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**Mechanisms and clinical significance of early recurrences of atrial arrhythmias after catheter ablation for atrial fibrillation**

Liang JJ *et al*. Early recurrences after AF ablation

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**Abstract**

Early recurrences of atrial arrhythmias (ERAA) after ablation is common and strongly predicts late recurrences and ablation failure. However, since arrhythmia may eventually resolve in up to half of patients with ERAA, guidelines do not recommend immediate reintervention for ERAA episodes occurring during a 3-mo post-ablation blanking period. Certain clinical demographic, electrophysiologic, procedural, and ERAA-related characteristics may predict a higher likelihood of long-term ablation failure. In this review, we aim to discuss potential mechanisms of ERAA, and to summarize the clinical significance, prognostic implications, and treatment options for ERAA.

**Key words:** Atrial fibrillation; Recurrence; Catheter ablation; Pulmonary vein isolation

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**Core tip:** There have been several studies examining the predictors of early recurrences of atrial arrhythmias (ERAA) during the blanking period after atrial fibrillation (AF) ablation and the predictive value of such early recurrences on late recurrences. In this review, we summarize the mechanisms and predictors, clinical significance, prognostic implications, and treatment options of ERAA after AF ablation.

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**INTRODUCTION**

Catheter ablation is an effective treatment option for patients with symptomatic atrial fibrillation (AF). The cornerstone of AF ablation involves pulmonary vein isolation (PVI). Early recurrences of atrial arrhythmia (ERAA) are frequent in the post-ablation period, and may occur as either AF or organized atrial tachycardia (OAT), and in some instances may resolve over time without requiring repeat intervention. These early recurrences are thought to be related to post-ablation inflammation, edema, and healing. As such, the consensus guideline statements have recommended employing a 3-mo “blanking period” after AF ablation during which AF or OAT recurrences should not be considered as ablation failure[1]. In this review, we will define and discuss the implications of ERAA, as well as summarize the literature with regards to methods to prevent and treat ERAA.

**BLANKING PERIODS AND EARLY RECURRENCES**

The use of a blanking period has been employed under the assumption that not all ERAA episodes results in late recurrences. The 2012 HRS/EHRA/ECAS Expert Consensus Statement recommends the use of a 3-mo blanking period after ablation, during which time ERAA episodes not be classified as treatment failure. However, the authors of the guideline statement do state that the use of a shorter blanking period (< 3 mo) is acceptable as long as it is pre-specified and described in the study methods[1]. In line with the consensus statement, most operators tend to avoid repeat ablation for ERAA occurring within the blanking period unless patients are extremely symptomatic with recurrences which are refractory to antiarrhythmic drugs (AADs) and repeated cardioversions.

Variable blanking periods have been utilized across published studies, ranging anywhere from 72 h up to 3 mo post-ablation[2]. While the HRS/EHRA/ECAS consensus statement selected 3 mo as the blanking period of choice, the optimal blanking period to maximize the sensitivity and specificity of prognostic implication of ERAA- and therefore the optimal cutoff interval during which early re-ablation should be avoided, remains poorly studied.

**DETECTION OF ERAA IN THE BLANKING PERIOD**

Methods of monitoring used to detect ERAA episodes have varied between studies. There is a wide range of intensiveness with regards to duration and strategy of monitoring, and detection of ERAA is dependent on type of monitoring post-ablation. The least intensive monitoring strategies involve symptom-driven 12-lead electrocardiogram, and 24-h or 48-h Holter monitoring ordered only when patients endorse symptoms of palpitations or notice an abnormal pulse. More intensive strategies which studies have utilized include handheld symptom-driven rhythm monitor applications, 30-d transtelephonic monitors, and auto-triggered external and implantable subcutaneous loop recorders. Landmark trials in patients with cryptogenic stroke have demonstrated that more intensive rhythm monitoring for longer durations using transtelephonic monitoring devices (*i.e.*, CardioNet, Malvern, PA; LifeWatch, Rosemont, IL; Medicomp, Melbourne, FL) or implantable cardiac monitors (*i.e.*, Reveal XT and Reveal LINQ; Medtronic, Minneapolis, MN) may increase the likelihood of detecting asymptomatic AF[3,4]. However, since most operators tend to avoid early reablation for paroxysmal recurrences of asymptomatic ERAA during the blanking period, the optimal method of post-ablation monitoring (or whether any monitoring is necessary at all, for that matter) remains controversial.

**FREQUENCY OF ERAA**

In a pooled analysis by Andrade *et al*[2], the incidence of ERAA after radiofrequency catheter ablation across multiple studies utilizing a 3-mo blanking period ranged from 16%-67% with a mean pooled estimate of approximately 38%. The incidence of ERAA is highest immediately post-ablation and tends to decrease over time throughout the blanking period[5,6]. Rates of ERAA appear to be similar after ablation with radiofrequency or cryoablation, although there may be differences in the predictive value of inflammatory responses on the incidence of ERAA post-ablation between techniques.

For example, in the multicenter Sustained Treatment of Paroxysmal Atrial Fibrillation (STOP-AF) trial, which randomized patients with paroxysmal AF to medical therapy *vs* PVI with cryoballoon ablation, 51% of patients treated with cryoablation experienced ERAA within the first 3 months post-ablation, and those with ERAA (*vs* without ERAA) were significantly more likely to experience late recurrence (55.6% *vs* 12.7%; *P* < 0.001) [7].

Ciconte *et al*[8] studied 100 patients with persistent AF treated with PVI using second-generation cryoballoon *vs* radiofrequency ablation and found that the rates of both ERAA (51.9% *vs* 48.1%; *P* = 1.0) and late recurrence (47.6% *vs* 52%; *P* = 0.84) were similar between ablation technologies. Among all patients, ERAA in their study predicted late recurrence with a hazard ratio of 6.31 (CI: 3.37-11.83, *P* < 0.01).

In a nonrandomized fashion, Miyazaki *et al*[9] prospectively examined 82 consecutive patients with paroxysmal AF treated with PVI using either radiofrequency ablation *vs* cryoablation with the second generation cryoballoon. While the peak hs-CRP level was similar between ablation techniques, the level of hs-CRP 2 days post-ablation predicted development of ERAA in those treated with radiofrequency (HR 1.7; 95%CI: 1.01-2.87; *P* = 0.048) but not cryoablation, suggesting that degree of inflammatory marker response may have a stronger predictive value for ERAA after radiofrequency compared with cryoablation.

**PREDICTORS OF ERAA**

Prior studies have identified clinical and demographic characteristics, arrhythmia characteristics, electrocardiographic and echocardiographic characteristics, and AF ablation procedural and post-procedural characteristics which are predict the development of ERAA after ablation, several of which we have listed in Table 1[2,5,7,10-22].

**MECHANISMS AND PATHOPHYSIOLOGY OF ERAA**

The incidence and clinical significance of ERAA after surgical MAZE is strikingly similar to that of catheter ablation. Approximately 50%-60% of patients develop in-hospital ERAA after MAZE, and those with ERAA have a higher rate of late recurrence (30%) *vs* those whose hospital course is not complicated by ERAA (5%-10%)[23,24].

The mechanism of ERAA after catheter ablation probably differs from that of late recurrences, and is likely dependent on the initial ablation strategy. In patients with paroxysmal AF treated with limited ablation strategies focused primarily on achieving PVI, we have found that late recurrence is usually due to chronic reconnection of previously isolated PVs. In patients with persistent AF treated with empiric linear ablation or those who undergo more extensive substrate-based ablation, gaps in lines may predispose to the development of late macroreentrant OATs. ERAA within the first 7 d post ablation occurs in the setting of an intensely inflammatory milieu. As such, it is difficult to differentiate in the early post-ablation period whether ERAA results from transient post-ablation inflammation (which is likely to resolve without the need for repeat ablation) *vs* chronic PV reconnection. Furthermore, using a rigorous trigger induction protocol, we have identified that non-PV triggers of AF may exist in 11% of patients presenting for AF ablation[25]. Thus the persistence of non-PV triggers due to inadequate identification and elimination of non-PV triggers during the initial ablation procedure can allow for both ERAA and late recurrences to occur.

Lim *et al*[26] measured the blood concentration of several inflammatory markers (hs-CRP, Troponin T, CK-MB, fibrinogen, and D-dimer) before ablation, and serially at different time periods (1, 2, 3, 7 d, and 1 mo) after ablation and correlated the degree of inflammatory marker elevation with AF recurrence documented at different time points post-ablation. They found that the degree of elevation of hs-CRP, troponin-T, and fibrinogen predicted ERAA within 3 d post-ablation, but not at 3 or 6 mo.

Das *et al*[27] examined the association between timing of ERAA with the likelihood of PV reconnection at repeat electrophysiology study in 40 patients with nonparoxysmal AF treated with PVI. After the index ablation procedure, all 40 patients were brought back for electrophysiology study regardless of whether they had recurrence post-ablation. The operator was blinded to the presence and timing of ERAA, and all PVs were assessed for reconnection using a circular mapping catheter. All identified sites of reconnection were reablated to reisolate PVs, regardless of the presence or absence of ERAA. In total, 17 (42%) of the patients had ERAA within the first 2 months after ablation, preceding the repeat electrophysiology study. The authors found that ERAA occurring within the second month was strongly associated with PV reconnection, and also strongly predicted “extensive reconnection” of ≥ 2 PVs. Contrarily, ERAA limited to the first month post-ablation had no association with PV reconnection. The results of the study suggested that ERAA within the first month was more likely to be related to transient factors such as inflammation, temporary autonomic imbalances, and the time-course of lesion formation, while ERAA occurring after the first month was more likely to represent ablation failure and PV reconnection[28].

***Ablation strategies***

The initial ablation strategy may affect the prognostic implications of ERAA. With approaches which involve more extensive substrate-based ablation, ERAA is more likely to be related to edema and inflammation, and accordingly may be more likely to resolve with time. Meanwhile, ERAA in patients treated with less extensive ablation approaches mainly (*i.e.*, targeting PV and non-PV triggers, for example), may be more likely to represent PV reconnection or inadequate trigger elimination. Since these triggers are unlikely to resolve spontaneously without intervention over time, eventual reablation may be necessary for these patients to achieve freedom from AF.

Post-hoc analysis of data from the Substrate and Trigger Ablation for Reduction of Atrial Fibrillation (STAR-AF) trial (which compared PVI alone, ablation of complex fractional atrial electrograms (CFAE) alone, and PVI plus CFAE) showed that patients treated with PVI alone who experienced ERAA (*vs* those without ERAA) had significantly higher rates of late recurrence[29]. Interestingly, the predictive value of ERAA on late recurrence was not as strong among those treated with CFAE or PVI plus CFAE. This suggests that substrate-based approaches involving extensive ablation may cause higher incidence of AF related to acute reversible changes post-ablation.

We at our institution employ a strategy aimed at elimination of PV and non-PV triggers. In our experience, patients with recurrent AF after ablation who present for repeat ablation nearly always have PV reconnection and/or non-PV triggers[30]. Non-PV triggers which were not targeted during the initial ablation may manifest as PACs during the ERAA period post-ablation, and may predict late AF recurrence. Gang *et al*[31] examined 7-d Holter monitors in 124 patients six months post-PVI (3 mo after the blanking period had ended) and found that frequent premature atrial complexes (PACs) strongly predicted late AF recurrence. Patients who developed late recurrence had a median of 248 PACs per day compared *vs* those without late recurrence (77 PACs per day). Based on receiver operating characteristic curve analysis, the authors calculated that the presence of ≥ 142 PACs/d predicted late AF recurrence with a hazard ratio of 2.84 (CI: 1.26-6.43; *P* = 0.01). While their study did not examine the predictive value of PACs during the ERAA blanking period, one could hypothesize that atrial ectopy originating from PV and non-PV foci manifesting as PACs during the blanking period might represented inadequately targeted triggers or partial PV reconnection.

**ERAA CHARACTERISTICS WHICH PREDICT LATE RECURRENCE**

The occurrence of ERAA after ablation is well known to be a strong independent predictor of late recurrence and long-term ablation failure. In the pooled analysis of several studies by Andrade *et al*[2], there was a 53.7% late recurrence rate among patients with ERAA compared *vs* only 6.9% in patients without ERAA. Several studies have examined whether certain types of ERAA (AF *vs* OAT or atrial flutter) are more predictive of late ablation success. While some authors have suggested success rates after repeat ablation in patients who recur as OAT (*vs* AF) after their initial ablation attempt, it remains unclear whether OAT in the ERAA period is more or less predictive of late ablation failure[32].

Nalliah *et al*[33] examined 119 consecutive patients with paroxysmal or persistent AF who underwent ablation with PVI and additional ablation (50% underwent mitral isthmus linear ablation, and 18% had additional CFAE ablation) to determine the impact of AF and OAT occurring within the blanking period. Patients were not closely monitored for asymptomatic AF during the blanking period, but ERAA as AF was detected in 28% and OAT in 25% within the 3 mo blanking period. Overall, early AF predicted late AF (HR 3.53; 95%CI: 1.72-7.29; *P* = 0.001) and early OAT predicted late OAT (HR 5.62; 95%CI: 2.88-10.95; *P* < 0.0001). Interestingly, early AF did not predict late OAT, and early OAT did not predict late AF. The authors also found that AF and OAT occurring in the third month of the blanking period had different predictive values for late recurrence: AF in the third month predicted late AF, although OAT in the third month did not predict late OAT.

We do not routinely do empiric linear ablation at our institution, and the majority of patients experiencing ERAA after ablation have AF only (71%; *vs* 5% with early OAT only and 24% with both early AF/OAT) [28]. In our experience, we have found no differences in the likelihood to develop late recurrences based on ERAA type (AF *vs* OAT) (*P* = 0.92). Since we employ a limited ablation strategy limited to antral PVI and targeting of non-PV triggers, it is possible that in patients treated with more extensive substrate-based ablation approaches involving linear or CFAE ablation, the presence of ERAA as OAT may suggest the presence of gaps in the ablation lines or incomplete CFAE ablation, resulting in late OAT, frequently necessitating repeat ablation.

The predictive value of ERAA appears to be dependent on both frequency and timing of ERAA within the blanking period. We have shown that in patients treated with a limited ablation strategy focused on PVI and elimination of non-PV triggers, the predictive value of ERAA episodes during the first 6 weeks post-ablation is quite variable based on these factors[28]. In our study, we divided the 6-wk blanking period into three separate intervals (Early: weeks 1-2; Intermediate: weeks 3-4; and Late: weeks 5-6), and found that patients with ERAA in a single interval (OR 3.2, 95%CI: 1.7-5.8 *vs* no ERAA) are significantly less likely to have late recurrence within 1 year *vs* those with ERAA spanning over multiple intervals (OR 14.6, 95%CI: 7.3-29.6).

Mugnai, et al. have shown similar prognosis of late ERAA within the blanking period after ablation for paroxysmal AF using second-generation cryoballoon ablation instead of radiofrequency energy. In their study of 331 consecutive patients treated with cryoballoon ablation, all patients with ERAA occurring in the second half of the 3-mo blanking period experienced subsequent recurrences after the blanking period- suggesting that ERAA occurring later within the blanking period are more predictive of ablation failure[34].

Willems *et al*[35] recently reported the results of a predefined secondary analysis of the prospective, randomized Adenosine Following Pulmonary Vein Isolation to Target Dormant Conduction Elimination trial where the authors analyzed the significance of ERAA at different times throughout the 3-mo blanking period in predicting late recurrences. They divided ERAA which occurred during month 1, 2, and 3 of the blanking period and found that the 1-year ablation success rate was significantly higher among patients without ERAA (77.2% 1-year freedom from AF), while success rates decreased as ERAA occurred later within the blanking period: 62.6% ERAA in month 1, 36.4% in month 2, and 7.8% in month 3 (*P* < 0.0001), with HR 1.84 for month 1, 4.45 for month 2, 9.64 for month 3. The authors identified a blanking period of 50 d to yield the greatest discriminatory potential by reviewer operating characteristic analysis, and given the dismal (> 90%) late recurrence rates among patients with ERAA during month 3, the results of this study question whether the 3-mo blanking period should be revised.

**PREVENTION OF ERAA**

***AADs***

A number of studies have demonstrated that the use of AADs after ablation reduces the incidence of ERAA and reduces hospitalizations and cardioversions during the blanking period. However, meta-analyses have shown that long-term ablation success remains unaffected by early AAD use[36-38]. This would suggest that AADs might mask the early indicators of failed ablation, which may be allowed to manifest only once AADs are withdrawn. While this may indeed decrease hospitalization rates and healthcare expenditure, it may also simply be delaying the recognition of ablation failure.

The Antiarrhythmics After Ablation of Atrial Fibrillation (5A Study) Randomized 110 patients with PAF to AAD (propafenone, flecainide, sotalol, or dofetilide) *vs* no AAD after AF ablation[39]. Those in the AAD group were less likely to have sustained AF recurrence (> 24 h), AF-related hospital admission, cardioversion, AAD adjustment or drug intolerance (19% *vs* 42%; *P* = 0.005 for primary composite endpoint) six-weeks post ablation.

The Efficacy of Antiarrhythmic Drugs Short-Term Use After Catheter Ablation for Atrial fibrillation trial was a multicenter prospective randomized controlled trial which compared the use of AADs for 90 d post ablation *vs* control in patients after catheter ablation for paroxysmal AF[40]. The authors aimed to examine whether prevention of ERAA with AADs would promote LA remodeling and therefore improve long-term ablation success. They enrolled 2038 patients (1016 randomized to AADs, 1022 control) and the primary endpoint was AF recurrence (lasting > 30), need for repeat ablation, hospitalization, or use of class I or III AAD at 1 year. They found that although those in the AAD group were more likely to be free from AF during the 90-d treatment period (59% *vs* 52%; HR 0.84, 95%CI: 0.73-0.96; *P* = 0.01), there was no difference in any of the primary outcome measures at 1 year post-ablation.

The recurrence of arrhythmia following short-term oral AMIOdarone after CATheter ablation for atrial fibrillation trial was a two-center double-blind, randomized placebo-controlled trial which randomized 212 patients with paroxysmal or persistent AF treated with AF ablation to 8 wk of oral amiodarone *vs* placebo following catheter ablation[41]. The authors aimed to determine whether temporary amiodarone use post-ablation would decrease both early and late recurrences. Patients in the amiodarone group had significantly lower rates of ERAA within the blanking period (34% *vs* 53%; *P* = 0.006) but there was no difference in rates of late recurrence at 6 mo between groups (39% *vs* 48%; *P* = 0.18). Additionally, AF-related hospitalization (RR 0.43, 95%CI: 0.23-0.77, *P* = 0.006) and the need for cardioversion (RR 0.36, 95%CI: 0.20-0.62, *P* = 0.0004) within the blanking period was significantly reduced in those treated with short-term amiodarone- driven mainly by those with persistent AF, as demonstrated in a subgroup analysis.

***Anti-inflammatory agents: Corticosteroids and colchicine***

The pro-inflammatory milieu in the immediate post-ablation period is thought to contribute to the development of ERAA, thus many investigators have examined the utility of anti-inflammatory agents to prevent inflammation-induced ERAA. The two major pharmacologic anti-inflammatory agents which have been studied include corticosteroids and colchicine.

Studies examining the use of steroids post-ablation to reduce ERAA have produced conflicting results. Koyama *et al*[42] randomized 125 patients with PAF to steroids (2 mg/kg IV hydrocortisone given immediately post-procedure, followed by 0.5 mg/kg per day oral prednisone for 3 d) *vs* placebo and found that patients randomized to treatment with corticosteroids were less likely to have ERAA within 3 d (7% *vs* 31%), but had similar rates of ERAA between days 4-30. Kim *et al*[43] randomized 138 patients to treatment with steroids *vs* control after ablation. Patients randomized to steroids in their study were treated with intravenous methylprednisolone (0.5 mg/kg per dose) for 2 d followed by 12 mg of oral methylprednisolone for 4 d. Those treated with steroids had a lower rate of ERAA in the 3 mo blanking period (23.4% *vs* 48.6%, *P* = 0.003) but there was no difference in late recurrence rate up to 24 mo (*P* = 0.918). In their multivariate model, the use of steroids was independently associated with lower rate of ERAA (OR 0.45; 95%CI: 0.25-0.83, *P* = 0.01).

The anti-inflammatory agent colchicine has also been tested as an antiarrhythmic agent to prevent ERAA after AF ablation. In a double-blind fashion, Deftereos *et al*[44] randomized 80 patients with paroxysmal AF to colchicine (0.5 mg twice daily for 3 mo) *vs* placebo after AF ablation (antral PVI and left atrial isthmus ablation). Patients randomized to the colchicine arm had lower levels of inflammatory markers post-ablation (C-reactive protein and IL-6) compared with placebo, and were less likely to experience ERAA within the 3-mo blanking period (16% *vs* 33.5%; OR 0.38; 95%CI: 0.18-0.8) *vs* placebo. In a larger subsequent study, Deftereos *et al*[45] found that patients randomized to colchicine for 3 mo post-ablation had a significantly lower single-procedure late AF recurrence rate after a median follow-up duration 15 mo (31.1% *vs* 49.5%; OR: 0.46; 95%CI: 0.26-0.81). Colchicine is a relatively benign medication (with its major side-effect being gastrointestinal upset), and the results of these preliminary studies are certainly promising. However, future, larger prospective studies are required to confirm the benefit of colchicine after ablation before it can be widely accepted.

**TREATMENT OF ERAA**

***Timing of cardioversion***

In patients experiencing ERAA after AF ablation, early cardioversion might improve long-term ablation success. Restoration of sinus rhythm may prevent AF-induced progression of adverse LA remodeling, thus facilitating maintenance of sinus rhythm. Chilikuri *et al*[46] examined timing to cardioversion (before *vs* after the 3-mo blanking period) in patients with nonparoxysmal AF treated with ablation and reported an extremely low (16%) rate of long-term ablation success in patients treated with early cardioversion for persistent AF/OAT during the blanking period, although the rate of long-term freedom from AF was even more dismal (8%) among those who underwent late cardioversion after the blanking period. Baman *et al*[47] examined the effect of the timing of cardioversion after ERAA in 93 patients treated with antral PVI for AF. They found that time to cardioversion was inversely correlated with long-term freedom from AF off AAD: Those who were cardioverted within 30 d (*vs* those cardioverted after 30 d) of ERAA were more likely to remain in sinus rhythm over the remainder of the study duration (OR 22.5, 95%CI: 4.87-103.88, *P* < 0.0001). Additionally, time between ERAA and cardioversion was the only independent predictor of sinus rhythm maintenance in their multivariate model.

At our institution we aim to restore sinus rhythm as soon as possible in patients with ERAA since we believe that maintenance of sinus rhythm allows for favorable structural, electrical, and mechanical remodeling of the atria and may maximize the likelihood of achieving long-term ablation success. However, it remains to be determined whether the benefits of this approach are similar between paroxysmal and non-paroxysmal types of AF.

***Early reablation***

The optimal timing for repeat ablation in patients with ERAA remains unknown. As discussed throughout this review, a number of factors including arrhythmia characteristics, patient characteristics, ablation procedural characteristics, and recurrence characteristics play a role in predicting long-term ablation success. The goal is to identify patients in whom ERAA is not just due to transient post-ablation factors, and in whom ablation early in the recurrence course may be more likely to result in long-term ablation success. In a study by Lellouche *et al*[14], of 302 patients with persistent and paroxysmal AF, they reported their experience of 302 patients with persistent and paroxysmal AF, 151 patients had ERAA, 61 of whom were treated with very early reablation (within 1 mo of the index ablation). They found that patients who underwent early reablation had a significantly lower rate of late recurrences (51% *vs* 91%; *P* < 0.0001), although they required more total procedures over the entire follow-up period (2.5 ± 0.7 *vs* 2.2 ± 0.6; *P* = 0.02). Additionally, Andrade *et al*[7] found that patients with ERAA after cryoablation in the STOP AF trial who underwent early reablation during the blanking period were significantly less likely to have late recurrences out to 1 year follow-up (33% *vs* 56% late recurrence rate; HR 0.04, 95%CI: 0.01-0.32; *P* = 0.002). While their results suggest that early reablation within the blanking period for ERAA after cryoablation improves long-term ablation success, the authors acknowledge that it is possible that reablation may not have been necessary in all patients since it is possible that ERAA may have resolved spontaneously in some.

Recently, Yanagisawa *et al*[48] performed a retrospective analysis examining outcomes after early reablation during the first 3 months post-ablation in 66 patients with ERAA. Compared to 66 propensity-matched controls who did not undergo early reablation, the patients treated with early reablation had a significantly lower rate of late recurrence (64% *vs* 44%; *P* = 0.023), but required more additional procedures (0.4 *vs* 1.2 procedures; *P* = 0.001). Interestingly, the benefit of early reablation for ERAA was limited to those with paroxysmal AF (37% *vs* 66% late recurrence rate for early reablation *vs* no early reablation; *P* = 0.008), while there was no significant benefit to early reablation in those with persistent AF (56% *vs* 60%; *P* = 0.77). Furthermore, 36% of those with ERAA who did not undergo early reablation had no further recurrences in after the 3-mo blanking period.

We have recently shown that in patients with nonparoxysmal AF treated with a limited ablation strategy of antral PVI and targeting of non-PV triggers, patients who recur as paroxysmal (rather than persistent) AF type are more likely to experience long-term ablation success (unpublished data). We believe that patients with persistent or longstanding persistent AF who experience paroxysmal-type ERAA after ablation may represent a subgroup of patients in whom early reablation (even during the blanking period) can improve long-term ablation success. Transformation of nonparoxysmal AF to paroxysmal AF may represent favorable alteration of the underlying substrate, and we hypothesize that early intervention before AF is allowed to become persistent again (and cause adverse LA electrical and structural remodeling) might result in improved outcomes.

**CONCLUSION**

Early recurrences of atrial arrhythmia are common in the post-ablation period, and detection of ERAA is dependent on the monitoring strategy. Although ERAA clearly predicts late AF recurrences, some patients with ERAA do not develop late recurrence and thus the guidelines recommend a 3-mo blanking period during which recurrences should not be considered as ablation failure. However, ERAA episodes which occur later within the blanking period (particularly after the first 2 weeks) as well as multiple ERAA occurrences appear to be strongly predictive of late recurrence. Thus, the optimal blanking period during which ERAA events may be benign remains unclear. While pharmacologic agents such as AADs and corticosteroids reduce the incidence of ERAA, they do not improve long-term ablation success. Colchicine is a promising medication which has been shown in isolated studies to decrease both early and late recurrences but larger prospective studies are necessary to validate this effect. Whether reablation should be performed in patients experiencing ERAA remains undetermined. Further studies are necessary to elucidate the optimal timing for reablation based on patient and ERAA characteristics to maximize long-term ablation success.

**REFERENCES**

1 **Calkins H,** Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA, Crijns HJ, Damiano RJ, Jr., Davies DW, DiMarco J, Edgerton J, Ellenbogen K, Ezekowitz MD, Haines DE, Haissaguerre M, Hindricks G, Iesaka Y, Jackman W, Jalife J, Jais P, Kalman J, Keane D, Kim YH, Kirchhof P, Klein G, Kottkamp H, Kumagai K, Lindsay BD, Mansour M, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Nakagawa H, Natale A, Nattel S, Packer DL, Pappone C, Prystowsky E, Raviele A, Reddy V, Ruskin JN, Shemin RJ, Tsao HM, Wilber D; [Heart Rhythm Society Task Force on Catheter and Surgical Ablation of Atrial Fibrillation](http://www.ncbi.nlm.nih.gov/pubmed/?term=Heart%20Rhythm%20Society%20Task%20Force%20on%20Catheter%20and%20Surgical%20Ablation%20of%20Atrial%20Fibrillation%5BCorporate%20Author%5D). 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design: a report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. Developed in partnership with the European Heart Rhythm Association (EHRA), a registered branch of the European Society of Cardiology (ESC) and the European Cardiac Arrhythmia Society (ECAS); and in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), the Asia Pacific Heart Rhythm Society (APHRS), and the Society of Thoracic Surgeons (STS). Endorsed by the governing bodies of the American College of Cardiology Foundation, the American Heart Association, the European Cardiac Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, the Asia Pacific Heart Rhythm Society, and the Heart Rhythm Society. *Heart Rhythm* 2012; **9:** 632-696 [PMID: 22386883 DOI: 10.1016/j.hrthm.2011.12.016]

2 **Andrade JG**, Khairy P, Verma A, Guerra PG, Dubuc M, Rivard L, Deyell MW, Mondesert B, Thibault B, Talajic M, Roy D, Macle L. Early recurrence of atrial tachyarrhythmias following radiofrequency catheter ablation of atrial fibrillation. *Pacing Clin Electrophysiol* 2012; **35**: 106-116 [PMID: 22054110 DOI: 10.1111/j.1540-8159.2011.03256.x]

3 **Sanna T**, Diener HC, Passman RS, Di Lazzaro V, Bernstein RA, Morillo CA, Rymer MM, Thijs V, Rogers T, Beckers F, Lindborg K, Brachmann J. Cryptogenic stroke and underlying atrial fibrillation. *N Engl J Med* 2014; **370**: 2478-2486 [PMID: 24963567 DOI: 10.1056/NEJMoa1313600]

4 **Gladstone DJ**, Spring M, Dorian P, Panzov V, Thorpe KE, Hall J, Vaid H, O'Donnell M, Laupacis A, Côté R, Sharma M, Blakely JA, Shuaib A, Hachinski V, Coutts SB, Sahlas DJ, Teal P, Yip S, Spence JD, Buck B, Verreault S, Casaubon LK, Penn A, Selchen D, Jin A, Howse D, Mehdiratta M, Boyle K, Aviv R, Kapral MK, Mamdani M. Atrial fibrillation in patients with cryptogenic stroke. *N Engl J Med* 2014; **370**: 2467-2477 [PMID: 24963566 DOI: 10.1056/NEJMoa1311376]

5 **Themistoclakis S**, Schweikert RA, Saliba WI, Bonso A, Rossillo A, Bader G, Wazni O, Burkhardt DJ, Raviele A, Natale A. Clinical predictors and relationship between early and late atrial tachyarrhythmias after pulmonary vein antrum isolation. *Heart Rhythm* 2008; **5**: 679-685 [PMID: 18325850 DOI: 10.1016/j.hrthm.2008.01.031]

6 **Joshi S**, Choi AD, Kamath GS, Raiszadeh F, Marrero D, Badheka A, Mittal S, Steinberg JS. Prevalence, predictors, and prognosis of atrial fibrillation early after pulmonary vein isolation: findings from 3 months of continuous automatic ECG loop recordings. *J Cardiovasc Electrophysiol* 2009; **20**: 1089-1094 [PMID: 19549038 DOI: 10.1111/j.1540-8167.2009.01506.x]

7 **Andrade JG**, Khairy P, Macle L, Packer DL, Lehmann JW, Holcomb RG, Ruskin JN, Dubuc M. Incidence and significance of early recurrences of atrial fibrillation after cryoballoon ablation: insights from the multicenter Sustained Treatment of Paroxysmal Atrial Fibrillation (STOP AF) Trial. *Circ Arrhythm Electrophysiol* 2014; **7**: 69-75 [PMID: 24446022 DOI: 10.1161/circep.113.000586]

8 **Ciconte G**, Baltogiannis G, de Asmundis C, Sieira J, Conte G, Di Giovanni G, Saitoh Y, Irfan G, Mugnai G, Hunuk B, Chierchia GB, Brugada P. Circumferential pulmonary vein isolation as index procedure for persistent atrial fibrillation: a comparison between radiofrequency catheter ablation and second-generation cryoballoon ablation. *Europace* 2015; **17**: 559-565 [PMID: 25582875 DOI: 10.1093/europace/euu350]

9 **Miyazaki S**, Kuroi A, Hachiya H, Nakamura H, Taniguchi H, Ichihara N, Takagi T, Iwasawa J, Iesaka Y. Early Recurrence After Pulmonary Vein Isolation of Paroxysmal Atrial Fibrillation With Different Ablation Technologies - Prospective Comparison of Radiofrequency vs. Second-Generation Cryoballoon Ablation. *Circ J* 2016; **80**: 346-353 [PMID: 26638872 DOI: 10.1253/circj.CJ-15-1051]

10 **Lee SH**, Tai CT, Hsieh MH, Tsai CF, Lin YK, Tsao HM, Yu WC, Huang JL, Ueng KC, Cheng JJ, Ding YA, Chen SA. Predictors of early and late recurrence of atrial fibrillation after catheter ablation of paroxysmal atrial fibrillation. *J Interv Card Electrophysiol* 2004; **10**: 221-226 [PMID: 15133358 DOI: 10.1023/b: jice.0000026915.02503.92]

11 **Kornej J**, Hindricks G, Kosiuk J, Arya A, Sommer P, Husser D, Rolf S, Richter S, Huo Y, Piorkowski C, Bollmann A. Comparison of CHADS2, R2CHADS2, and CHA2DS2-VASc scores for the prediction of rhythm outcomes after catheter ablation of atrial fibrillation: the Leipzig Heart Center AF Ablation Registry. *Circ Arrhythm Electrophysiol* 2014; **7**: 281-287 [PMID: 24610790 DOI: 10.1161/circep.113.001182]

12 **Moon J**, Lee HJ, Kim JY, Pak HN, Lee MH, Kim YJ, Joung B. Prognostic Implications of Right and Left Atrial Enlargement after Radiofrequency Catheter Ablation in Patients with Nonvalvular Atrial Fibrillation. *Korean Circ J* 2015; **45**: 301-309 [PMID: 26240584 DOI: 10.4070/kcj.2015.45.4.301]

13 **Arya A**, Hindricks G, Sommer P, Huo Y, Bollmann A, Gaspar T, Bode K, Husser D, Kottkamp H, Piorkowski C. Long-term results and the predictors of outcome of catheter ablation of atrial fibrillation using steerable sheath catheter navigation after single procedure in 674 patients. *Europace* 2010; **12**: 173-180 [PMID: 19889688 DOI: 10.1093/europace/eup331]

14 **Lellouche N**, Jaïs P, Nault I, Wright M, Bevilacqua M, Knecht S, Matsuo S, Lim KT, Sacher F, Deplagne A, Bordachar P, Hocini M, Haïssaguerre M. Early recurrences after atrial fibrillation ablation: prognostic value and effect of early reablation. *J Cardiovasc Electrophysiol* 2008; **19**: 599-605 [PMID: 18462321 DOI: 10.1111/j.1540-8167.2008.01188.x]

15 **Kosiuk J**, Breithardt OA, Bode K, Kornej J, Arya A, Piorkowski C, Gaspar T, Sommer P, Husser D, Hindricks G, Bollmann A. The predictive value of echocardiographic parameters associated with left ventricular diastolic dysfunction on short- and long-term outcomes of catheter ablation of atrial fibrillation. *Europace* 2014; **16**: 1168-1174 [PMID: 24569573 DOI: 10.1093/europace/eut415]

16 **Masuda M**, Mizuno H, Enchi Y, Minamiguchi H, Konishi S, Ohtani T, Yamaguchi O, Okuyama Y, Nanto S, Sakata Y. Abundant epicardial adipose tissue surrounding the left atrium predicts early rather than late recurrence of atrial fibrillation after catheter ablation. *J Interv Card Electrophysiol* 2015; **44**: 31-37 [PMID: 26123095 DOI: 10.1007/s10840-015-0031-3]

17 **Koyama T**, Sekiguchi Y, Tada H, Arimoto T, Yamasaki H, Kuroki K, Machino T, Tajiri K, Zhu XD, Kanemoto M, Sugiyasu A, Kuga K, Aonuma K. Comparison of characteristics and significance of immediate versus early versus no recurrence of atrial fibrillation after catheter ablation. *Am J Cardiol* 2009; **103**: 1249-1254 [PMID: 19406267 DOI: 10.1016/j.amjcard.2009.01.010]

18 **Yao Y,** Yao W, Bai R, Lu ZH, Tang RB, Long DY, Jiang CX, Sang CH, Zhang JQ, Yu RH, Du X, Liu XH, Dong JZ, Ma CS. Plasma homocysteine levels predict early recurrence after catheter ablation of persistent atrial fibrillation. *Europace* 2016 [PMID: 27194539 DOI: 10.1093/europace/euw081]

19 **Yokokawa M**, Tada H, Koyama K, Ino T, Naito S, Oshima S, Taniguchi K. Thickening of the left atrial wall shortly after radiofrequency ablation predicts early recurrence of atrial fibrillation. *Circ J* 2010; **74**: 1538-1546 [PMID: 20571248]

20 **Bertaglia E**, Stabile G, Senatore G, Zoppo F, Turco P, Amellone C, De Simone A, Fazzari M, Pascotto P. Predictive value of early atrial tachyarrhythmias recurrence after circumferential anatomical pulmonary vein ablation. *Pacing Clin Electrophysiol* 2005; **28**: 366-371 [PMID: 15869666 DOI: 10.1111/j.1540-8159.2005.09516.x]

21 **Choi JI**, Pak HN, Park JS, Kwak JJ, Nagamoto Y, Lim HE, Park SW, Hwang C, Kim YH. Clinical significance of early recurrences of atrial tachycardia after atrial fibrillation ablation. *J Cardiovasc Electrophysiol* 2010; **21**: 1331-1337 [PMID: 20586828 DOI: 10.1111/j.1540-8167.2010.01831.x]

22 **Li XP**, Dong JZ, Liu XP, Long DY, Yu RH, Tian Y, Tang RB, Zheng B, Hu FL, Shi LS, He H, Ma CS. Predictive value of early recurrence and delayed cure after catheter ablation for patients with chronic atrial fibrillation. *Circ J* 2008; **72**: 1125-1129 [PMID: 18577822 DOI: 10/1253/circj.72.1125]

23 **Benussi S**, Nascimbene S, Agricola E, Calori G, Calvi S, Caldarola A, Oppizzi M, Casati V, Pappone C, Alfieri O. Surgical ablation of atrial fibrillation using the epicardial radiofrequency approach: mid-term results and risk analysis. *Ann Thorac Surg* 2002; **74**: 1050-106; discussion 1057 [PMID: 12400744]

24 **Hornero F**, Rodriguez I, Estevez V, Gil O, Canovas S, Garcia R, Leon JM. Analysis of the postoperative epicardial auriculogram after surgical ablation of atrial fibrillation: risk stratification of late recurrences. *J Thorac Cardiovasc Surg* 2007; **133**: 1493-1498 [PMID: 17532946 DOI: 10.1016/j.jtcvs.2007.01.038]

25 **Santangeli P**, Zado ES, Hutchinson MD, Riley MP, Lin D, Frankel DS, Supple GE, Garcia FC, Dixit S, Callans DJ, Marchlinski FE. Prevalence and distribution of focal triggers in persistent and long-standing persistent atrial fibrillation. *Heart Rhythm* 2016; **13**: 374-382 [PMID: 26477712 DOI: 10.1016/j.hrthm.2015.10.023]

26 **Lim HS**, Schultz C, Dang J, Alasady M, Lau DH, Brooks AG, Wong CX, Roberts-Thomson KC, Young GD, Worthley MI, Sanders P, Willoughby SR. Time course of inflammation, myocardial injury, and prothrombotic response after radiofrequency catheter ablation for atrial fibrillation. *Circ Arrhythm Electrophysiol* 2014; **7**: 83-89 [PMID: 24446024 DOI: 10.1161/circep.113.000876]

27 **Das M**, Wynn GJ, Morgan M, Lodge B, Waktare JE, Todd DM, Hall MC, Snowdon RL, Modi S, Gupta D. Recurrence of atrial tachyarrhythmia during the second month of the blanking period is associated with more extensive pulmonary vein reconnection at repeat electrophysiology study. *Circ Arrhythm Electrophysiol* 2015; **8**: 846-852 [PMID: 26108982 DOI: 10.1161/circep.115.003095]

28 **Liang JJ**, Elafros MA, Chik WW, Santangeli P, Zado ES, Frankel DS, Supple GE, Schaller RD, Lin D, Hutchinson MD, Riley MP, Callans DJ, Marchlinski FE, Dixit S. Early recurrence of atrial arrhythmias following pulmonary vein antral isolation: Timing and frequency of early recurrences predicts long-term ablation success. *Heart Rhythm* 2015; **12**: 2461-2468 [PMID: 26187447 DOI: 10.1016/j.hrthm.2015.07.015]

29 **Andrade JG**, Macle L, Khairy P, Khaykin Y, Mantovan R, De Martino G, Chen J, Morillo CA, Novak P, Guerra PG, Nair G, Torrecilla EG, Verma A. Incidence and significance of early recurrences associated with different ablation strategies for AF: a STAR-AF substudy. *J Cardiovasc Electrophysiol* 2012; **23**: 1295-1301 [PMID: 22897339 DOI: 10.1111/j.1540-8167.2012.02399.x]

30 **Lin D**, Santangeli P, Zado ES, Bala R, Hutchinson MD, Riley MP, Frankel DS, Garcia F, Dixit S, Callans DJ, Marchlinski FE. Electrophysiologic findings and long-term outcomes in patients undergoing third or more catheter ablation procedures for atrial fibrillation. *J Cardiovasc Electrophysiol* 2015; **26**: 371-377 [PMID: 25534677 DOI: 10.1111/jce.12603]

31 **Gang UJ**, Nalliah CJ, Lim TW, Thiagalingam A, Kovoor P, Ross DL, Thomas SP. Atrial ectopy predicts late recurrence of atrial fibrillation after pulmonary vein isolation. *Circ Arrhythm Electrophysiol* 2015; **8**: 569-574 [PMID: 25904494 DOI: 10.1161/circep.114.002052]

32 **Ammar S**, Hessling G, Reents T, Fichtner S, Wu J, Zhu P, Kathan S, Estner HL, Jilek C, Kolb C, Haller B, Deisenhofer I. Arrhythmia type after persistent atrial fibrillation ablation predicts success of the repeat procedure. *Circ Arrhythm Electrophysiol* 2011; **4**: 609-614 [PMID: 21856772 DOI: 10.1161/circep.111.963256]

33 **Nalliah CJ**, Lim TW, Kizana E, Qian P, Kovoor P, Thiagalingam A, Ross DL, Thomas SP. Clinical significance of early atrial arrhythmia type and timing after single ring isolation of the pulmonary veins. *Europace* 2015; **17**: 1038-1044 [PMID: 25935165 DOI: 10.1093/europace/euu314]

34 **Mugnai G**, de Asmundis C, Hünük B, Ströker E, Velagic V, Moran D, Ruggiero D, Hacioglu E, Poelaert J, Verborgh C, Umbrain V, Beckers S, Coutino-Moreno HE, Takarada K, Brugada P, Chierchia GB. Second-generation cryoballoon ablation for paroxysmal atrial fibrillation: Predictive role of atrial arrhythmias occurring in the blanking period on the incidence of late recurrences. *Heart Rhythm* 2016; **13**: 845-851 [PMID: 26724490 DOI: 10.1016/j.hrthm.2015.12.034]

35 **Willems S**, Khairy P, Andrade JG, Hoffmann BA, Levesque S, Verma A, Weerasooriya R, Novak P, Arentz T, Deisenhofer I, Rostock T, Steven D, Rivard L, Guerra PG, Dyrda K, Mondesert B, Dubuc M, Thibault B, Talajic M, Roy D, Nattel S, Macle L. Redefining the Blanking Period After Catheter Ablation for Paroxysmal Atrial Fibrillation: Insights From the ADVICE (Adenosine Following Pulmonary Vein Isolation to Target Dormant Conduction Elimination) Trial. *Circ Arrhythm Electrophysiol* 2016; **9**: [PMID: 27516462 DOI: 10.1161/circep.115.003909]

36 **Goldenberg GR,** Burd D, Lodzinski P, Stabile G, Udell JA, Newman D, Shurrab M, Crystal E. Antiarrhythmic therapy as an adjuvant to promote post pulmonary vein isolation success-a meta-analysis. *J Interv Card Electrophysiol* 2016 [PMID: 27357216 DOI: 10.1007/s10840-016-0157-y]

37 **Xu X**, Alida CT, Yu B. Administration of antiarrhythmic drugs to maintain sinus rhythm after catheter ablation for atrial fibrillation: a meta-analysis. *Cardiovasc Ther* 2015; **33**: 242-246 [PMID: 26031448 DOI: 10.1111/1755-5922.12133]

38 **Chen W**, Liu H, Ling Z, Xu Y, Fan J, Du H, Xiao P, Su L, Liu Z, Lan X, Zrenner B, Yin Y. Efficacy of Short-Term Antiarrhythmic Drugs Use after Catheter Ablation of Atrial Fibrillation-A Systematic Review with Meta-Analyses and Trial Sequential Analyses of Randomized Controlled Trials. *PLoS One* 2016; **11**: e0156121 [PMID: 27224469 DOI: 10.1371/journal.pone.0156121]

39 **Roux JF**, Zado E, Callans DJ, Garcia F, Lin D, Marchlinski FE, Bala R, Dixit S, Riley M, Russo AM, Hutchinson MD, Cooper J, Verdino R, Patel V, Joy PS, Gerstenfeld EP. Antiarrhythmics After Ablation of Atrial Fibrillation (5A Study). *Circulation* 2009; **120**: 1036-1040 [PMID: 19738139 DOI: 10.1161/circulationaha.108.839639]

40 **Kaitani K**, Inoue K, Kobori A, Nakazawa Y, Ozawa T, Kurotobi T, Morishima I, Miura F, Watanabe T, Masuda M, Naito M, Fujimoto H, Nishida T, Furukawa Y, Shirayama T, Tanaka M, Okajima K, Yao T, Egami Y, Satomi K, Noda T, Miyamoto K, Haruna T, Kawaji T, Yoshizawa T, Toyota T, Yahata M, Nakai K, Sugiyama H, Higashi Y, Ito M, Horie M, Kusano KF, Shimizu W, Kamakura S, Morimoto T, Kimura T, Shizuta S. Efficacy of Antiarrhythmic Drugs Short-Term Use After Catheter Ablation for Atrial Fibrillation (EAST-AF) trial. *Eur Heart J* 2016; **37**: 610-618 [PMID: 26417061 DOI: 10.1093/eurheartj/ehv501]

41 **Darkner S**, Chen X, Hansen J, Pehrson S, Johannessen A, Nielsen JB, Svendsen JH. Recurrence of arrhythmia following short-term oral AMIOdarone after CATheter ablation for atrial fibrillation: a double-blind, randomized, placebo-controlled study (AMIO-CAT trial). *Eur Heart J* 2014; **35**: 3356-3364 [PMID: 25182250 DOI: 10.1093/eurheartj/ehu354]

42 **Koyama T**, Tada H, Sekiguchi Y, Arimoto T, Yamasaki H, Kuroki K, Machino T, Tajiri K, Zhu XD, Kanemoto-Igarashi M, Sugiyasu A, Kuga K, Nakata Y, Aonuma K. Prevention of atrial fibrillation recurrence with corticosteroids after radiofrequency catheter ablation: a randomized controlled trial. *J Am Coll Cardiol* 2010; **56**: 1463-1472 [PMID: 20951321 DOI: 10.1016/j.jacc.2010.04.057]

43 **Kim YR**, Nam GB, Han S, Kim SH, Kim KH, Lee S, Kim J, Choi KJ, Kim YH. Effect of Short-Term Steroid Therapy on Early Recurrence During the Blanking Period After Catheter Ablation of Atrial Fibrillation. *Circ Arrhythm Electrophysiol* 2015; **8**: 1366-1372 [PMID: 26541350 DOI: 10.1161/circep.115.002957]

44 **Deftereos S**, Giannopoulos G, Kossyvakis C, Efremidis M, Panagopoulou V, Kaoukis A, Raisakis K, Bouras G, Angelidis C, Theodorakis A, Driva M, Doudoumis K, Pyrgakis V, Stefanadis C. Colchicine for prevention of early atrial fibrillation recurrence after pulmonary vein isolation: a randomized controlled study. *J Am Coll Cardiol* 2012; **60**: 1790-1796 [PMID: 23040570 DOI: 10.1016/j.jacc.2012.07.031]

45 **Deftereos S**, Giannopoulos G, Efremidis M, Kossyvakis C, Katsivas A, Panagopoulou V, Papadimitriou C, Karageorgiou S, Doudoumis K, Raisakis K, Kaoukis A, Alexopoulos D, Manolis AS, Stefanadis C, Cleman MW. Colchicine for prevention of atrial fibrillation recurrence after pulmonary vein isolation: mid-term efficacy and effect on quality of life. *Heart Rhythm* 2014; **11**: 620-628 [PMID: 24508207 DOI: 10.1016/j.hrthm.2014.02.002]

46 **Chilukuri K**, Dukes J, Dalal D, Marine JE, Henrikson CA, Scherr D, Sinha S, Berger R, Cheng A, Nazarian S, Spragg D, Calkins H. Outcomes in patients requiring cardioversion following catheter ablation of atrial fibrillation. *J Cardiovasc Electrophysiol* 2010; **21**: 27-32 [PMID: 19793148 DOI: 10.1111/j.1540-8167.2009.01593.x]

47 **Baman TS**, Gupta SK, Billakanty SR, Ilg KJ, Good E, Crawford T, Jongnarangsin K, Ebinger M, Pelosi F, Bogun F, Chugh A, Morady F, Oral H. Time to cardioversion of recurrent atrial arrhythmias after catheter ablation of atrial fibrillation and long-term clinical outcome. *J Cardiovasc Electrophysiol* 2009; **20**: 1321-1325 [PMID: 19602031 DOI: 10.1111/j.1540-8167.2009.01553.x]

48 **Yanagisawa S,** Inden Y, Kato H, Fujii A, Mizutani Y, Ito T, Kamikubo Y, Kanzaki Y, Ando M, Hirai M, Shibata R, Murohara T. Effect and Significance of Early Reablation for the Treatment of Early Recurrence of Atrial Fibrillation After Catheter Ablation. *Am J Cardiol* 2016 [PMID: 27453516 DOI: 10.1016/j.amjcard.2016.06.045]

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**Table 1 Characteristics which are predictive of the development of early recurrences of atrial arrhythmias after atrial fibrillation ablation**

|  |  |
| --- | --- |
| **Clinical characteristics** | **Ablation procedural characteristics** |
| Older age[5] | Incomplete PVI[13,20] |
| Male gender[7] | AF inducibility[21] |
| Hypertension[5] | Multiple AF foci[10] |
| Structural heart disease[10,20] | LA free wall AF foci[10] |
| Longer AF duration[5] | Lack of AF termination during procedure[22] |
| Nonparoxysmal AF type[5] | Lack of SVC isolation[5] |
| CHA2DS2-VASc, R2CHADS2 scores[11] |  |
| **Imaging characteristics** | **Inflammatory markers** |
| Left atrial size/volume[5] | Higher body temperature post-ablation[17] |
| Right atrial size/volume[12] | C-reactive protein[17] |
| Left ventricular size/volume[13] | Homocysteine[18] |
| Left ventricular systolic dysfunction[14] | Increased LA roof thickness with delayed enhancement MRI 24 h post-ablation[19] |
| Left ventricular diastolic dysfunction[15] |  |
| Left atrial epicardial adipose tissue[16] |  |

Table modified from Andrade JG, *et al*. *Pacing Clin Electrophysiol* 2012; **35:** 106-16[2].AF: Atrial fibrillation; PVI: Pulmonary vein isolation; MRI: Magnetic resonance imaging.