Received: 10 October 2024 | Revised: 28 February 2025 | Accepted: 16 March 2025

DOI: 10.1002/joa3.70049

Journal of Arrhythmia Open Access WILEY

ORIGINAL ARTICLE

Does organized atrial tachycardia after a pulmonary vein isolation-only procedure portend better outcome of repeat ablation compared to recurrent atrial fibrillation?

Tamás János Riesz MD | **Gábor Bencsik MD, PhD** | **László Sághy MD, PhD** | **Róbert Pap MD, PhD**

Cardiac Electrophysiology Division, Cardiology Center, Department of Internal Medicine, University of Szeged, Szeged, Hungary

Correspondence
Tamás János Riesz, Cardiac Electrophysiology Division, Cardiology Center, Department of Internal Medicine, University of Szeged, Szeged, Hungary.
Email: riesztamasj@gmail.com

Abstract

Background: Better outcome has been suggested for repeat procedures after atrial fibrillation (AF) ablation, when recurrence presented as organized atrial tachycardia (OAT) compared to recurrent AF. However, this contradicts the finding of more advanced atrial remodeling in patients with OAT recurrence and may be related to iatrogenesis by substrate modification during the index procedure. Therefore, we examined the prognostic significance of the type of recurrent arrhythmia after pulmonary vein isolation (PVI) without additional substrate modification.

Methods: We included 185 patients (88 female, 64 ± 9 years) undergoing repeat ablation after index PVI for recurrent OAT (24%) or AF (76%). The recurrence rate, arrhythmia-free survival time, and the type of further recurrences were recorded.

Results: There was no difference in the rate and mean time of arrhythmia-free survival between patients with OAT versus AF recurrence after the first (49% vs. 52%, $p = .72$ and 51.08 ± 6.66 vs. 53.37 ± 4.75 months, $p = .54$, respectively) and last (60% vs. 58%, $p = .80$ and 63.2 ± 7.04 vs. 61.2 ± 5.32 months, $p = .23$, respectively) redo procedure. AF occurred in the majority of subsequently recurring patients in both groups. No significant difference was found in the outcome of redo procedures between patients with typical flutter and atypical OAT, but a higher rate of successful rhythm control was observed in those with paroxysmal, as compared to persistent AF recurrence.

Conclusion: After a PVI-only index procedure, recurrent OAT is not associated with a better outcome of redo procedures compared to recurrent AF. After repeat ablations, both groups experience AF as the dominant further recurrence.

KEYWORDS
atrial fibrillation, organized atrial tachycardia, pulmonary vein isolation, recurrence

1 | BACKGROUND

Recurrent arrhythmia after ablation for atrial fibrillation (AF) may present as organized atrial tachycardia (OAT) versus paroxysmal or persistent AF. Several authors reported a more favorable outcome of redo procedures when the recurring arrhythmia was OAT, as compared to recurrent AF.[1–4] However, these and other studies also report the conflicting finding of more advanced left atrial (LA) remodeling (more dilated LA, more persistent AF, older age etc.) in patients with recurrent OAT[3–5] a factor consistently associated with *more* recurrences[6,7] The explanation for this discrepancy may lie in the fact that substrate modification (linear and/or electrogram-guided ablation) was attempted in addition to pulmonary vein isolation (PVI) during the index procedure in the above studies. These extra-pulmonary vein (PV) ablations are well known for their potential to cause iatrogenic OAT[8] and their utility in AF suppression is limited, if any.[9] Therefore, some of the patients who recurred with OAT might have had their AF controlled by PVI but experienced a man-made arrhythmia. If the latter is eliminated during a redo procedure, their prognosis can be more favorable than those who failed PVI in the first place. It follows that arrhythmia recurrence in the form of OAT may have different prognostic implications in the case of a PVI-only initial strategy. We investigated the prognostic value of the type of recurrent arrhythmia (OAT/persistent and paroxysmal AF) after PVI-only on the outcome of repeat ablation.

2 | MATERIALS AND METHODS

2.1 | Study population

In our retrospective study, 185 consecutive patients were included, who had redo ablation between January 2009 and December 2019 to treat recurrence of atrial arrhythmia following an index PVI. For comparison, the number of de novo PVI procedures was 1134 during the same period. We excluded patients with linear ablation other than at the cavotricuspid isthmus (CTI) and those with electrogram-based ablation at the index procedure. To examine the effect of a history of typical atrial flutter, subgroups were created comprising those with or without a history of CTI ablation before or during the index procedure. Baseline characteristics of the study population are shown in Table 1. The study was approved by the institutional review board (222/2019-SZTE).

2.2 | Index procedure

After providing written informed consent, all patients underwent antral PVI, without empirical left atrial linear ablation. Ablation of the CTI was carried out at the index procedure in patients with documented or induced typical atrial flutter. Non-CTI dependent atrial macroreentry occurring during the index procedure was typically not targeted. Spontaneously occurring non-PV triggers were targeted at the discretion of the treating physician. Isoproterenol provocation was not routinely performed at the index procedure. Radiofrequency (RF) energy was applied with a deflectable, open-irrigated catheter, using a point-by-point technique around ipsilateral PVs. Ablation at the inter-PV carina was not part of the lesion set. Adenosine testing after PVI was typically not performed. The procedures were guided by intracardiac echocardiography and a real-time, 3D non-fluoroscopic navigation system (NavX or CARTO). The mapping system was used to create a left atrial shell and in the placement and titration of ablation lesions. However, mapping of left atrial voltage was not routinely performed. A circular mapping catheter was used for the recording of PV potentials and the verification of the isolation. Complete isolation of all the PVs after a 30-min waiting period was the endpoint of the procedure.

TABLE 1 Comparison of patients with paroxysmal and persistent AF before index PVI.

Type of initial atrial fibrillation	Paroxysmal	Persistent	*p*
Number of patients	90	95	
Male (%)	49	56	.671
Ejection fraction (%)	63.16 ± 7.48	61.70 ± 8.01	.208
Left atrial AP diameter (mm)	43.99 ± 5.83	46.57 ± 6.58	.007
Time to recurrence after index PVI (months)	16.44 ± 15.02	17.11 ± 12.93	.742
Follow-up time after last redo (months)	40.97 ± 26.72	32.97 ± 21.14	.026
Age (years)	63.82 ± 9.25	64.73 ± 8.07	.479
Hypertension (%)	72	75	.754
Diabetes mellitus (%)	12	14	.513
Ischemic heart disease	11	11	.309
CHADS-VASc score	1.80	1.81	.957
Recurrent OAT (%)/AF(%)	27/73	22/78	.470
Gap-related OAT (%)	9	2	.053

Abbreviations: AF, atrial fibrillation; OAT, organized atrial tachycardia; PVI, pulmonary vein isolation.

2.3 | Follow-up

Patients had follow-up visits 3 months, 6 months, and 1 year after the index procedure, and yearly thereafter. Symptom status, 12-lead ECG, 24-h or 1-week Holter ECG, and transtelephonic ECG were used for assessing AF recurrence. Asymptomatic recurrences were sought by 1-week Holter monitoring at least 6 months after the procedure. Recurrences were defined as any atrial arrhythmia lasting more than 30 s. Recurrent AF was defined by irregularly irregular R-R intervals, absence of distinct P waves, and irregular atrial activations on surface and/or intracardiac ECG. OAT was defined by regular atrial activation and fixed or regularly irregular RR intervals. Patients who experienced both recurrent OAT and AF during follow-up after the index procedure were enrolled in the AF recurrence group. The same categorization was used when analyzing the type of recurrence after redo procedures. The mechanism of OAT was determined during the redo procedure, except for patients with ECG-documented typical flutter undergoing empirical CTI ablation in sinus rhythm. Paroxysmal arrhythmia was defined by termination spontaneously or by cardioversion within 7 days. Patients with persistent AF had sustained arrhythmia lasting >7 days.

2.4 | Redo ablation

All redo procedures were performed due to recurrent arrhythmia at least 3 months after the index ablation.

In patients with recurrent AF, reconnected PVs were reisolated similarly to the index procedure. Pharmacologic stimulation using isoproterenol infusion (3–20 μg/min) to disclose non-PV triggers and subsequent extra-PV ablation were executed mostly in cases where minimal PV reconnection was found, at the discretion of the operator. No empirical linear ablation was performed.

In case of documented, recurrent OAT if the patient presented in sinus rhythm, programmed atrial stimulation (with up to 3 extrastimuli and two drive cycle lengths, without isoproterenol) was performed for arrhythmia induction. Alternatively, if the ECG documentation of the clinical arrhythmia was characteristic of typical flutter (counterclockwise CTI dependent atrial flutter) empirical ablation of the CTI was performed in sinus rhythm, and the induction protocol was performed afterwards.

If the patient presented with ongoing OAT, entrainment pacing was performed first at the CTI. If CTI-dependent flutter was diagnosed, linear RF ablation of the CTI was carried out. When the atrial flutter terminated and bidirectional CTI block was achieved, induction was attempted by programmed stimulation to reveal further atrial arrhythmias. For non-CTI-dependent flutter, activation mapping with an electroanatomic (EA) mapping system (CARTO 3, Biosense Webster, Diamond Bar, CA, USA) and further entrainment mapping was used to delineate the arrhythmia circuit. A non-CTI-dependent atrial flutter was defined as gap-related when activation mapping suggested an origin around PV ostia, and entrainment pointed to participation of reconnected PV myocardial sleeves, at least two gaps in the previously placed PVI ring were demonstrated: one serving as an entrance, the other as an exit to electrical activation, and the flutter terminated during ablation of one of the gaps. Other non-CTI-dependent flutters were targeted by linear RF lesions, connecting electrically silent regions (spontaneous or previous ablation scar or mitral annulus). Linear ablation was considered successful after termination of the ongoing arrhythmia and demonstration of conduction block across ablation lines by pacing close to the line and observing an activation detour on the opposite side. The latter was the endpoint of empirical ablation in the case of non-inducible OAT.

2.5 | Subsequent follow up, study end points

Follow-up after a redo procedure followed the same protocol as after the index PVI. The primary end point of this study was freedom from recurrent atrial arrhythmia and recurrence-free survival time after the last redo ablation, without antiarrhythmic drugs (AAD). The secondary end point was successful rhythm control, defined as lack of recurrence on or off AADs.

2.6 | Statistical analysis

Baseline characteristics of the study population with discrete and continuous variables were compared with chi-square test and independent samples t-test, respectively. Recurrence rates in different groups of the study population were compared with chi-square test, while Kaplan–Meier curve and log-rank analysis were applied to evaluate recurrence-free survival time.

3 | RESULTS

The indication for the index procedure was paroxysmal AF in 90 (48%) patients, and persistent AF in 95 (52%) patients. Twenty-two patients (12%) had a history of non-PV ablation before the index procedure (CTI in 15, AV nodal slow pathway in 4 and focal atrial tachycardia ablation in 2 patients).

During the index procedure, only PVI was performed in 152 (82%) patients. All PVs were successfully isolated. Additional cavotricuspid isthmus (CTI) ablation was carried out in 30 (16%) cases, superior vena cava (SVC) isolation in 2 (1%), focal LA ablation in 3 (2%), and AV nodal slow pathway ablation in 1 (0.5%) case.

Among the 185 patients, only OAT recurrence was recorded in 45 (24%), and AF in 140 (76%) cases. Patients who had recurrent AF and OAT as well were enrolled in the AF group. Recurrent AF was paroxysmal in 100 (71%) and persistent in 40 (29%) patients (Table 1). Recurrent arrhythmia was persistent and still ongoing at the beginning of the redo ablation in 27 of 45 (60%) patients in the OAT group.

Baseline parameters did not differ significantly between patients with OAT or AF recurrence, except OAT patients had a shorter time

TABLE 2 Comparison of patients with OAT and AF recurrence.

Type of recurrent arrhythmia	OAT	AF	*p*
Number of patients	45	140	
Male (%)	49	54	.584
Ejection fraction (%)	61.95 ± 8.33	62.55 ± 7.61	.661
Left atrial AP diameter (mm)	44.95 ± 5.79	45.45 ± 6.52	.661
Rate of persistent AF before index PVI (%)	53	47	.470
Time to recurrence after index PVI (months)	11.51 ± 8.83	18.48 ± 14.86	<.001
Follow-up time after last redo (months)	44.45 ± 27.55	34.39 ± 22.70	.029
Age (years)	64.60 ± 9.90	64.19 ± 8.25	.800
Hypertension (%)	69	75	.419
Diabetes mellitus (%)	13	13	.934
Ischemic heart disease (%)	15	9	.240
Mean CHADS-VASc score	1.73	1,48	.677
PV-reconnections at 1. redo ablation (%)	82	94	.022
Mean number of ablations	1.267	1.136	.126

Abbreviations: AF, atrial fibrillation; OAT, organized atrial tachycardia; PVI, pulmonary vein isolation.

to recurrence after index PVI (Table 2). Minimum follow-up time was 1 year; mean follow-up time was 37 ± 24 months.

All patients had at least 1 redo and 23 (12%) underwent multiple repeat ablations after the initial PVI. The maximum number of redo procedures was 4. The first redo ablation was performed after 503.5 ± 418.4 days from the initial procedure.

Reconnection of PVs was documented during the first redo ablation in 168 patients (90%), 37/45 (82%) in the OAT group and 131/140 (94%) in the AF group ($p = .022$). Both left and right PVs were reconnected in 91 (54%), only left PVs in 25 (15%) and only right PVs in 52 (31%) cases. In the 23 patients who underwent a second redo ablation, reconnection was detected in 11 (48%); 4 out of 9 OAT patients (44%) and 7 out of 14 AF patients (50%) ($p = .79$). In eight patients, left and right PVs were both reconnected; in two cases reconnection was observed in the left, and in one patient in the right PVs. Recurrent PV reconnection was detected in only two of eight (25%) subsequent redo procedures, in one case on both sides and in the other the left PVs were affected.

Among patients without PV reconnection, eight (43%) were from the OAT group. In these cases, ablation of the OAT was attempted. In one case, AV nodal reentry was also inducible, and the slow pathway was ablated. The remaining nine patients without PV reconnection were from the AF group. The ablation targets were ongoing (one patient) or induced (two patients) CTI-dependent flutter, inducible left atrial OAT (two patients), and complex electrograms (in the rest).

3.1 | The success of the first redo ablation in the OAT and AF recurrence groups

No significant difference was observed in the success rate after the first redo ablation between OAT and AF groups (49% vs. 52%, $p = .72$) (Figure 1). Also, recurrence-free survival time was not different between groups (51.08 ± 6.66 vs. 53.37 ± 4.75 months, $p = .54$). Moreover, the majority of recurring patients after the first redo ablation had recurrent AF during further follow-up in both groups (71% and 82% of recurrences in the OAT and AF groups, respectively, $p = .26$).

3.2 | The success of multiple redo ablations

No significant difference was observed between OAT and AF groups in the rate of recurrence-free patients after the last redo procedure (60% vs. 58% $p = .80$), in the success of rhythm control (84% vs. 85%, $p = .93$) and in mean recurrence-free survival time (63.2 ± 7.04 vs. 61.2 ± 5.32 months, $p = .23$) (Figures 1 and 2C).

Recurring patients after the last procedure had AF in 95% and 92% in the OAT and AF groups, respectively ($p = .32$).

3.3 | Subgroup analyses

Separate analyses were conducted for patient groups with initially persistent and paroxysmal AF. In the subgroup of 95 patients with persistent AF before the index PVI, recurrence was OAT in 21 (22%) cases, AF in 74 (78%) cases, with 34 (46%) having recurrent persistent AF among the latter. In this subgroup, no significant difference was observed between those with OAT as compared to those with AF recurrence in the success rate after the first (43% vs. 42%, respectively, $p = .94$) or last redo procedure (57% vs. 47%, respectively, $p = .43$), and the rate of successful rhythm control (81% vs. 76%, respectively, $p = .61$) (Figure 2B). In the subgroup undergoing index PVI for paroxysmal AF, there was also no difference in the primary or secondary outcome measures between patients with OAT versus AF recurrence (all $p > .1$) (Figure 2C).

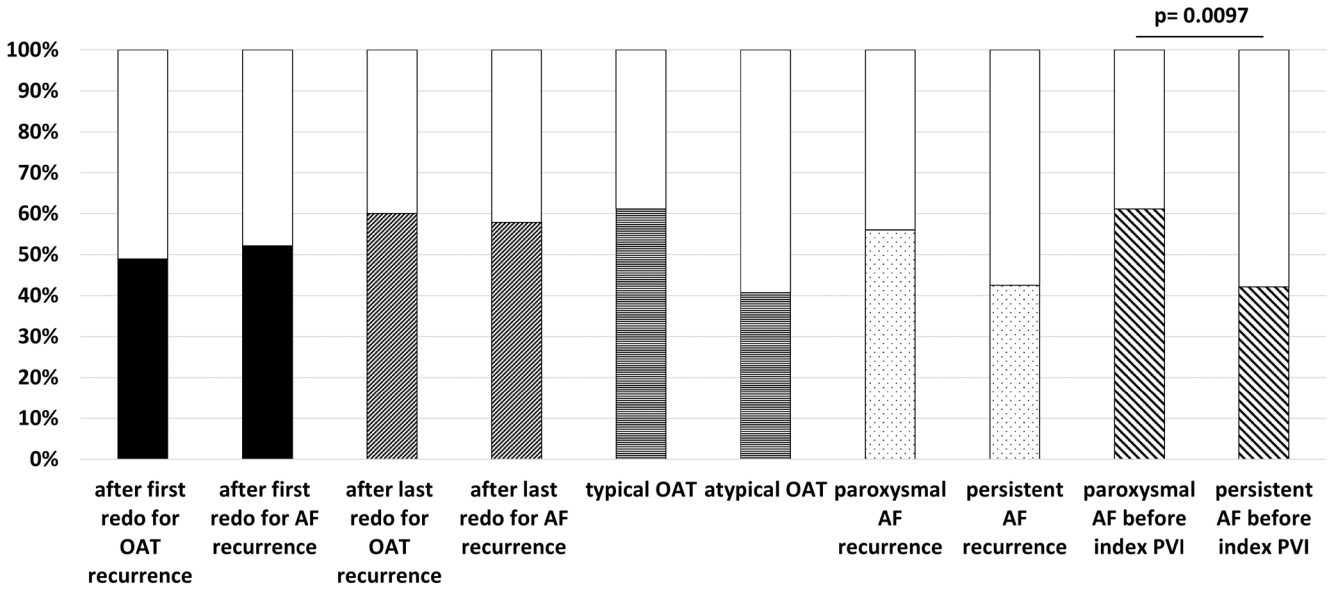

FIGURE 1 Rate of recurrence-free patients (shaded rectangles) in different groups. AF, atrial fibrillation; OAT, organized atrial tachycardia; PVI, pulmonary vein isolation.

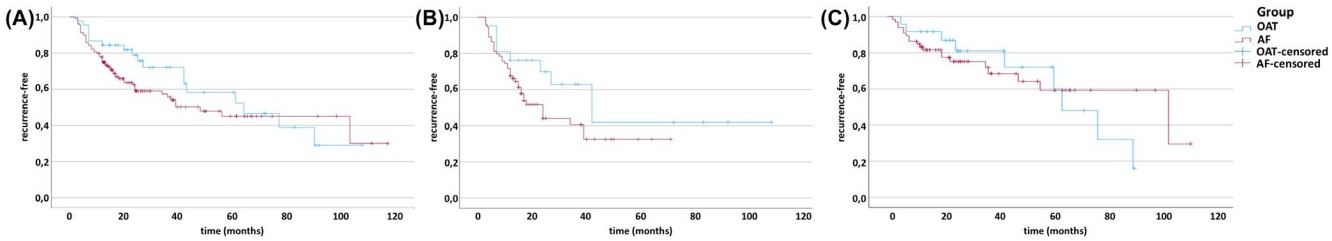

FIGURE 2 Recurrence-free survival after last redo ablation. (A) All patients. (B) Patients with persistent AF at initial PVI. (C) Patients with paroxysmal AF at initial PVI. AF, atrial fibrillation; OAT, organized atrial tachycardia.

Subgroup analysis showed a higher rate of OAT versus AF recurrence in patients with a history of CTI ablation, compared to those without such a history (36% vs. 20%, $p = .024$). However, OAT versus AF recurrence was not predictive of the success of first or subsequent redo procedures in either of the subgroups (ie. patients with and without a prior history of CTI ablation, all $p > .1$).

3.4 | Impact of OAT and AF type on success of redo procedures

Among 45 patients with only OAT recurrence after index PVI, the arrhythmia was categorized as CTI-dependent flutter in 18 patients (40%). CTI ablation was successfully performed in all of them. The other 27 (60%) patients were diagnosed with atypical OAT. The most common arrhythmia mechanisms in this group were: roof-dependent left atrial flutter (25%), targeted by roof line ablation; perimitral flutter (21%), treated by anterior (50%) or posterior (50%) mitral line ablation; and gap-related flutter (18%) treated by redo PVI. The acute success of non-CTI dependent flutter ablation was 80%. Five (18%) patients also had focal atrial tachycardia successfully ablated. Altogether, 8 (17%) patients had multiple OATs targeted during the redo procedure.

Comparing only the successful recurrent OAT ablations with redo ablation for AF recurrence, the success rate (56% vs. 51%, $p = .71$, respectively) and the rate of successful rhythm control (89% vs. 85%, $p = .36$, respectively) did not show a significant difference. On the other hand, when OAT ablation was acutely unsuccessful, the prognosis tended to be worse than after successful OAT ablation (25% vs. 68% success, $p = .026$ and 63% vs. 89% ultimate rhythm control, $p = .059$).

There was no significant difference in the rate of recurrence-free patients and successful long-term rhythm control between CTI-dependent and atypical OAT (61% vs. 41%, $p = .18$ and 78% vs. 89%, $p = .35$, respectively). Recurrence-free survival time did not show a difference either (50.55 ± 8.37 vs. 47.9 ± 9.4 months, respectively, $p = .717$).

Gap-related OAT tended to be more common in patients with paroxysmal AF before index PVI (Table 1). In this subgroup, the success rate after the last redo was numerically, but non-significantly higher in patients with gap-related OAT, compared to other OAT (83% vs. 56%, $p = .22$).

The success of redo procedures was higher in patients who had undergone the index PVI for paroxysmal AF, as compared to persistent AF after the first (61% vs. 42%, $p=.01$), and after the last redo ablation (68% vs. 48%, respectively, $p=.012$). Ultimate rhythm control was also achieved more frequently (93% vs. 77%, $p=.002$).

The difference in success rate of redo procedures and recurrence-free survival did not reach statistical significance between patients with paroxysmal versus persistent AF recurrence after index PVI (56% vs. 43%, $p=.14$ and 58.83 ± 5.58 vs. 28.9 ± 4.69 months, respectively, $p=.093$), but paroxysmal AF recurrence was associated with a higher rate of successful rhythm control (92% vs. 68%, $p<.0002$) (Figure 1).

4 | DISCUSSION

In this retrospective, observational study, we evaluated consecutive patients undergoing repeated catheter ablation after index PVI and investigated the prognostic significance of recurrent organized atrial tachycardia (OAT) versus recurrent AF. The main findings of this study are twofold:

1. Organized atrial tachycardia as recurrent arrhythmia after a PVI-only index procedure does not portend improved effectiveness of first and subsequent redo procedures, as compared to recurrent AF.
2. Further follow-up after redo procedures discloses AF in the majority of recurring patients, independently from whether they had OAT or AF recurrence after index PVI.

Our findings contradict previous studies that showed improved effectiveness of redo procedures in the case of OAT. These reports themselves are in conflict with publications showing more advanced atrial remodeling in patients who experience OAT recurrence after PVI, as compared to those with recurrent AF.[5,10–12]

4.1 | Is OAT recurrence after PVI "road to sinus rhythm"[13]?

Post-PVI OAT may seem a more attractive target for repeat ablation, due to the possibility of straightforward characterization of the mechanism and selection of ablation strategy during redo procedures. In contrast, recurrent AF after PVI may be more difficult to deal with—especially when PVs are found to be durably isolated—owing to the lack of an established ablation strategy beyond PVI. The question remains, however: do the above considerations translate into a more favorable outcome of redo procedures performed for recurrent OAT, compared to recurrent AF?

In a recent large retrospective study, noninvasive measures of atrial remodeling were found to be strongly associated with incident OAT after AF ablation.[10] Magnetic resonance detection of advanced atrial cardiomyopathy was shown to be associated with OAT recurrence after AF ablation.[5] High-density voltage mapping studies have shown increased low-voltage areas in patients with OAT recurrence as compared to those with recurrent AF.[11,12] Adverse remodeling and scarring (manifest in low-voltage) are the most important predictors of failure of AF ablation.[14]

Surprisingly, however, several studies have reported a *better* prognosis of post-AF ablation OAT, compared to recurrent AF.[1–4] This finding is even more unexpected in light of the fact that patients with recurrent OAT in the same studies were generally older and had more dilated LA and more persistent AF before index ablation, compared to those with recurrent AF.[3,4]

4.2 | How can the contradiction be resolved?

Apart from advanced remodeling, another consistent predictor of OAT recurrence after AF ablation is the performance of linear ablation at the index procedure.[2] It has been shown to be an independent predictor of atypical flutter recurrence.[5,8,10] More OAT recurrence was noted with linear ablation added to PVI in randomized studies.[15,16] Furthermore, mapping has shown that the majority of macroreentrant OAT after AF ablation involves gaps in prior ablation lines.[16–18] Recurrent atypical flutter may be considered an iatrogenic arrhythmia in this regard.[16,19] In our series, the only iatrogenic arrhythmia was related to PVI: gap-related flutter after PVI-only index procedures. This particular arrhythmia, seen primarily in paroxysmal AF patients, differs from remodeling-driven OAT and becomes less important with better technology producing durable PVI.

Thus, the discrepancy in studies showing better outcomes in the case of OAT recurrence despite more advanced atrial remodeling may be resolved by the following. A variable percentage (60%–100%) of patients in these studies underwent linear ablation and/or electrogram-based ablation beyond PVI at the index procedure.[1,2,4] Some of them would have done well with PVI only, but developed iatrogenic OAT from extra-PV ablation. If those postablation OATs could be eliminated during a redo procedure, the patient—who has been kept AF-free by PVI—will be free of recurrence. From this scenario, a better prognosis with postablation OAT might be erroneously inferred.

Also suggestive of the proarrhythmic potential of extra-PV substrate modification is the higher proportion of OAT recurrence in these studies (46–58%[1,2] with typical flutter included, 30–38% atypical flutter only[3,4]), compared to ours (10% typical, 15% atypical flutter).

According to the present study, when the index procedure is confined to PVI-only, recurrent OAT does not portend a better prognosis compared to recurrent AF, supporting the assumption that linear ablation and/or electrogram-based ablation at the index procedure influence the results of previous studies.

4.3 | Persistent versus paroxysmal AF patients

We found no difference in terms of the prognostic implications of OAT versus AF recurrence between patients with persistent

or paroxysmal AF. OAT recurrence may be more straightforward to target during a redo procedure, but this is counteracted by its association with advanced atrial remodeling, especially in patients with persistent AF. In paroxysmal AF patients, structural remodeling may play less of a role, but recurrence of both OAT and AF after PVI is more commonly gap-related.[20] For them, repeat PVI offers an equally effective treatment independent of whether their recurrence presents in the form of OAT or AF.

4.4 | High rate of recurrent AF after redo

The other important finding of our study is that most recurring patients after redo ablation experience AF, even if the justification for the redo procedure was postablation OAT.

Our patients did not undergo empirical substrate modification during the index PVI or subsequent redo procedures, and only clinical macroreentry was targeted. In this type of population—with less propensity for iatrogenic OAT—those that continue to have further recurrences after redo tend to have AF (also) during long-term follow-up, even if they had only OAT after the index PVI.

4.5 | Limited success in the management of postablation OAT

Others have also shown a high rate of AF recurrence after left atrial macroreentrant tachycardia ablation.[21] On the other hand, recurrent atrial tachycardia is also common after procedures targeting postablation OAT: despite using ultra-high-density mapping, a significant recurrence rate (26% and 46%) was registered in two contemporary studies.[22,23] As seen in our series, acute procedural failure of post-PVI OAT ablation further compromises the outcome of redo procedures. Technological progress likely will change this yet unfavorable prognosis.

4.6 | Limitations

The findings of our study should be interpreted considering all the inherent limitations of a single center, retrospective dataset. Index procedures were done in an era of less advanced technology, resulting in low durability of PVI. However, we observed no difference in the outcome of patients with OAT versus AF recurrence even after multiple procedures, when the rate of reconnected PVs in the total population was likely very low. Our observed frequency of PV reconnection was very similar to previous studies exploring the prognostic significance of the type of arrhythmia recurrence: they report on average 86% in patients with recurrent OAT and 97% in those with recurrent AF.[1,3,4] Therefore, this cannot account for the observed difference from these studies, but rather their adding extra-PV ablation is likely to be responsible. Better tools to produce more durable PVI and linear lesions may change the outcome of redo procedures in the future.

Further limitation of this study is that the connection between structural remodeling and OAT or AF recurrence could not be studied due to the lack of systematic voltage or substrate mapping data during index and redo procedures.

5 | CLINICAL IMPLICATIONS

The view of post-AF ablation OAT being a "road to sinus rhythm" has developed over the years,[1,13] despite data showing more advanced atrial remodeling in these patients.[3,4,10–12] This assumption can lead to undue expectations and drive serial redo procedures for patients with recurrent OAT. When the index procedure is confined to PVI-only, our results show similar success rate compared to persistent AF recurrence and point to a possible iatrogenic nature of OAT in previous studies.

These findings have important implications for shared decision making with patients who experience recurrence after initial PVI.

ACKNOWLEDGMENTS

We would like to express our gratitude to Dr. Ferenc Rárosi, PhD, from the Department of Medical Physics and Informatics, University of Szeged, for his help in statistical analysis.

CONFLICT OF INTEREST STATEMENT

No conflict of interest can be disclosed on behalf of the authors. The authors did not receive support from any organization for the submitted work.

DATA AVAILABILITY STATEMENT

Data available on reasonable request from the corresponding author.

ETHICS STATEMENT

The study was approved by the institutional review board (222/2019-SZTE).

PATIENT CONSENT

Informed consent has been obtained from the involved patients.

TRIAL REGISTRATION

Our work does not have a clinical trial registration. No materials were reproduced from other sources, hence no permission was necessary.

ORCID

Tamás János Riesz https://orcid.org/0000-0003-1615-2765
Róbert Pap https://orcid.org/0000-0002-7009-5063

REFERENCES

1. Ammar S, Hessling G, Reents T, Fichtner S, Wu J, Zhu P, et al. Arrhythmia type after persistent atrial fibrillation ablation predicts success of the repeat procedure. Circ Arrhythm Electrophysiol. 2011;4(5):609–14. https://doi.org/10.1161/CIRCEP.111.963256
2. Baldinger SH, Chinitz JS, Kapur S, Kumar S, Barbhaiya CR, Fujii A, et al. Recurrence of atrial arrhythmias despite persistent pulmonary vein isolation after catheter ablation for atrial fibrillation. JACC Clin

Electrophysiol. 2016;2(6):723–31. https://doi.org/10.1016/j.jacep.2016.05.013
3. Akhtar T, Daimee UA, Sivasambhu B, Boyle TA, Arbab-Zadeh A, Marine JE, et al. Ablation outcomes for atypical atrial flutter versus recurrent atrial fibrillation following index pulmonary vein isolation. J Cardiovasc Electrophysiol. 2021;32(6):1631–9. https://doi.org/10.1111/jce.15051
4. Choi Y, Kim S, Baek JY, Kim SH, Kim JY, Kim TS, et al. Acute and long-term outcome of redo catheter ablation for recurrent atrial tachycardia and recurrent atrial fibrillation in patients with prior atrial fibrillation ablation. J Interv Card Electrophysiol. 2021;61(2):227–34. https://doi.org/10.1007/s10840-020-00795-x
5. Ferro E, Perez N, Althoff T, Guasch E, Prat S, Doltra A, et al. Magnetic resonance detection of advanced atrial cardiomyopathy increases the risk for atypical atrial flutter occurrence following atrial fibrillation ablation. EP Europace. 2023;25. https://doi.org/10.1093/europace/euad276
6. D'Ascenzo F, Corleto A, Biondi-Zoccai G, Anselmino M, Ferraris F, di Biase L, et al. Which are the most reliable predictors of recurrence of atrial fibrillation after transcatheter ablation?: a meta-analysis. Int J Cardiol. 2013;167(5):1984–9. https://doi.org/10.1016/j.ijcard.2012.05.008
7. Tuan TC, Chang SL, Tsao HM, Tai CT, Lin YJ, Hu YF, et al. The impact of age on the electroanatomical characteristics and outcome of catheter ablation in patients with atrial fibrillation. J Cardiovasc Electrophysiol. 2010;21(9):966–72. https://doi.org/10.1111/j.1540-8167.2010.01755.x
8. Wójcik M, Berkowitsch A, Zaltsberg S, Hamm CW, Pitschner HF, Kuniss M, et al. Predictors of early and late left atrial tachycardia and left atrial flutter after catheter ablation of atrial fibrillation: long-term follow-up. Cardiol J. 2015;22(5):557–66. https://doi.org/10.5603/CJ.a2015.0040
9. Verma A, Jiang CY, Betts TR, Chen J, Deisenhofer I, Mantovan R, et al. Approaches to catheter ablation for persistent atrial fibrillation. N Engl J Med. 2015;372(19):1812–22. https://doi.org/10.1056/NEJMoa1408288
10. Gucuk Ipek E, Marine J, Yang E, Habibi M, Chrispin J, Spragg D, et al. Predictors and incidence of atrial flutter after catheter ablation of atrial fibrillation. Am J Cardiol. 2019;124(11):1690–6. https://doi.org/10.1016/j.amjcard.2019.08.026
11. Hashiguchi N, Chiang CH, Rottner L, Rottner L, Reißmann B, Rillig A, et al. Reverse structural atrial remodeling and atrial tachycardia in patients with repeat ablation for atrial fibrillation. Pacing Clin Electrophysiol. 2023;46:11–9. https://doi.org/10.2139/ssrn.3845865
12. Lyan E, Yalin K, Abdin A, Sawan N, Liosis S, Lange SA, et al. Mechanism, underlying substrate and predictors of atrial tachycardia following atrial fibrillation ablation using the second-generation cryoballoon. J Cardiol. 2019;73(6):497–506. https://doi.org/10.1016/j.jjcc.2019.02.006
13. Heck PM, Rosso R, Kistler PM. The challenging face of focal atrial tachycardia in the post AF ablation era. J Cardiovasc Electrophysiol. 2011;22(7):832–8. https://doi.org/10.1111/j.1540-8167.2011.02090.x
14. Kanda T, Masuda M, Asai M, Iida O, Okamoto S, Ishihara T, et al. Impact of left atrial low-voltage areas during initial ablation procedures on very late recurrence of atrial fibrillation. J Cardiovasc Electrophysiol. 2022;33(8):1697–704. https://doi.org/10.1111/jce.15607
15. Yao Y, Hu F, Du Z, He J, Shi H, Zhang J, et al. The value of extensive catheter linear ablation on persistent atrial fibrillation (the CLEAR-AF study). Int J Cardiol. 2020;316:125–9. https://doi.org/10.1016/j.ijcard.2020.05.032
16. Masuda M, Inoue K, Tanaka N, Watanabe T, Makino N, Egami Y, et al. Long-term impact of additional ablation after pulmonary vein isolation: results from EARNEST-PVI trial. J Am Heart Assoc. 2023;12(17):e029651. https://doi.org/10.1161/JAHA.123.029651
17. Chae S, Oral H, Good E, Dey S, Wimmer A, Crawford T, et al. Atrial tachycardia after circumferential pulmonary vein ablation of atrial fibrillation. J Am Coll Cardiol. 2007;50(18):1781–7. https://doi.org/10.1016/j.jacc.2007.07.044
18. Kitamura T, Takigawa M, Derval N, Denis A, Martin R, Vlachos K, et al. Atrial tachycardia circuits include low voltage area from index atrial fibrillation ablation relationship between RF ablation lesion and AT. J Cardiovasc Electrophysiol. 2020;31(7):1640–8. https://doi.org/10.1111/jce.14576
19. Daubert JP. Iatrogenic left atrial tachycardias: where are we? J Am Coll Cardiol. 2007;50(18):1788–90. https://doi.org/10.1016/j.jacc.2007.07.043
20. Fichtner S, Sparn K, Reents T, Ammar S, Semmler V, Dillier R, et al. Recurrence of paroxysmal atrial fibrillation after pulmonary vein isolation: is repeat pulmonary vein isolation enough? A prospective, randomized trial. Europace. 2015;17(9):1371–5. https://doi.org/10.1093/europace/euu389
21. Vicera JJB, Lin YJ, Lin CY, Lu DY, Chang SL, Lo LW, et al. Electrophysiological and clinical characteristics of catheter ablation for isolated left side atrial tachycardia over a 10-year period. J Cardiovasc Electrophysiol. 2019;30(7):1013–25. https://doi.org/10.1111/jce.13945
22. Takigawa M, Derval N, Frontera A, Martin R, Yamashita S, Cheniti G, et al. Revisiting anatomic macroreentrant tachycardia after atrial fibrillation ablation using ultrahigh-resolution mapping: implications for ablation. Heart Rhythm. 2018;15(3):326–33. https://doi.org/10.1016/j.hrthm.2017.10.029
23. Takigawa M, Derval N, Martin CA, Vlachos K, Denis A, Nakatani Y, et al. Mechanism of recurrence of atrial tachycardia: comparison between first versus redo procedures in a high-resolution mapping system. Circ Arrhythm Electrophysiol. 2020;13(1):e007273. https://doi.org/10.1161/CIRCEP.119.007273

How to cite this article: Riesz TJ, Bencsik G, Sághy L, Pap R. Does organized atrial tachycardia after a pulmonary vein isolation-only procedure portend better outcome of repeat ablation compared to recurrent atrial fibrillation? J Arrhythmia. 2025;41:1–8. https://doi.org/10.1002/joa3.70049