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# Recurrent Atrial Fibrillation After Catheter Ablation: Considerations For Repeat Ablation And Strategies To Optimize Success

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**Abstract**

Recurrent AF after catheter ablation occurs in at least 20 to 40% of patients. Repeat ablation is primarily considered for those with symptomatic AF recurrences (often drug-refactory) occurring at least 3 months or more post-ablation. Pulmonary vein reconnection is almost universally encountered, and repeat isolation of electrically connected pulmonary veins should be the primary ablation strategy. Beyond repeat PVI and possible ablation of non-PV triggers, there is little to no evidence that additional substrate modification improves outcomes. In addition to repeat ablation, it is critical to address and treat comorbid conditions which increase arrhythmia risk post-ablation. Specifically, obesity, hypertension, and sleep-disordered breathing should be targeted and modified to increase the likelihood of success.

## Introduction

Catheter ablation of atrial fibrillation (AF) has become an increasingly frequent procedure per-formed in electrophysiology laboratories worldwide. It is most often performed for maintenance of sinus rhythm in patients with symptomatic, drug-refractory paroxysmal or persistent AF or as an initial rhythm control strategy in lieu of anti-arrhythmic drug therapy in patients with paroxys-mal AF.[1] The increased efficacy of catheter ablation over anti-arrhythmic drug therapy to main-tain sinus rhythm has been demonstrated in a number of randomized, controlled trials and meta-analyses.[2-12] Unfortunately, recurrent atrial fibrillation or atrial tachycardia after an index AF ab-lation procedure results in repeat ablation in 20 to 40% of patients.[13] A number of dilemmas are presented by patients with recurrent AF after catheter ablation: Which patients should be con-sidered for a second procedure and when should repeat ablation be performed? What is the op-timal approach to ablation in a patient undergoing a repeat procedure? What additional interven-tions may reduce the likelihood of recurrence post-ablation? The purpose of this review is to summarize the available relevant data surrounding repeat ablation for atrial fibrillation and identi-fy areas needing further investigation.

**Key Words:**
Atrial Fibrillation Ablation, Repeat Catheter Ablation, Pulmonary Vein Reconnection, Atrial Fibrillation Lifestyle Modification.

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None.

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## Rationale For Repeat Catheter Ablation

The primary ablation strategy for AF is creation of electrical isolation of all pulmonary veins (PVs) with demonstration of bidirectional (entrance and exit) conduction block post-ablation.[1] The most commonly reported finding at repeat catheter ablation is resumption of con-duction to (and from) previously targeted pulmonary veins.[14-17] Durable PV isolation (PVI) may be so difficult to achieve after a single AF ablation that some have reported recovery of conduc-tion in 1 or more PVs in all patients undergoing repeat ablation.[18-19] Amazingly, pulmonary vein reconnection has been identified in up to 92% of patients undergoing a third or greater proce-dure.[20] Electrical isolation of the pulmonary veins is more likely to be permanent after a repeat ablation procedure. Consequently, one rationale for repeat ablation is to "finish" what was started during the first procedure and attempt to ensure permanent electrical isolation of all pulmonary veins. In addition, studies have shown incremental success with higher rates of long-term free-dom from AF with repeat ablation possibly resulting from a higher rate of permanent PV isola-tion.[12,19,21]

## Timing Of Repeat Catheter Ablation

Among patients with recurrent arrhythmias post-ablation, there are a number of consid-erations impacting patient management. First, the patient's symptoms should heavily influence subsequent management strategies. Patients with minimal to no symptoms who are adequately rate-controlled may be suitable for a rate-control and anticoagulation strategy rather than con-tinuing to pursue sinus rhythm. The timing of recurrence is also important when considering a repeat procedure. Recurrent arrhythmias within the first two to three months post-ablation may resolve spontaneously or not recur after cardioversion so a repeat procedure is often deferred in this timeframe.[1] The mechanism of recurrent arrhythmia (AF versus atrial

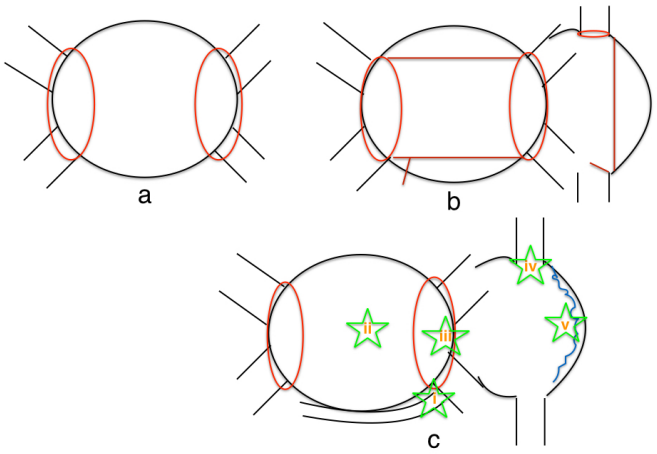


**Figure 1:** Potential ablation strategies during repeat AF procedures: a) repeat pulmonary vein isolation only with confirmation of entrance and exit block from each vein; b) pulmonary vein isolation with ad-ditional linear lesions (posterior wall isolation with linear lesions connecting the superior and infe-rior pulmonary veins; mitral isthmus ablation; +/- right atrial linear lesions); c) pulmonary vein iso-lation and ablation of non-pulmonary vein triggers (i = coronary sinus; ii = LA posterior wall (and left atrial appendage, not pictured); iii = fossa ovalis/interatrial septum; iv = crista terminalis/right atrium; v = superior vena cava)

tachycardia/flutter) may also play a role in decision-making. Patients typically considered for repeat ablation have recurrent, symptomatic AF more than 3 months after initial ablation. Early repeat ablation may be considered for recurrent arrhythmia (particularly atrial tachycardia or atrial flutter) that is diffi-cult to manage medically and recurs despite cardioversion. Recurrent atrial flutter or tachycar-dia post-ablation may be better managed with a repeat procedure as such arrhythmias can be difficult to rate control, frequently recur after cardioversion, and are often due to gaps in areas of prior ablation and have a relatively high success rate with repeat ablation. The focus of this re-view is recurrent atrial fibrillation after catheter ablation and not management of post-ablation atrial flutter or tachycardia.

An additional consideration is the likelihood of success with repeat catheter ablation. Factors shown to negatively impact recurrence rates include left atrial properties (volume, fibro-sis), associated systemic disease (hypertension, obstructive sleep apnea), concomitant heart disease (particularly mitral valve disease and hypertrophic cardiomyopathy), and duration of atrial fibrillation (e.g., longstanding persistent AF has a higher recurrence rate than paroxysmal AF, table 1).[1] Patients with multiple negative prognostic factors for recurrence perhaps are best managed medically (if possible) rather than exposed to the risks of ablation with low likelihood of success. It would not be appropriate to pursue repeat ablation in asymptomatic patients with the hope of obviating need for long-term oral anticoagulation when the CHA2DS2-VASc score indi-cates a moderate to high risk of stroke. Repeat catheter ablation is most commonly accepted for patients with well-documented arrhythmia recurrences who are symptomatic (despite a trial of anti-arrhythmic drug therapy) and are more than 3 months removed from the initial proce-dure.[1]

## Strategies For Repeat Catheter Ablation

When AF recurs after PVI and PV reconnection is identified at repeat ablation it seems prudent to re-isolate any reconnected PVs. If the PVs have reconnected, however, how does one know that PV reconnection is the cause of recurrent arrhythmia? Going a step further, should additional ablation beyond repeat PVI be performed? If the PVs have not reconnected what ablation strategy should be employed? Considerations include using different energy deliv-ery sources to repeat PVI (e.g., using cryoablation if radiofrequency was used initially), creation of linear lesions in the left and/or right atrium, isolation of the superior vena cava or coronary si-nus, ablation at atrial sites with fractionated electrograms during AF, ablation at sites of vagal in-puts to the atria, and targeting non-PV triggers (figure 1). It is important to note there are no randomized controlled trials addressing these issues in patients with recurrent AF. The data re-porting outcomes with repeat AF ablation are derived from retrospective and observational co-hort and case-control studies. The most recent consensus statement on catheter ablation of AF suggests the first step when performing a repeat procedure is to check each PV for electrical reconduction followed by reisolation of PVs as necessary as there is data showing reasonably good outcomes with repeat PVI alone.[1,15] If there is little to no evidence of PV reconduction, non-PV foci should be sought and consideration should be given to modification of the ar-rhythmogenic substrate although no particular linear lesion set or alternative ablation approach is recommended in the guidelines.[1]

## Techniques To Enhance Durability Of Pulmonary Vein Isolation

As pulmonary vein reconnection is near universal among patients undergoing repeat ab-lation, it is prudent when re-isolating PVs to employ techniques shown to increase the likelihood of durable PVI. This is more likely to occur with the delivery of contiguous, transmural lesions regardless of the energy deliver system. It is postulated that improved acute lesion delivery will translate to enhanced long-term outcomes. A number of procedural techniques have been ad-vocated to improve the likelihood of transmural lesion formation thereby increasing the likelihood of durable PVI and (hopefully) freedom from arrhythmia. General anesthesia compared to con-scious sedation lowers reconnection rates among patients with recurrences who underwent re-peat ablation (19 vs 42%).[22] Efforts to minimize respiratory motion, particularly using high-frequency jet ventilation, have also been shown to improve freedom from AF at 1 year post-ablation.[23] Catheter stability may be further enhanced by manipulation through a steerable sheath, and use of such technology has been shown to improve short-term AF freedom rates post-ablation.[24] Ablation using multi-pore irrigated tip catheter technologies results in lower peri-procedural PV reconnection rates compared to standard irrigated tip catheters.[25] Contact force sensing technologies provide continuous feedback regarding catheter contact force and stability, and ablating with a contact force > 10 grams is associated with a lower likelihood of acute pul-monary vein reconnection and improved outcomes at 1 year.[26,27] Pulmonary vein reconnection rates were no different between standard radiofrequency ablation (using an open-irrigation RF catheter) and the first generation cryoballoon system among patients presenting for repeat abla-tion in a small study of 50 patients with paroxysmal AF.[28]

Rigorous testing to confirm bidirectional (entrance and exit) conduction block post-ablation improves long-term success rates.[29] A reasonable post-ablation wait period to assess for acute PV electrical reconnection seems to improve outcomes, and a study of 181 patients sug-gests waiting at least 35 minutes after acute isolation is the optimal observation time.[30]

Assessing for non-capture along the circumferential lesion set is

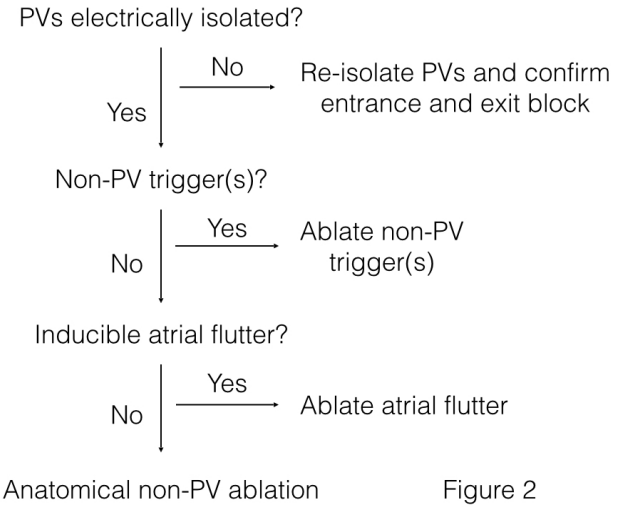


**Figure 2: Rational approach to a repeat AF ablation procedure**

one method for testing the integ-rity of the ablation line, and re-ablating sites of pace capture resulted in greater AF freedom (83 vs 52%) at 1-year follow-up in a prospective study.[31] Administration of adenosine to assess for dormant conduction can be useful for identifying gaps in the ablation line and pulmonary veins with higher risk of reconnection.[32] Additional ablation of acutely reconnected pulmonary veins after adenosine administration may or may not improve long-term outcomes as data is mixed.[33,34]

It is important to note that none of these approaches has been systematically studied to determine their true impact on promoting durable pulmonary vein isolation. It is also worth noting that absence of AF recurrence does not necessarily indicate permanent pulmonary vein isola-tion, and PV reconnection noted at repeat procedure may be incidental and not causative with regard to arrhythmia recurrence. That being said our initial approach during a repeat AF ablation procedure is to first and foremost ensure pulmonary vein isolation by ablating any reconnected pulmonary veins and confirming bidirectional conduction block (figures 2 and 3). Our standard approach is to use a contact force sensing catheter within a steerable sheath guided by an elec-troanatomic mapping system and intracardiac echocardiography. A circular mapping catheter is used to confirm bidirectional conduction block, and adenosine is routinely administered with re-ablation of any sites exhibiting dormant conduction. A comprehensive EP study is then per-formed to assess for other inducible arrhythmias or non-PV triggers with additional ablation as needed.

## Options Beyond Pulmonary Vein Isolation: Ablation Of Non-Pulmonary Vein Triggers And Substrate Modification

As pulmonary vein electrical reconnection is a common finding at repeat ablation, it seems prudent to re-isolate any reconnected PVs as an initial repeat ablation strategy as men-tioned above. The decision to pursue additional ablation beyond PVI is difficult, and there is little data to guide whether additional ablation, if any, should be performed during a repeat procedure. Several studies have reported improved outcomes with a strategy of PVI and additional ablation of spontaneous or inducible non-pulmonary vein AF triggers.[15,16,20,35,36] One of these studies reported outcomes among 169 patients with recurrent AF despite 2 or more prior ablation proce-dures.[20] Astonishingly, only 8% of patients had all PVs isolated at baseline despite more than 1 prior ablation. Non-pulmonary vein triggers were rigorously sought with incremental doses of isoproterenol (3, 6, 12, and 20 μg/min and/or burst atrial pacing to provoke AF followed by cardi-oversion with or without low-dose isoproterenol). The majority of AF triggers localized to the pulmonary veins, although other triggers were identified (Eustachian ridge and crista terminalis; coronary sinus; SVC; LA posterior wall; left atrial appendage; interatrial septum). With a strategy of repeat PVI and targeting non-PV triggers, 81% of patients had arrhythmia control at up to 1-year follow-up.

Beyond PVI and ablation of non-PV triggers, there is very little data to guide whether ad-ditional substrate modification should be performed during a repeat ablation procedure. On one hand, it could be argued that recurrent AF is a failure of the initial strategy so a different strategy (i.e., substrate modification) should be attempted. Alternatively, one could postulate that the primary goal of repeat ablation is to ensure durable PVI, and non-PV based ablation strategies should be reserved for patients without PV reconnection. Extensive ablation may come with the costs of altering atrial contractile properties, increasing the risk for procedural complications, and placing the patient at risk for iatrogenic atrial flutter(s) if bidirectional block is not achieved across linear lesions.[37] Ultimately, the critical question is how important the PVs are in driving a given patient's arrhythmia. Comparing the cycle length of PV triggers to the cycle length in the coro-nary sinus during AF may provide some indication as to the role of the PVs in supporting a patient's arrhythmia.[38] Pulmonary vein electrogram frequency tends to be much higher than the coronary sinus early in the disease process (suggesting PV isolation will result in a high likelihood of arrhythmia control), whereas the PV electrogram frequency is often lower than the coronary sinus as the disease process becomes more advanced (suggesting non-PV sources may be of increased importance and PV isolation alone may not result in optimal outcome).

There are no randomized controlled trials evaluating the efficacy of substrate modifica-tion techniques in patients with recurrent AF. The available data for non-PV based ablation come from patients undergoing de novo ablation procedures. Substrate modification techniques such as left atrial linear ablation, focal impulse or rotor modulation, ablation of complex fraction-ated atrial electrograms (CFAEs), and ganglionated plexi modification have been evaluated pri-marily in patients undergoing initial ablation for persistent and longstanding persistent AF. Ex-trapolation of these results to patients undergoing repeat ablation should be done with caution. Electrical isolation of the LA posterior wall has been evaluated primarily in patients with persistent AF with mixed results.[39,40] Ablation of areas with complex fractionated activity (CFAEs) have been investigated in patients with paroxysmal and persistent AF. Nademanee et al. targeted CFAEs defined as sites with low-amplitude potentials and continuous electrical activity or cycle length < 120 ms and reported a success rate of 91% at 1-year follow-up.[41] A more recent study evaluated adjunctive ablation of CFAE sites (identified with an automated mapping system) ver-sus ablation of sites with continuous electrical activity.[42] At 1-year follow-up, freedom from ar-rhythmia, although modest, was higher with CFAE ablation compared with ablation of sites with continuous electrical activity (50 vs 28%). Adjunctive CFAE ablation has not been uniformly demonstrated to improve outcomes as one study randomly assigned 156 patients to PVI plus ablation of inducible non-PV triggers versus one of two additional strategies: PVI + empiric abla-tion of common non-

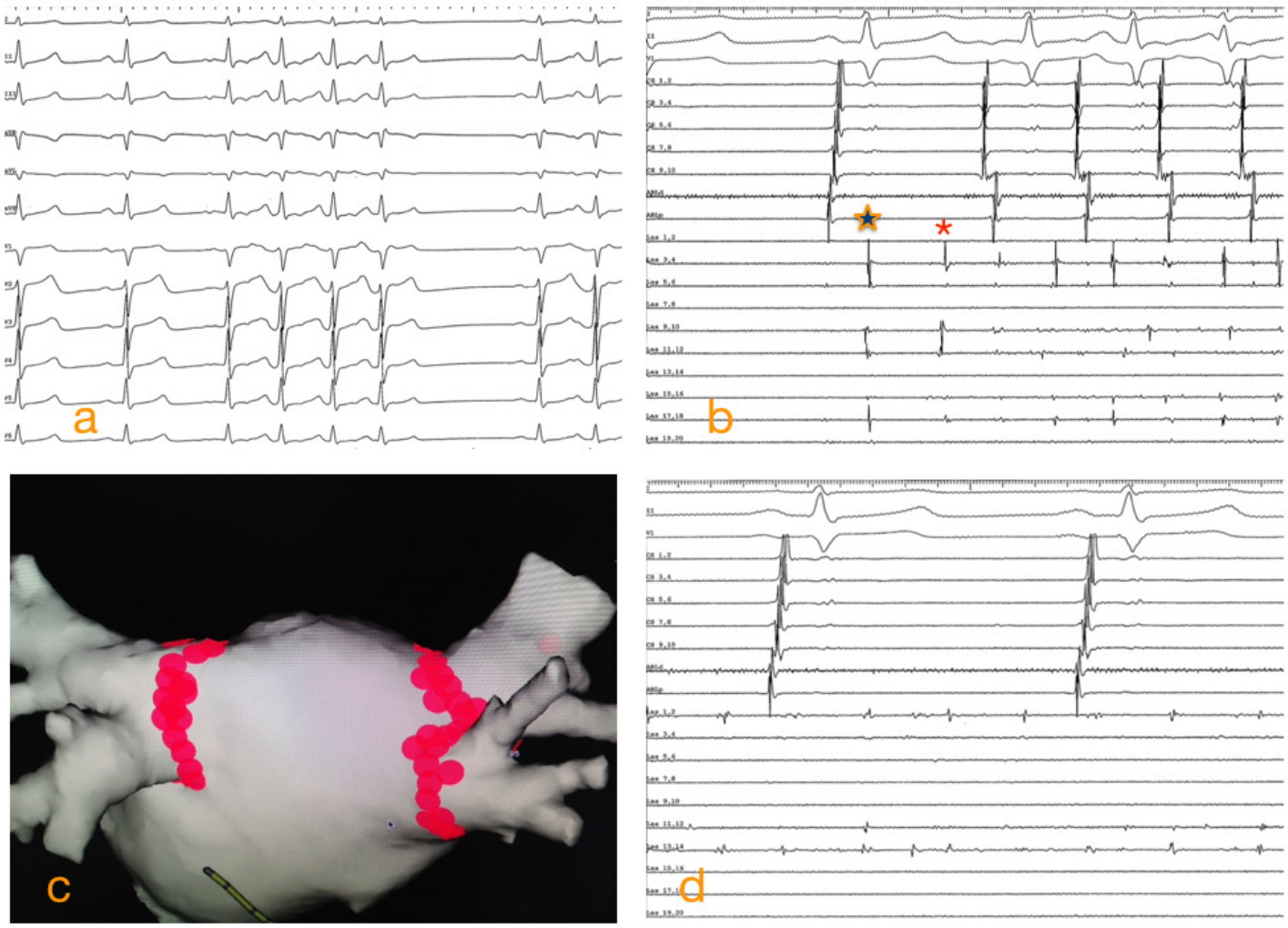


**Figure 3:** **Illustrative case of a 47 year-old man undergoing repeat catheter ablation for atrial fibrillation. Paroxysmal AF had been diagnosed 2 years prior, and the patient underwent catheter ablation approximately 12 months earlier at another institution. He was AF free for nearly 9 months but then began having recurrent symptoms with paroxysmal AF documented. a) baseline rhythm at the start of the procedure under general anesthesia; frequent short bursts of AF noted; b) dis-played are 3 surface ECG leads and intracardiac recordings from a decapolar catheter in the coronary sinus (labeled cs 9,10 through cs 1,2) and a circular mapping catheter (labeled Las 19,20 through Las 1,2) placed in the right superior pulmonary vein; note the delayed pulmonary vein potential (star) and initiation of AF triggered by spontaneous firing from the RSPV (asterisk); the other 3 PVs remained electrically isolated from the prior procedure; c) electroanatomic map with a posterior view of the left atrium; the RSPV was re-isolated using RF ablation and addition-al tags were placed at sites around the remaining pulmonary veins were there was bipolar volt-age < 0.2 mV and no pace capture; 4) the circular mapping catheter in the right superior pulmo-nary vein demonstrates AF in the RSPV with exit block while the atria remain in sinus rhythm**

PV AF trigger sites or PVI + ablation of left atrial CFAE sites.[43] Ablation of CFAE sites did not result in improved arrhythmia control at 1-year follow-up. In addition, a more recent randomized trial (STAR AF II) further assessed the role of adjunctive CFAE and linear ablation among patients with persistent atrial fibrillation.[44] At 18 months follow-up, 59% of PVI only patients were free from recurrent arrhythmia as opposed to 49% of patients who underwent PVI + CFAE ablation and 46% of patients who underwent PVI + empiric linear ablation.

The autonomic nervous system may play a role in initiating and maintaining AF through several mechanisms: facilitating spontaneous premature atrial depolarizations; shortening of atrial and PV effective refractory periods; and increasing heterogeneity of refractoriness. Con-sequently, a number of authors have investigated the role of adjunctive ganglionated plexus (GP) ablation. A randomized trial involving 67 patients with paroxysmal AF assigned to PVI ver-sus PVI plus GP ablation showed improved outcomes at 10 month follow-up (45.5 vs 73.5%).[45] This is an area of active investigation and additional data involving a larger number of patients is needed to determine if GP ablation truly improves outcomes.

Recent studies have reported the presence of stable reentrant circuits ("rotors") within the atria of AF patients which may provide an additional target during AF ablation.[46-48] The CON-FIRM trial reported initial experience in 92 patients treated either with FIRM-guided ablation with PVI versus PVI alone.[49] FIRM ablation was associated with slowing or termination of AF in 86% of patients, and over follow-up 82% of FIRM patients remained free of AF compared with 45% in the PVI-only group. More recently, two additional studies evaluated the efficacy of FIRM abla-tion on early and long-term outcomes and reported less optimistic results. One study reported 6-month outcomes among 29 patients (20 persistent, 9 longstanding persistent) undergoing FIRM-identified rotor ablation alone.[50] Single-procedure freedom from atrial tachyarrhythmias without anti-arrhythmic drugs was 17%. The other study reported

**Table 1: Risk factors for atrial fibrillation recurrence after ablation**

| | |
|---|---|
| Age | Increased risk of recurrence with advancing age |
| AF duration and type | (Longstanding persistent > persistent > paroxysmal) |
| Cardiac structural changes | Left atrial dilatation; left ventricular function; hypertrophic cardiomyopathy; valvular heart disease |
| Clinical features | Hypertension; obesity; obstructive sleep apnea/sleep disordered breathing; metabolic syndrome; thyroid disease |

outcomes among 43 patients (56% paroxysmal) who underwent FIRM ablation and PVI.[51] At 18 month follow-up only 21% of patients were free from arrhythmia off antiarrhythmic drugs.

Additional studies have evaluated the benefit of assessing for low-voltage areas at the time of ablation and performing additional substrate modification of these sites. A study involving 178 patients (65% persistent) found low voltage abnormalities in 35% and 10% of persistent and paroxysmal patients, respectively.[52] Low voltage areas were defined as sites with ≥ 3 adjacent points with bipolar voltage < 0.5 mV. Catheter ablation of low voltage areas in addition to PVI resulted in 12-month arrhythmia freedom of 70% compared with 27% among 26 patients with low voltage abnormalities who did not undergo further substrate modification. Another study as-sessed outcomes among 85 patients who underwent PVI and ablation of low voltage areas as-sociated with either fractionated or discrete rapid local activity within or along the border zones of low voltage areas compared with 42 "control" patients with persistent AF who underwent PVI alone.[53] Arrhythmia freedom at 13 months was 69% among patients who underwent ablation of low voltage areas compared with 47% in the PVI-alone control group.

Substrate modification techniques (i.e., linear ablation; targeting of CFAEs or low voltage areas) have yielded conflicting results among patients undergoing de novo ablation and have not been studied and are of unclear benefit in patients undergoing repeat AF ablation. Given that the majority of studies investigating non-PV based ablation have shown little to no improvement over PVI alone (e.g., STAR AF II), it is hard to advocate for extensive atrial ablation. The majority of evidence suggests repeat PVI (if the PVs have reconnected) and ablation of non-PV triggers seems to be the most effective strategy. If the PVs have not reconnected, it seems reasonable to perform a comprehensive EP study to assess for inducible atrial flutter(s) or atrial tachycar-dia(s) and reserve substrate modification for patients in whom the PVs have not reconnected and other arrhythmias are not inducible. If linear ablation is performed it is imperative that bidi-rectional block be confirmed to avoid creating the substrate for iatrogenic atrial arrhythmias.

## Repeat AF Ablation: Cryoablation Versus Radiofrequency?

When patients have recurrent AF after ablation is a certain energy delivery system pre-ferred for repeat PVI? If cryoablation was used in the index procedure, should radiofrequency (RF) be employed in a subsequent procedure or vice versa? There is limited data addressing this subject but one interesting study is worth mention. Pokushalov et al. randomly assigned 80 patients with recurrent paroxysmal AF after a first PVI using radiofrequency ablation to repeat PVI with either cryoablation or RF.[54] Study participants had implantable loop recorders to moni-tor for recurrence. At 1-year follow-up more patients randomized to repeat ablation with RF (58%) were AF-free compared with those who underwent cryoablation (43%). This finding sug-gests repeat PVI with RF, as opposed to cryoablation, results in improved outcomes although this study is small and the results should be validated in a larger number of patients.

## Pre-Procedural And Intra-Procedural Imaging To Guide Ablation

Ideally pre-procedural imaging could be used to identify sites of PV reconnection or pro-vide clues to the mechanism of recurrent arrhythmia to guide repeat ablation. Late gadolinium-enhanced (LGE) MRI has been used to identify gaps in lesion sets which may be targeted acute-ly or with repeat ablation.[55-57] One study involving 15 patients undergoing repeat ablation for AF found pre-ablation late gadolinium-enhanced MRI accurately identified gaps in areas of prior ab-lation resulted in shorter procedure times by allowing more targeted ablation.[58] In addition, as previously mentioned there is some evidence suggesting improved outcomes if areas of low voltage are targeted in addition to PVI. If this is validated in subsequent studies and found bene-ficial in patients undergoing repeat ablation, LGE-MRI may be useful for pre-procedure planning by helping identify abnormal substrate which could be targeted for ablation.

A critical step forward may be noninvasive imaging of electrical activation to identify the processes essential to maintaining an individual's arrhythmia. Identification of focal drivers or rotational activities prior to entering the electrophysiology laboratory may facilitate a tailored abla-tion strategy more likely to be successful than empirically applying the same lesion sets to each patient regardless of arrhythmia mechanism. Medtronic, Inc. and CardioInsight's ECVUETM is a noninvasive system which captures body surface electrical data to create and visualize epicardi-al 3D electroanatomic maps. The system has proven successful in mapping and ablation of persistent AF in a multicenter study.[59] In the study, 118 persistent AF patients underwent pre-ablation body surface mapping with data used to guide ablation of AF drivers. Acute success (AF termination) was achieved in 64% with driver-based ablation alone. At mean 6 months' fol-low-up, 83% of patients were AF free including recurrent atrial tachycardia in 38%. Although ad-ditional work needs to be done to validate the accuracy of noninvasive electrical mapping, the concepts and available data are intriguing. Noninvasive electrical mapping may become a valu-able pre-ablation tool for both de novo and repeat AF ablation procedures by potentially identify-ing areas critical to a patient's AF mechanism(s) prior to entry into the EP laboratory.

## Ancillary Interventions To Minimize AF Recurrence

In addition to procedural interventions to treat AF, one should also screen for and modify any comorbid conditions which may increase the likelihood of AF recurrence (table 1). Specifi-cally, it is prudent to address obesity; sleep-disordered breathing/obstructive sleep apnea; hyper-tension; smoking and alcohol consumption. Obesity is a clearly defined risk factor for AF.[60] It increases the risk of hypertension, metabolic syndrome/diabetes mellitus, and obstructive sleep apnea (OSA), all of which have also been associated with development of atrial fibrillation. Weight reduction has been shown to reduce AF symptom burden and severity.[61] Obstructive sleep apnea independently increases the risk of incident atrial fibrillation and increases the risk of recurrent AF after ablation.[62,63] OSA promotes atrial structural and electrical remodeling includ-ing atrial enlargement and low-voltage areas with conduction abnormalities.[64] Treatment of OSA with continuous positive airway pressure (CPAP) improves arrhythmia-free survival post-catheter ablation.[63] A recent study demonstrated aggressive risk factor modification including weight reduction (initial goal to reduce body weight by 10% followed by target BMI < 25 kg/m$^2$); blood pressure management with target

< 130/80 mmHg; aggressive lipid and glycemic control; treatment of obstructive sleep apnea if the apnea-hypopnea index (AHI) was > 30/hour; and ab-stinence from smoking and alcohol significantly improved arrhythmia-free survival.[65] Additional research is needed to define optimal targets for management of AF risk factors, but it is clear that treatment of comorbid conditions optimizes AF control.

## Conclusions

Recurrent AF after catheter ablation occurs in at least 20 to 40% of patients. Repeat ab-lation is primarily considered for those with symptomatic AF recurrences (often drug-refactory) occurring at least 3 months or more post-ablation. Pulmonary vein reconnection is almost uni-versally encountered, and repeat isolation of electrically connected pulmonary veins should be the primary ablation strategy. Beyond repeat PVI and possible ablation of non-PV triggers, there is little to no evidence that additional substrate modification improves outcomes. If substrate modification and linear lesions are created, however, it is imperative to confirm bidirectional con-duction block to avoid creating substrate for iatrogenic atrial arrhythmias. In addition to repeat ablation, it is critical to treat the "whole" patient by addressing comorbid conditions which in-crease arrhythmia risk post-ablation. Specifically, obesity, hypertension, and sleep-disordered breathing should be targeted and modified to increase the likelihood of success.

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