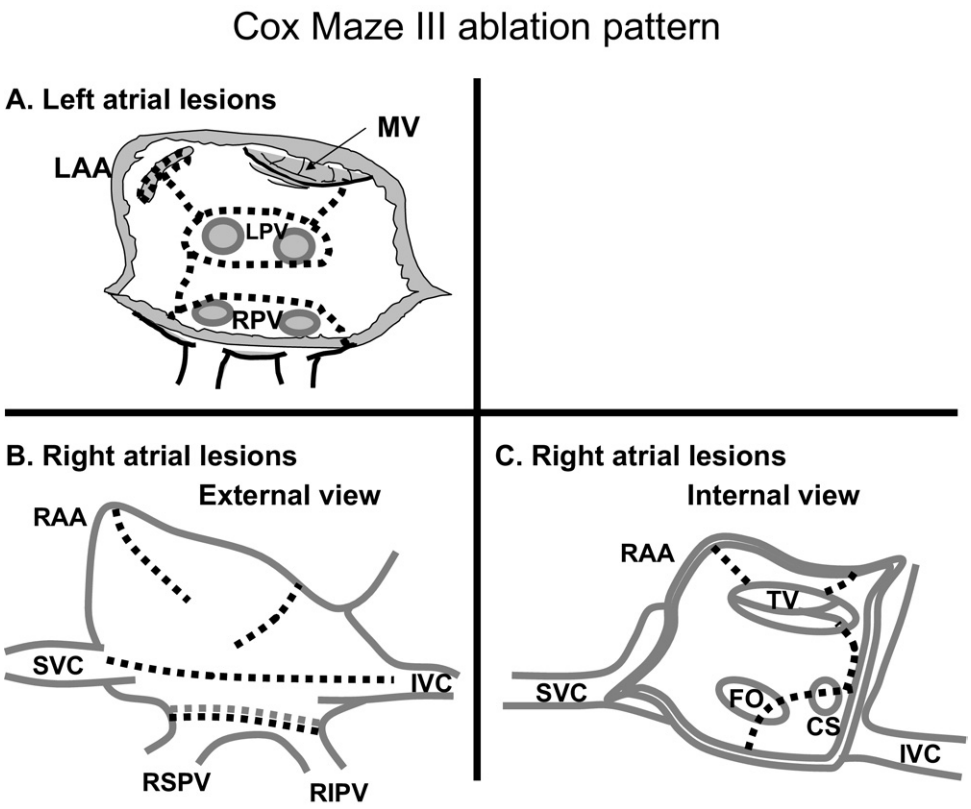

Figure 2. Cox Maze III ablation pattern. **(A)** Left-sided lesion set. The left atrium is shown as viewed from the right side by the surgeon through an atriotomy in the Waterston's groove. Ablation lines inside the left atrium (dotted lines) shown as they can be performed using various ablation devices. Irrigated radiofrequency probes or cryosurgical probes are preferred. LAA indicates left atrial appendage excised. **(B)** Right-sided lesion set. The right atrium is shown as viewed from the right side by the surgeon. The vertical dotted line indicates an ablation line in the right atrium between the superior and inferior vena cavae; it can be performed with a bipolar radiofrequency probe or cryosurgical probe. An incision on the central part of this line is made to open the right atrium. Additional lines are performed on the free wall until the right atrioventricular groove and along the right atrial appendage. The double dotted line indicates isolation of the right pulmonary veins with radiofrequency energy. **(C)** Right-sided lesion set (continued). The right atrium is shown open as viewed from the right side by the surgeon. Ablation lines (dark dotted lines) are performed inside the right atrium. See text and reference 64 for details. CS, coronary sinus; FO, fossa ovalis; IVC, inferior vena cava; LAA, left atrial appendage; LPV, left pulmonary veins; MV, mitral valve; RAA, right atrial appendage; RIPV, right inferior pulmonary vein; RPV, right pulmonary veins; RSPV, right superior pulmonary vein; SVC, superior vena cava; TV, tricuspid valve.

indications for surgical treatment of AF: (1) symptomatic patients with AF undergoing other cardiac surgical procedures; (2) selected asymptomatic patients with AF undergoing cardiac surgery in whom the ablation can be performed with minimal risk; and (3) symptomatic patients with AF who prefer a surgical approach, have experienced 1 or more failed attempts at catheter ablation, or are not candidates for catheter ablation.[30] We modified these recommendations to take into account the recent data on the results of the various surgical options to treat AF. It should also be recognized that all treatment options are not available in all centres dealing with challenging cardiac disorders. There may be significant differences in the experience and skills of the teams in various institutions. The quality of evidence varies significantly with regard to the multiple aspects of surgical care in the field of AF. We therefore developed the recommendations with respect to AF surgery, along with a type-specific surgical algorithm shown in Table 1, to help surgeons select the most appropriate procedure based on the patient's underlying cardiac status and pattern of AF.

Table 1. Recommended type-specific surgical strategies*

Cardiac status or type of atrial fibrillation	Paroxysmal	Persistent, mixed, or continuous
Lone atrial fibrillation	PVI	PVI+
Mitral valve surgery	PVI+	Bi-atrial (CM) or PVI+
Aortic valve/CABG surgery	PVI	PVI+

CABG, coronary artery bypass grafting procedure; CM, lesion set mimicking the full Cox Maze III procedure including left atrial procedure (as in Fig. 2, A) plus right atrial lines along the sulcus terminalis and to the tricuspid valve, plus right atrial isthmus ablation (as in Fig. 2, B); PVI, pulmonary vein isolation (see Fig. 1); PVI+, left atrial procedure consisting of pulmonary vein isolation (in pairs or with a box lesion) and connecting lines to the left atrial appendage and the mitral valve annulus (see Fig. 2, A).

*All procedures must include exclusion or resection of the left atrial appendage.

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