



Research Article

Current Trends in Non-Pharmacological Management of Atrial Fibrillation; Review of The Literature

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Abstract

With the increasing aging population, the incidence and prevalence of Atrial Fibrillation (AF) continue to rise posing significant challenges to the patients and health care systems. Non pharmaceutical therapeutic modalities for the management of AF during the past two decades have significantly evolved. Pulmonary Vein Isolation (PVI) is the cornerstone of catheter ablation for most patients. Thermal (RFA, Cryo) and non-thermal (PFA) catheter ablation have become first line treatment for selective paroxysmal and persistent AF patients. Catheter ablation has proven to be very effective for rhythm control and patient survival. While Pulse Field Ablation (PFA) carries the lowest periprocedural complication burden, the risk for esophageal injury during RFA and phrenic nerve injury during cryoablation remain a concern that require preventive measures. Surgical ablation as a stand-alone procedure or in a minimally invasive hybrid approach is the most effective rhythm control modality while avoiding major complications. Surgical ablation in the setting of concomitant cardiac surgery (especially mitral valve surgery) improves AF free time and overall survival becoming a standard of practice. Thromboembolism prevention via surgical techniques or clipping of the Left Atrial Appendage (LAA) during concomitant heart surgery or minimally invasive approach has also proven to decrease thromboembolic events and improve survival. In order to optimize patient outcomes, the evaluation and decision making of patients with AF should be conducted in a multidisciplinary fashion with emphasis in post procedure long term monitoring.

Keywords: Atrial Fibrillation; Catheter Ablation, Cryoablation (Cryo); Laser Balloon; Left Atrial Appendage Occlusion; Pulsed Field Ablation (PFA); Pulmonary Vein Isolation; Radiofrequency Ablation (RFA); Surgical Ablation

Introduction

Atrial Fibrillation (AF) is the most common sustained supraventricular arrhythmia characterized by rapid, disorganized atrial activation causing ineffective atrial contraction. With the aging population and rising obesity rates, its incidence and prevalence are increasing worldwide, [1,2]. It is estimated for the United States to have around 6 million AF cases of which 11% are

undiagnosed [3]. AF is associated with significantly higher health care resource utilization and costs. According to US data from Optum (United Healthcare), patients with AF had an annual cost of \$63,031, which is \$27,896 more than patients without AF [4]. AF is also associated with a 1.5-to-2-fold increased risk of death, [5] with the mortality risk being higher in women than in men [5], a 2.4-fold risk of stroke [6], 1.5-fold risk of myocardial infarction [7], 2-fold risk of sudden death [8], 1.5-fold risk of cognitive impairment or dementia [9], and 5-fold risk of Heart Failure [10].

Risk factors for AF such as increasing age, left atrial dilatation, hypertension, diabetes mellitus, obesity, heart failure, coronary artery disease, chronic kidney disease, chronic obstructive

pulmonary disease, stroke, obstructive sleep apnea, smoking, biomarkers and genetic factors have been validated with several single studies, meta-analyses and randomized studies [11-14]. There is compelling evidence that with an appropriate management of these risk factors, the burden of AF could be significantly ameliorated. In order to make the clinical diagnosis of AF, a rhythm documentation with an Electrocardiogram (ECG) is required. The ECG features of AF are the following: absence of distinct P waves on the surface ECG; irregular atrial activations with an atrial cycle length that is usually <200 ms; and irregular R-R intervals that persists for at least 30s [15]. The duration-based AF classification system employed by the American College of Cardiology / American Heart Association (AHA)/HRS [16], categorizes AF into four clinical patterns based on duration and persistence: (i) **paroxysmal AF**, defined as a continuous AF episode lasting longer than 30 s but terminating spontaneously or with intervention within 7 days of onset; (ii) **persistent AF**, defined as a continuous AF episode lasting longer than 7 days but <1 year; (iii) **long-standing persistent AF**, defined as continuous AF 1 year in duration, in patients where rhythm control management is being attempted; and (iv) **permanent AF**, defined as AF for which a therapeutic decision has been made not to pursue sinus rhythm restoration. A recent study of patients with paroxysmal AF with a 2 yr follow up, revealed a progression rate to persistent or permanent AF of 8.4% [17]. However, a separate study with a 10yr follow up, revealed a progression rate of 22-36% [18]. AF is a chaotic, rapid (300-500

bpm), and irregular atrial rhythm that manifests itself in a chronic and progressive fashion with exacerbations and remissions. AF often originates from waves of electrical activity stemming from ectopic rapid discharges most commonly generated in the Pulmonary Veins (PVs) of the left atrium [19] or in response to reentrant activity promoted by heterogeneous conduction due to interstitial fibrosis [20]. The management of AF has significantly evolved throughout the years. The ESC/ European Association for Cardio-Thoracic Surgery (EACTS) societies recently provided guidelines in the management of AF by introducing the **AF-CARE** framework providing a structured approach while enhancing patient-centered care and outcomes [21,22], (Figure 1). The pillars of the management framework include: **(C)** Comorbidity and risk factor management; **(A)** Avoid stroke and thromboembolism through adequate anticoagulation; **(R)** Reduce symptoms by rate and rhythm control; **(E)** Evaluation and proactive reassessment and monitoring. The pharmacological management of anticoagulation, rate and rhythm control in AF are outside the scope of this review. The aim of this study is to review the current trends and management strategies for non-pharmacological rhythm control and thromboembolism prevention. This includes the different types of catheter ablations, stand-alone surgical ablation, surgical ablation concomitant with cardiac surgery, minimally invasive hybrid ablation (surgical/catheter ablation) and the different surgical and noninvasive approaches for the management of the left atrial appendage for thromboembolism prevention.

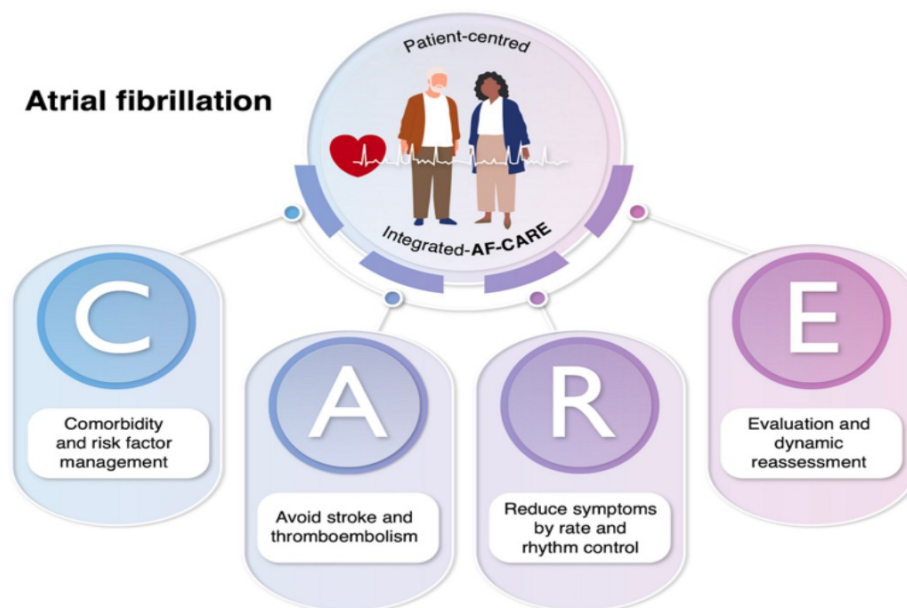


Figure 1: AF- CARE – EACTS.

Methods

A PubMed search was conducted for the terms atrial fibrillation, catheter ablation, surgical ablation and left atrial appendage exclusion. The search went back at least two decades prioritizing single center, multi-center randomized studies, meta-analysis of randomized studies and single center prospective and retrospective treatment changing studies. The most recent guidelines from national and international heart associations and societies were included.

Review of Literature / Discussion

Rhythm control is very effective in alleviating AF-related symptoms, improving quality of life and positively impacting survival [23,24]. In asymptomatic AF patients, AF continues to inflict significant negative hemodynamic consequences that can lead to heart failure [25]. Therefore, even asymptomatic patients with AF should have attempts made to convert to sinus rhythm with cardioversion. It is not uncommon for these asymptomatic patients to feel better after cardioversion and being able to categorize them as symptomatic and subsequently be eligible for future catheter ablation.

Catheter Ablation

Multiple randomized studies have established catheter ablation as the treatment of choice in patients with paroxysmal or persistent AF who are intolerant or resistant to anti-arrhythmic drugs [26-29]. Moreover, the 2024 ESC/EACTS Guidelines on AF upgraded the role of catheter ablation as first-line rhythm control treatment option in anti-arrhythmic drug-naïve patients with paroxysmal AF [21]. Also, supported by several randomized trials, catheter ablation has demonstrated superior efficacy and similar safety in comparison to anti-arrhythmic drugs regarding alleviation of patient symptoms, reduction of AF recurrences, improvement of quality of life, and delayed progression of AF [30,31]. A recent meta-analysis looking into cost-effectiveness of catheter ablation versus antiarrhythmic drugs in AF, appears to indicate a benefit for catheter ablation particularly in subgroups such as patients with permanent AF, structural heart disease, or heart failure with low ejection fraction who receive catheter ablation as first-line therapy [32]. Historically, in the early 1990s, the initial ablation attempts for AF were focused on the right atrium due to limited access to the left atrium and a lack of understanding of the pathophysiology of AF [33]. The ablations on the right atrium were often based on targeting areas of presumed conduction abnormalities with very limited efficacy and high recurrence rates [34]. These disappointing outcomes encouraged electrophysiologists to seek further sources or triggers for AF. This initiative led to the discovery that the principal ectopic beats triggers causing AF were originated in the left atrial pulmonary veins [35]. These findings shifted the focus

to ablating the pulmonary veins in the left atrium. Initially, focal ablations of the pulmonary veins were performed with mixed results due to high recurrence rates [36]. Pappone et al. introduced a more inclusive approach called **circumferential PV ablation** to overcome the limitations of targeting individual ectopic sites [37]. Instead of ablating isolated triggers, circumferential PV ablation consisted of creating continuous encircling lesions around the PV ostia to obtain electrical isolation of the PVs. This approach prevented ectopic impulses from reaching the left atrium significantly improving outcomes, offering higher success rates and becoming the gold standard for AF ablation. This circumferential PV ablation is known as Pulmonary Vein Isolation (PVI) and it is considered the cornerstone of AF catheter ablation. For the most part, PVI is the technique used for catheter ablation. In the rare cases of persistent or permanent AF additional approaches can be used such as Cavo tricuspid isthmus ablation, linear lesions ablation, left atrial posterior wall ablation, substrate ablation and vein of Marshall ablation. Depending of the type of energy used for ablation, there are different types of techniques available:

Radiofrequency ablation

Radiofrequency refers to an alternating electric current in the frequency range of 350 to 500 kHz. Radiofrequency current causes an increase in tissue temperature of the layers that are in direct contact with the tip of the ablation catheter. To achieve irreversible necrosis, local temperatures above 50°C are required. Clot formation and carbonization can occur on the ablation catheter if temperatures exceed 100°C, limiting the effectiveness of ablation [38]. The introduction of irrigated catheters has enhanced energy delivery efficiency with wider and deeper lesions [39]. A major challenge when radiofrequency is applied to the posterior wall of the left atrium is the possibility of inducing esophageal injury, which can result in an **atrio-esophageal fistula**, a rare (0.07%) but potentially fatal complication. In order to obtain larger and shallower lesions to improve the efficiency and safety of the procedure, High-Power and Short-Duration” (HPSD) protocols have been implemented [40]. When PVI is achieved by antral lesion lines, **pulmonary vein stenosis** will occur in less than 1% of cases [41]. **cardiac tamponade** can occur either as a result of catheter manipulation while penetrating the left atrium through the right atrium or as a radiofrequency perforation in 0.3–0.8% of patients [42].

Cryoablation

Cryogenic balloons were first used in humans in 2007. When the temperature of myocardial tissue is reduced, an initial phase of reversible cellular dysfunction occurs. Later, at about –25 °C, the injury becomes irreversible: ice crystals form in the cytoplasm, with a dysfunction of organelles and membranes, and this effect is further exacerbated during the rewarming phase, when crystals

expand before fully melting. As a consequence, the healing process leads to the formation of fibrotic tissue. Compared to radiofrequency ablation, cryoablation is less thrombogenic and arrhythmogenic [43,44]. The most frequent complication is transient **phrenic nerve paralysis** (3%). Potential nerve injury can be minimized with right phrenic nerve conduction monitoring [45]. Esophageal injury and pulmonary vein stenosis have been reported but at a lower rate compared to radiofrequency ablation.

Laser Balloon Ablation

A Laser Balloon delivers photothermal energy (980-nm diode) directed visually. Light is absorbed by tissue water, converting to heat and ultimately leading to cell injury. The operator is able to see the tissue contact and titrate energy delivery point-by-point within the balloon. Laser balloon ablation achieves high rates of durable isolation with a favorable safety profile [46].

Pulsed Field Ablation (PFA)

In contrast to radiofrequency ablation, cryoablation and laser ablation that rely on thermal energy, Pulsed Field Ablation involves delivering a series of repeated, short-duration electrical discharges that have minimal thermal effect but lead to an accumulation of charges on the two sides of the cell membrane. As a result, the phospholipid molecules that constitute the cell membrane re-orient themselves to form nanopores, which facilitates water permeability.

If the provided voltage has sufficient magnitude and duration, the altered membrane permeability would cause significant cellular homeostasis imbalance that leads to **irreversible electroporation** and immediate cell death. This process is followed by the death of additional myocardial cells during the six weeks post procedure period leading to the development of fibrous tissue by week eight maintaining the vascular and tissue structure. This phenomenon seems to be generated by the altered intracellular pH, the presence of free radicals and the release of mitochondrial cytosome [47]. While thermal techniques inflict tissue damage nonspecifically, PFA has the ability to act very differently depending of the type of tissue. Heart muscle cells are three times more vulnerable than the esophageal wall and four times more than the phrenic nerve [48], (Figure 2). In addition, the adipose tissue located between the posterior wall of the left atrium and the esophagus are spared from injury, acting as insulator and providing another layer of protection to the esophagus. As a consequence, the rate of esophageal injury compared to the thermal techniques is significantly lower [49,50]. PFA can be associated with cough, skeletal muscle contractions requiring sedoanesthesia [51] and coronary vasospasm warranting intracoronary nitrate administration during the procedure [52]. The different type of probes used in catheter ablation are illustrated in (Figure 3) and the most recent outcomes among the thermal techniques and PFA are illustrated in (Figure 4).

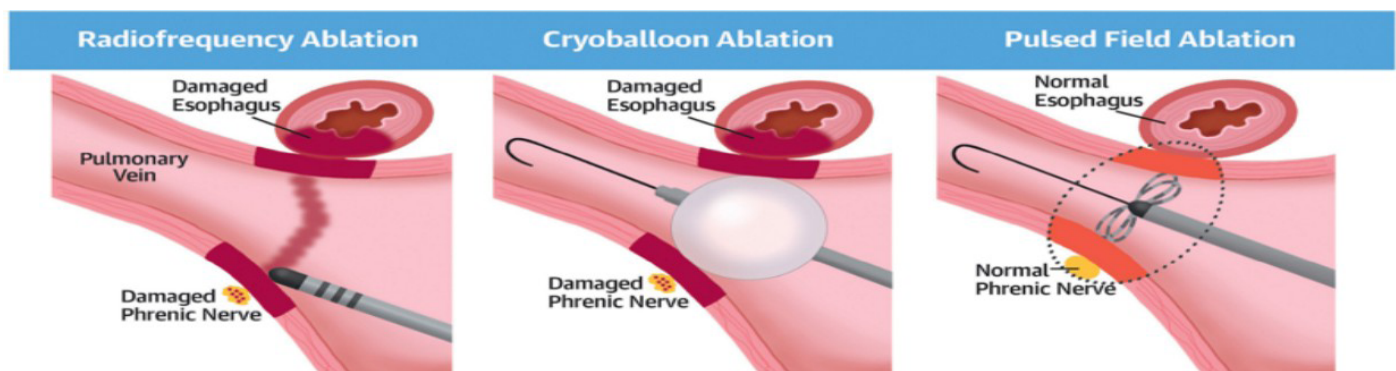


Figure 2: Catheter ablation complications. (Reddy, V.Y. et al. J Am Coll Cardiol. 2019;74(3):315-26.)

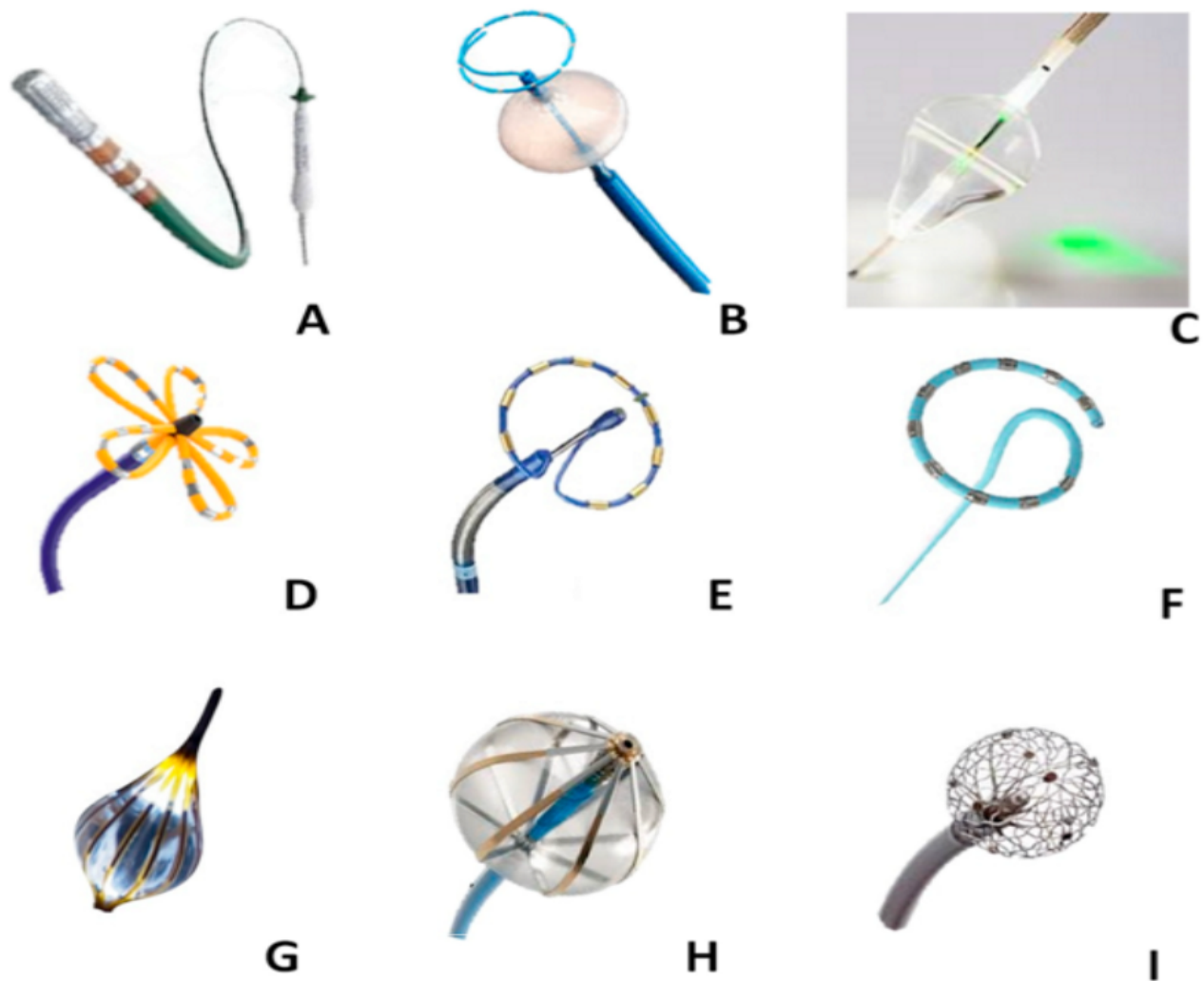


Figure 3: Catheter Ablation Probes Catheter ablation probes: (A) Radiofrequency (RF) Catheter, (B) Cryoballoon, (C) Laser Balloon, (D) Pentaspline PFA Catheter, (E) Fixed Circular PFA Loop, (F) Variable PFA Loop, (G) Visually Guided Compliant PFA Balloon, (H) Balloon-in-Basket PFA, (I) Focal Lattice-Tip. (Cristian Martignani et al, J. Clin. Med. 2026, 15, 751)

Study	n	Endpoint	Freedom from Endpoint (at 12 mos.)	p	Procedure Duration (min)	p	Fluoroscopy Time (min)	p	Complications	p
PFA vs. Thermal (Cryo and RF)										
Reddy et al. ADVENT	305 PFA 302 thermal	Recurrence of AT/AF or AADs or repeat TCA	73.1% 71.3%	n.s.	105.8 ± 29.4 123.1 ± 42.1	<0.05	21.1 ± 11.0 13.9 ± 12.8	<0.05	2.0% 1.3%	n.s.
Della Rocca et al. (HRMC trial)	174 PFA 348 Cryo 348 RF	AF/AT Recurrence	79.3% 74.7% 72.4%	n.s.	52.1 ± 14.6 64.5 ± 21.8 84.8 ± 24.8	<0.001	14.8 ± 3.4 17.6 ± 8.1 12.9 ± 6.9	<0.001	1.1% (*) 1.1% (*) 0.9% (*)	n.s.
Maurhofer et al.	40 PFA 80 Cryo 80 RF	AF/AT Recurrence	85.0% 76.8% 66.2%	n.s.	93 (79–116) 75 (60–97) 182 (134–23)	<0.001	26 (21–31) 17 (13–24) 7 (3–13)	<0.001	1 (**) 0% 0%	<0.04
PFA vs. cryo										
Badertscher et al.	106 PFA 75 Cryo	AF/AT Recurrence	76% 70%	n.s.	55 (43–64) 58 (48–69)	0.09	11 (9.3–14) 11 (8.7–16)	n.s.	2.8% 4%	n.s.
Rattka et al.	94 PFA 47 Cryo	AF/AT Recurrence	70% 61%	n.s.	162 ± 64 163 ± 62	n.s.	26 ± 9 23 ± 9	0.06	4.2% 2.1%	n.s.
Schipper et al.	54 PFA 54 Cryo	AF/AT Recurrence	74% 72%	n.s.	64.5 ± 17.5 73.0 ± 24.8	0.07	15.3 ± 4.7 12.3 ± 5.3	n.s.	3.7% 11%	n.s.
Urbanek et al.	200 PFA 200 Cryo	AF/AT Recurrence	74% 78%	n.s.	34.5 (29–40) 50 (45–60)	<0.001	7.1 (5.5–8.9) 6.9 (5.5–8.8)	n.s.	6 13	n.s.
PFA vs. RF HPSD										
Reinsch et al. (PRIORI study)	201 PFA 210 RF	AF/AT Recurrence	85% 79%	n.s.	61 (44–103) 125 (105–143)	<0.001	16 (13–20) 4 (2–5)	<0.001	3% 6.2%	n.s.

Figure 4: Comparison of outcomes PFA vs Cryo vs RFA. (Francesco M. Brasca et al, J. Clin. Med. 2025, 14, 2071)

Stand-Alone Surgical Ablation

The Cox-Maze procedure was developed by Dr. Cox in 1987 [53] and it is the most effective surgical treatment of AF. For the past two decades, the procedure has undergone modifications to simplify the complexity and reduce the cardiopulmonary bypass time. The Cox-Maze procedure IV (CMP-IV) introduced by Damiano et al, [54], replaces the surgical incisions with radiofrequency ablation and cryoablation (Figure 5) achieving surgical access either by medium sternotomy or right minithoracotomy. The largest series of stand-alone Cox-Maze procedure IV which included 236 patients of whom 59% had previously failed catheter ablation, demonstrated a freedom from atrial tachyarrhythmias at 10 years of 77% without 30-day mortality [55].The stand-alone CMP-IV with complete isolation of the posterior LA should be considered in all patients with symptomatic, refractory AF who have failed or are not good candidates for catheter ablation.

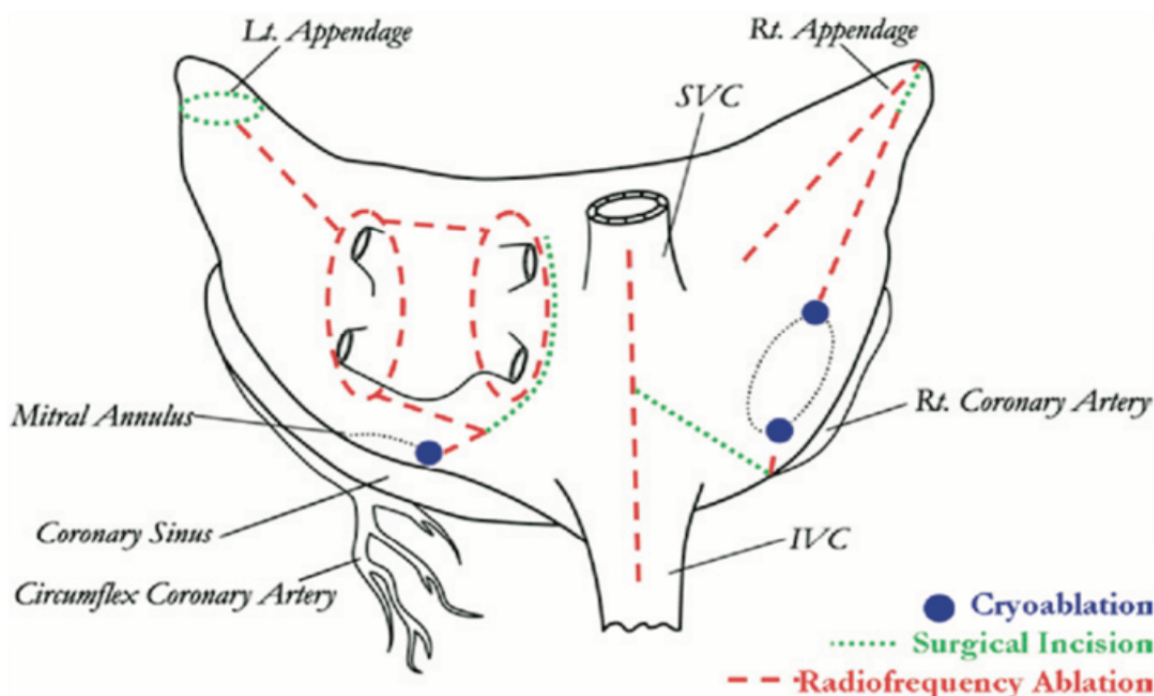


Figure 5: Cox-Maze Procedure IV. (Lall et al, J Thorac Cardiovasc Surg 2007;133:389-96)

Hybrid Atrial Fibrillation Ablation

During the past two decades, there have been significant advances in minimally invasive techniques. These approaches combine sternotomy-sparing minimal surgical incisions with different access sites, endoscopic visualization, with or without catheter ablation at the same or at a different stage (hybrid ablation). The lower invasiveness of these techniques compared with the surgical Cox maze procedure has made these approaches more appealing to patients and surgical societies. The main objective of this treatment strategy is to harmonize epicardial and endocardial ablation components to effectively target key drivers of AF, including the pulmonary veins and the left atrial posterior wall while preserving sinus rhythm. The timing of the epicardial and endocardial stage of the hybrid ablation procedure varies from institution to institution. In the single-stage model, epicardial and endocardial procedures can occur back-to-back in the same suite or separate suites or over sequential days. Completion of both phases in the same session prolongs procedural time, which may potentially put the patient at risk. The minimally invasive surgical part of the hybrid procedure is most frequently performed using a video-assisted thoracoscopic surgical approach where a camera port is placed in

the right fifth intercostal space, a 5 or 10 mm working port in the sixth or seventh intercostal space, and a 5 mm working port in the third intercostal space. The pericardium is opened anterior to the phrenic nerve. Antral isolation of the right pulmonary veins as a pair is performed with repetitive applications using a bipolar radiofrequency clamp. The same approach is followed on the left side but placed more posteriorly. The endocardial ablation adds coverage of the epicardial lesions around the pericardial reflections and any incompletely ablated posterior wall areas achieving electrical isolation of the pulmonary veins. The HARTCAP-AF trial randomized 41 symptomatic, ablation-naïve patients with persistent or long-standing persistent AF to an epicardial surgical ablation using bipolar radiofrequency ablation performed thoracoscopically with percutaneous endocardial ablation (Hybrid/one stage) vs. percutaneous endocardial catheter ablation [56]. Hybrid ablation resulted in significantly more patients in sinus rhythm off antiarrhythmic drugs at 12 months of follow-up (89 vs. 41%, $P=0.002$), without any significant difference in adverse events. The multicenter CEASE-AF trial randomized a total of 154 patients with drug-refractory, symptomatic persistent or long-standing persistent AF to either a staged hybrid ablation or catheter ablation [57]. Freedom from AF/AFL/AT >30 s off all Class I/

III antiarrhythmic drugs was significantly higher in the hybrid group as compared to the catheter ablation group (71.6 vs. 39.2%, $P < 0.001$) with similar major complication rates. There is no Randomized Control Trial (RCT) directly comparing minimally invasive epicardial surgical ablation alone vs. hybrid ablation.

Concomitant Surgical Ablation of Atrial Fibrillation

It is not uncommon for patients undergoing cardiac surgery to have a history of AF which if left untreated, has been linked to an increase risk of postoperative ischemic stroke and to negatively impact long-term survival [58]. Concomitant AF surgery has been shown to increase SR maintenance rate in multiple randomized and non-randomized trials [59,60]. A meta-analysis of 23 RCTs demonstrated that surgical AF ablation concomitant to cardiac surgery leads to an increased freedom from AF at 12 months [61].

In addition, multiple studies have demonstrated that performing surgical AF ablation concomitant with other cardiac surgeries such as mitral valve surgery and CABG is associated with an improved long-term survival [62,63]. The decision making for what techniques to use at the time of concomitant surgery is multifactorial (Figure 6) For patients undergoing mitral surgery, it is reasonable to perform a CryoMaze III or Cox maze IV adding left atrial appendage occlusion (LAAO) and Left Atrial (LA) ablation lesions including a box lesion. Right Atrial (RA) lesions can be added depending on factors such as need for tricuspid surgery, RA dilation, surgeon experience and patient comorbidities. When the Left atrium does not need to be opened for the concomitant procedure, then an epicardial ablation is performed in the form of bilateral Pulmonary Vein Isolation (PVI) with the EnCompass / Atricure bipolar radiofrequency clamp (Figure 7).

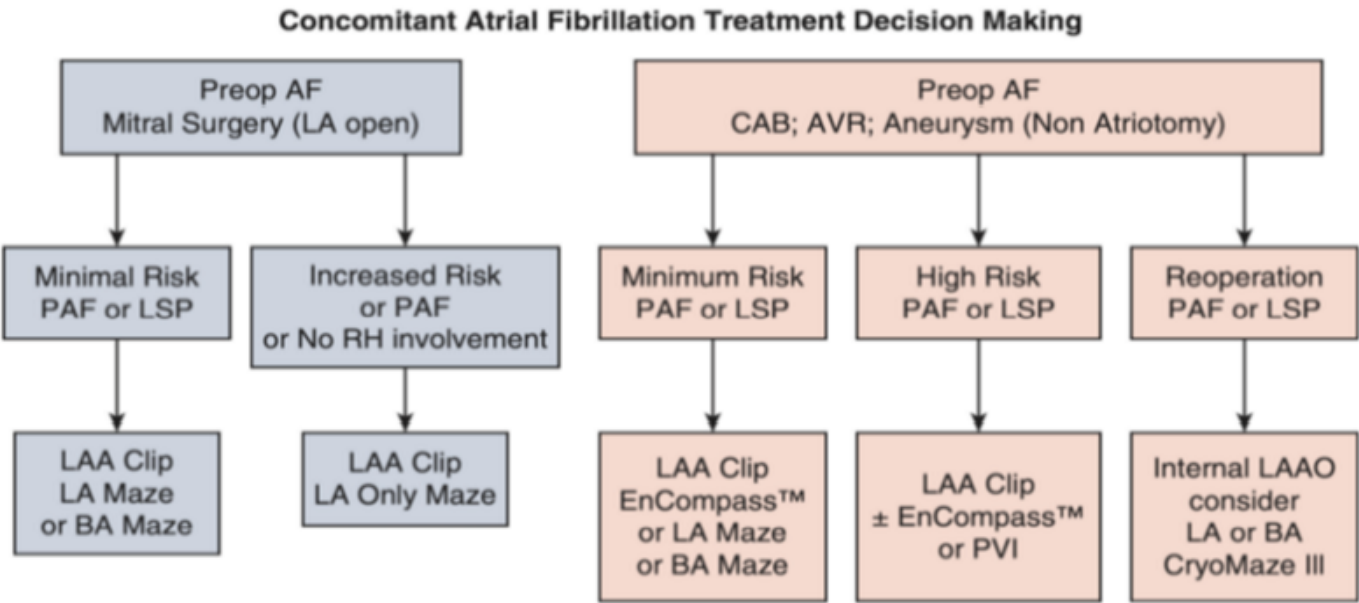


Figure 6: Decision making for concomitant atrial fibrillation treatment. **AF**, Atrial fibrillation; **PAF**, paroxysmal atrial fibrillation; **LSP**, long standing persistent; **RH**, right heart; **BA**, biatrial; **CAB**, coronary artery bypass; **AVR**, aortic valve replacement; **LAA**, left atrial appendage; **LAAO**, left atrial appendage occlusion. (McCarthy et al. J Thorac Cardiovasc Surg 2025;169:907-15)

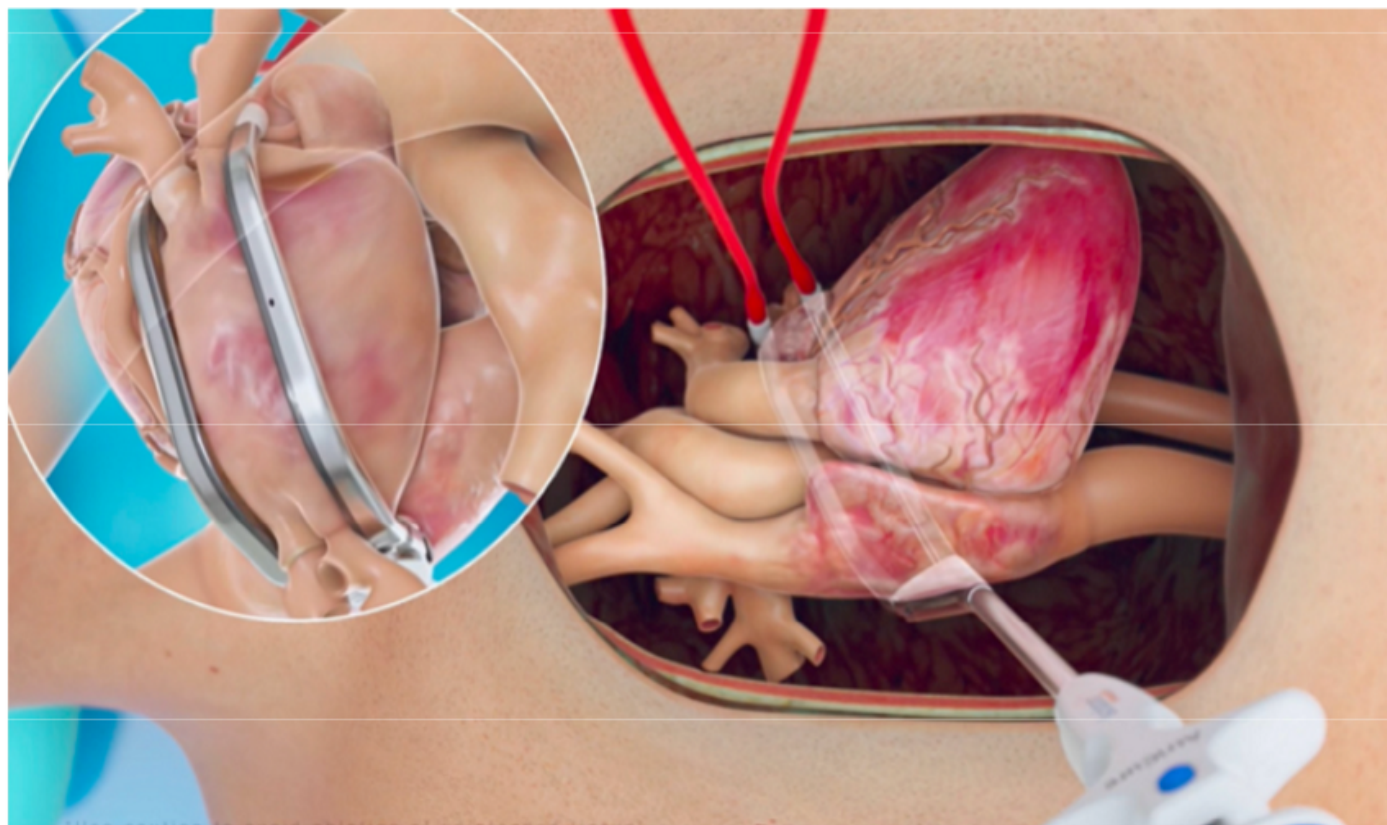


Figure 7: EnCompass (Atricure Inc, www.atricure.com), Radiofrequency Ablation Epicardial Bipolar Clamp

Left Atrial Appendage Occlusion (LAAO)

The Left Atrial Appendage (LAA) is the site of thrombus location in 90% of non-rheumatic AF patients with stroke and a target for stroke reduction in patients with AF [64]. Multiple anatomic variations of the LAA exist in size, shape, ostial profile, and number of lobes. The chicken wing is the most common (48%), followed by the cactus (30%), the windsock (19%), and the cauliflower (3%) [65,66]. The unique anatomic features may influence the outcomes of LAAO. Selecting the optimal technical approach, particularly if epicardial, should consider the overall morphology of the neck and body, in addition to the location of the adjacent structures such as the circumflex coronary artery (Figure 8). As illustrated in (Figure 8B), placement of the clip too far distal from the ostium would lead to an increase risk of clot formation. For a long neck and small ostium LAA, an epicardial LAAO strategy is ideal. In contrast, the cauliflower morphology is most often associated with embolic events due to its short overall length, variable number of lobes, thicker mural muscle bundles, and wide irregular neck [65,66].

Multiple percutaneous and surgical techniques have been used

for LAA elimination (Figure 9). Historically, the most common techniques for exclusion of the LAA have been internal ligation, excision, or stapling at the base [67-69]. Endocardial obliteration of the LAA through the open left atrium may be achieved by first intussuscepting the appendage and suturing carefully in two layers (Figure 10). This technique of endocardial LAA obliteration can be applied to all anatomic morphologies of the LAA, and it has been associated with < 1% per year risk of stroke when combined with surgical ablation [70]. While surgical excision has been shown to be effective, there has been concern for bleeding complications, especially in elderly patients with friable tissue. A more recent technique has been introduced where external clips are placed either under direct visualization orthoracoscopically at the base of the appendage (Figure 11), [71,72]. In a recent series of 291 patients undergoing epicardial deployment of AtriClip (AtriCure Inc) device during open-heart surgery, the LAA was successfully excluded in all patients at 3 years [73]. In a large RCT on LAA occlusion (LAAOS III), [74], over 4800 patients with AF undergoing cardiac surgery were randomized to LAA occlusion (amputation, stapling, or suturing) or no treatment while

continuing their OACs. At 3 years, there were significantly fewer strokes and systemic emboli in the surgically occluded as compared to the non-occluded cohort (4.8 vs.7%, P= 0.001). Also, the LAA occlusion with the AtriClip (AtriCure,Inc) using the stand-alone minimally invasive or thoracoscopic approach in patients with contraindications for anticoagulation or who are not candidates for transcatheter ablation, has proven to have long term safety and efficacy [75,76].

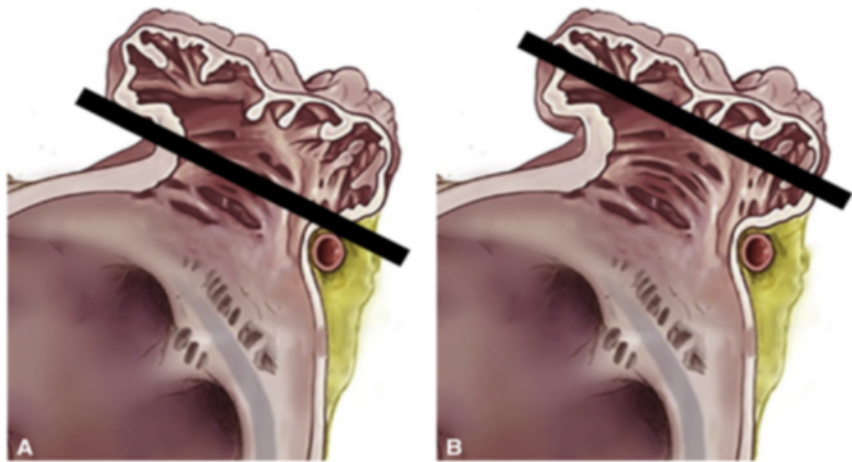


Figure 8: Left Atrial Appendage anatomy and safety landmark. (Dadhwar et al, J Thorac Cardiovasc Surg 2023;165:1398-404)

Technique	Description
Transcatheter	Occlusive device in left atrial appendage orifice
	Epicardial wire-based lasso occlusion
Surgical	Epicardial suture or endoloop without resection
	Epicardial staple exclusion without resection
	Epicardial staple with resection
	Epicardial clip exclusion without resection
	Epicardial clip exclusion with resection
	Endocardial patch with autologous or bovine pericardium
	Endocardial suture: Purse-string or linear single-layer closure
	Endocardial suture: Longitudinal double-layer obliteration and plication
	Endocardial resection and suture
	Endocardial resection and epicardial clip

Figure 9: LAAO Techniques. (Dadhwar et al, J Thorac Cardiovasc Surg 2023;165:1398-404)

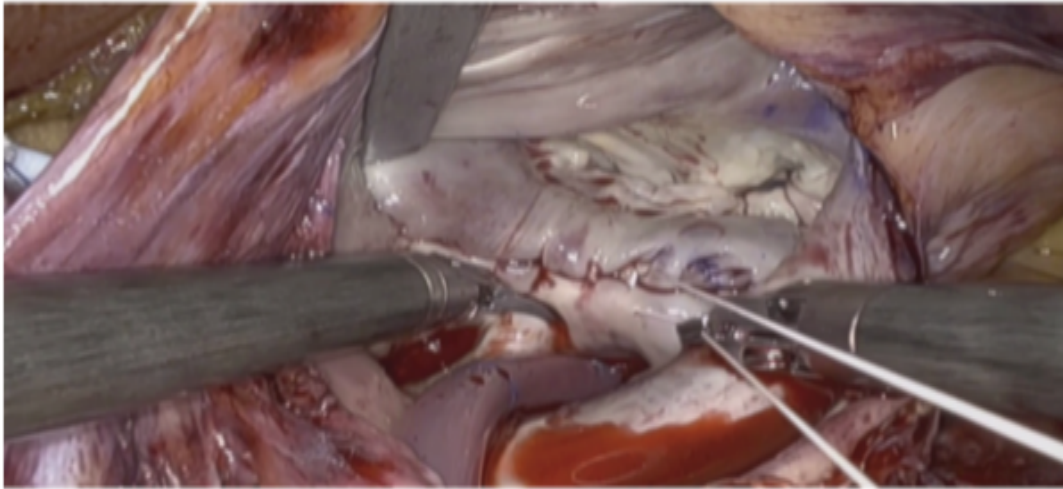


Figure 10: Technique of endocardial double-layer left atrial appendage obliteration. (Dadhwar et al, J Thorac Cardiovasc Surg 2023;165:1398-404. Video available at: [https://www.jtcvs.org/article/S0022-5223\(22\)00216-1](https://www.jtcvs.org/article/S0022-5223(22)00216-1))



Figure 11: AtriClip Flex and AtriClip Pro Mini devices. (AtriCure Inc, www.atricure.com)

Conclusion

As the different surgical ablation modalities continue to improve and evolve, the National and International Heart Associations and Societies continue to endorse their practice (Figure 12). Following the electrophysiological basis of Pulmonary Vein Isolation, catheter and surgical ablation have become first line treatment in selective patients with paroxysmal and persistent AF. LAAO by surgical techniques or non-invasive clipping has become standard of practice in concomitant cardiac surgery and first line treatment in other selective patients. The non pharmaceutical therapeutic options for rhythm control and thromboembolism prevention in AF patients have to be individualized to the specific AF pathophysiology, electrophysiology, anatomy, medical/surgical history and comorbidities of the patient. Ideally, the evaluation and decision making should be conducted in a multidisciplinary fashion with emphasis in post procedure long term monitoring.

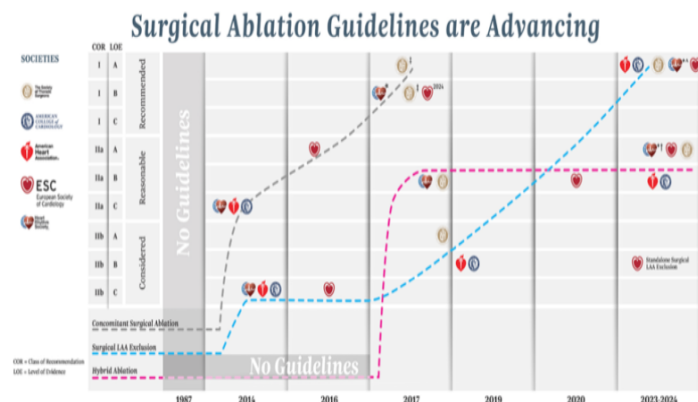


Figure 12: Adoption of surgical ablation techniques by different Heart As. (AtriCure Inc, www.atricure.com)

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