Atrial Tachycardia During Ongoing Atrial Fibrillation Ablation

– EnSite Array Analysis –

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Background: Atrial tachycardia (AT) occurring during atrial fibrillation (AF) ablation is sometimes difficult to identify and eliminate. EnSite Array (EA) visualizes beat-to-beat virtual activation of AT. The aim of the present study was to characterize AT occurring during AF ablation during ongoing AF, using EA.

Methods and Results: Among 90 patients with AF (paroxysmal, n=67; persistent, n=23) who underwent radiofrequency catheter ablation during ongoing AF, 33 (37%) had 46 ATs that developed during ablation, and 9 (10%) of these patients had 9 ATs that developed before ablation. AT was sustained in 39 and non-sustained in 7. Nineteen ATs resulted from a focal mechanism and 27 from macroreentry. The major AT foci were distributed in the pulmonary vein (n=8) and left atrial roof (n=3), and macroreentrant ATs mainly consisted of peri-mitral AT (n=10), common atrial flutter (n=10), and roof reentrant AT (n=3). After EA-guided ablation of AT, 41 ATs in 28 patients (85%) were eventually rendered non-inducible. During 21±8 months of follow-up, 30 of the 33 patients (91%) were free from AF/AT recurrence.

Conclusions: AT occurred in 37% of the patients during ongoing AF ablation, resulting from a focal or reentrant mechanism in diverse locations. Peri-mitral AT, common atrial flutter, and AT from the pulmonary vein were frequently observed. These ATs were eliminated by EA-guided radiofrequency ablation in most cases. (*Circ J* 2011; 75: 1080–1089)

Key Words: Atrial fibrillation; Atrial tachycardia; Catheter ablation; EnSite Array

Secondary atrial tachycardia (AT), which results from either a focal or reentrant mechanism, has been raised as a complication during and/or after atrial fibrillation (AF) ablation.^{1–13} Conventional fluoroscopy-guided ablation of secondary AT with a pacing maneuver has limited efficacy because it is sometimes difficult to identify an AT focus or a reentrant circuit. Although an electroanatomic mapping system has been used to overcome these shortcomings, some limitations remain because AT is sometimes non-sustained, multifocal, and easily changes into another AT, especially as a result of a pacing maneuver.

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EnSite Array (EA) visualizes beat-to-beat virtual activation of any form of tachycardia even if tachycardia is non-sustained, multifocal, or hemodynamically unstable.¹⁴ EA is therefore expected to reveal complex activations of second-

ary AT during AF ablation despite the fact that some left atrial (LA) lines are created by radiofrequency (RF) ablation. We discussed previously the strengths and shortcomings of EA in analyzing and ablating AT.¹⁵ The aim of the present study was to characterize AT occurring during AF ablation during ongoing AF using EA, and to assess whether EA-guided ablation of secondary AT is effective and safe.

Methods

Study Population

Ninety patients (paroxysmal AF [PAF], n=67; persistent AF [PeAF], n=23) underwent AF ablation during ongoing AF. Among them, 42 patients with PAF had sinus rhythm (SR) at the beginning of the procedure and AF was induced by atrial pacing before RF energy delivery. Those who had SR at the beginning of the procedure and induced AF that lasted <30 min were excluded from the study. Therefore AF abla-

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tion was started under AF in all patients. Among the 90 patients, 33 (37%) had at least 1 secondary AT, and these were the subjects of the present study.

Among the 33 patients, 24 had PAF and 9 had PeAF. The mean age was 59 ± 11 years and the mean duration of AF history was 4.9 ± 4.9 years. Among the 9 patients with PeAF, 2 patients were highly symptomatic and required cardioversion or anti-arrhythmia medication to restore SR repeatedly. The other 7 patients had AF persisting >7 days with a mean AF duration of 3.2 ± 1.2 months (range: 10 days–8 months). The mean LA dimension was 38 ± 6 mm and the mean left ventricular fractional shortening was $36 \pm 7\%$. The underlying heart disease was observed in 9 patients: left ventricular dysfunction in 3, hypertrophic cardiomyopathy in 2, and hypertensive heart disease in 1. Three patients had a history of open heart surgery (mitral stenosis in 1, atrial septal defect in 1, and Wolff–Parkinson–White syndrome in 1). Twenty-four patients had no underlying heart disease. Ablation of common atrial flutter (c-AFL) was previously performed in 1 patient. A mean of 1.2 ± 1.2 anti-arrhythmia medications failed to control AF before AF ablation. All anti-arrhythmia medications were discontinued at least 5 half-lives before the procedure. Informed written consent was obtained from all patients and the ablation procedure was performed under conscious sedation with i.v. administration of midazolam.

Definitions

PAF was defined as AF that terminated spontaneously within 7 days after the onset, and PeAF was defined as AF that required cardioversion or anti-arrhythmia medication to restore SR or that persisted for >7 days. AT was defined as tachycardia with regular atrial rhythm and constant atrial electrogram morphology, while AF was defined as tachycardia with irregular atrial rhythm and variable atrial electrogram morphology.

AT occurring during the AF ablation session was defined as early secondary AT, while AT occurring after the ablation session was defined as late secondary AT. Early secondary AT was classified into the following 2 categories: ongoing AT and pre-ablation AT. The former was defined as occurring during the ablation procedure and the latter as occurring before the initiation of RF energy delivery.

Table. Pre-Ablation and Ongoing AT Mechanism and Distribution

	Pre-ablation AT (n=9)	Ongoing AT (n=33)
Focal AT		
PV	1	8
LA roof	0	3
SVC	0	1
CS ostium	0	1
LA septum	0	1
LA inferior	0	1
LA appendage	0	1
Unknown	0	3
Total	1	19
Macroreentrant AT		
Peri-mitral	3	10
c-AFL	3	10
LA roof reentry	1	3
Peri-LA appendage	0	2
LA anterior localized AT	0	1
Double-loop (mitral isthmus + roof)	1	1
Total	8	27
Total of focal AT and macroreentrant AT	9	46

AT, atrial tachycardia; PV, pulmonary vein; LA, left atrial; SVC, superior vena cava; CS, coronary sinus; c-AFL, common atrial flutter.

Catheter Position and EA

A duo-decapolar catheter with 10 distal electrodes and 10 proximal electrodes (Livewire, St Jude Medical, Minnetonka, MN, USA) was placed in the coronary sinus (CS) through the internal jugular vein to record both the right atrial (RA) and CS potentials. Three trans-septal long sheaths were introduced into the LA using the standard Brockenbrough technique under fluoroscopy guidance. A multielectrode array catheter (MEA; St Jude Medical) was introduced into the LA through one of the trans-septal long sheaths (Mullins; Medtronic, Minneapolis, MN, USA), and the tip of the catheter was placed at the LA appendage (LAA) so as

Figure 2. Virtual activation map of peri-mitral AT, LA roof reentrant AT, peri-LAA AT, PV AT, LA inferior AT, and isochronal map of LA anterior localized AT. AT, atrial tachycardia; LA, left atrial; LAA, left atrial appendage; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; MV, mitral valve; PV, pulmonary vein; RIPV, right inferior pulmonary vein; RSPV, right superior pulmonary vein.

to locate the MEA body in the center of the LA. A 20-pole circular electrode catheter (Optima; St Jude Medical) for the recording of PV potentials and a non-irrigated ablation catheter with an 8-mm tip (Fantasista; Japan Lifeline, Tokyo, Japan) were introduced into the LA through the other 2 long sheaths.

The geometry of the LA was visualized using EA (EnSite version 6.0J; St Jude Medical). Details regarding the recording and analysis of EA and the use of EA for AF ablation have been described comprehensively in previous studies.^{16,17} During the review of the recorded data, a bandpass filter of 2.0–500 Hz was set for virtual unipolar electrogram recording in order to create an activation map. Activated clotting time (ACT) was monitored every 30 min and an adequate amount of heparin was injected to maintain ACT between 300 and 400 s.

AF Ablation

The RF energy was applied for 20–30 s in the temperature control mode with a maximum temperature setting of 50°C and a maximum power setting of 30–35 W depending on the ablation site. First, pulmonary vein antrum isolation (PVAI) was performed with an endpoint of complete electrical isolation of PV. If AF persisted or was induced (>5 min) by atrial pacing after PVAI, LA linear ablation at the LA roof and/or the LA bottom, and complex fractionated atrial electrogram (CFAE) ablation¹⁸ were also added, in this order until AF non-inducibility was observed.

AT Definitions and AT Ablation

The definition of focal AT was as follows: (1) radial activa-

tion spreading centrifugally from a single earliest activation site shown by EA; (2) QS pattern at the earliest activation site, with a sharp initial deflection in the contact and virtual unipolar electrogram; (3) atrial activation time accounting for <75% of the AT cycle length; and (4) AT was considered to be of RA origin when virtual activation occurred in the septal LA region with the virtual unipolar electrogram morphology of rS pattern, from which subsequent activation spread out toward the entire LA, and the RA electrogram preceded all LA electrograms.

Macroreentrant AT was defined as follows: (1) continuous sequence of atrial activation with the earliest activation adjacent to the latest activation, shown by EA; (2) atrial activation time accounting for >75% of the AT cycle length; and (3) classical entrainment criteria demonstrated.¹⁹ Pacing sites with a post-pacing interval (PPI) not exceeding the AT cycle length by >20 ms were considered to be within the reentry circuit. c-AFL was diagnosed on the basis of sawtooth waves in the 12-lead electrocardiogram and confirmed on PPI similar to the tachycardia cycle length at the cavo-tricuspid isthmus (CTI).

For focal AT, RF ablation was performed at the AT focus while for macroreentrant AT a line of block was created at the critical isthmus (eg, a line at the mitral isthmus, LA roof, or CTI). When macroreentrant AT was involved in the conduction gap resulting from an incomplete ablation line, point application of RF energy was performed to fill the gap and complete the ablation line. Bidirectional block was evaluated through activation mapping using EA by pacing performed at both sides adjacent to the ablation line. When AT was terminated spontaneously or by pacing, RF energy was applied during SR to the critical site of AT according to the mecha-

nism. All ATs recorded were targeted by RF ablation immediately after the occurrence of AT. An inducibility test was performed every time after AF or AT termination and again during SR after completion of all AF ablation procedures. If AF was induced, a stepwise approach was continued. The endpoints of the present study were as follows: (1) AF termination; (2) termination of AT or change to another AT; and (3) non-inducibility of AF and AT (<5 min).

Statistical Analysis

All continuous data are expressed as mean±SD or number and percentage, as appropriate. Categorical data were compared using the chi-square test. $P<0.05$ was considered statistically significant.

Results

Timing of Occurrence of Early Secondary AT

Among the 33 patients with ongoing AT, 19 had AF and 14 had SR at the beginning of the procedure. In the latter patients, rapid atrial pacing was performed in an attempt to induce AF before RF energy delivery; AF was induced in 5 of the 14 patients and AT was induced in the remaining 9 patients (pre-ablation AT). AF was induced after the ablation of pre-abla-

tion AT in these 9 patients, and AF ablation was started.

A flowchart of the resulting changes after the occurrence of ongoing AT during AF ablation is given in [Figure 1](#). AT was terminated and SR was restored in 24 patients (73%), and AT subsequently changed into AF again in 4 patients (12%); in 3 (9%) of these patients AF changed directly to SR, and in 1 patient (3%) AF remained unchanged after RF ablation. In the remaining 5 patients (15%), ongoing AT remained unchanged despite RF ablation of the AT. In a total of 6 patients (18%) who had persisting AT (n=5) or AF (n=1) at the end of AF ablation, SR was restored by cardioversion.

Comparison Between Ongoing AT and Pre-Ablation AT

Among the 46 ongoing ATs, 19 (41%) resulted from a focal mechanism with a mean cycle length of 244 ± 72 ms (range: 163–453 ms), and 27 (59%) resulted from a macroreentrant mechanism with a mean cycle length of 209 ± 31 ms (range: 140–257 ms). There was no significant difference in the mean cycle length between focal and macroreentrant ongoing ATs. In contrast, among the 9 pre-ablation ATs, 1 (11%) resulted from a focal mechanism with a cycle length of 239 ms, and 8 (89%) resulted from a macroreentrant mechanism with a mean cycle length of 195 ± 45 ms (range: 136–292 ms).

The mean number of ongoing ATs was 1.4 ± 0.9 per patient: 2 patients had 4 ATs, 2 had 3 ATs, 3 had 2 ATs, and 26 had 1 AT. Among the 9 patients with pre-ablation AT, 2 had 2 ongoing ATs and 7 had 1 ongoing AT. Ongoing AT was sustained in 39 (15 focal ATs, 24 macroreentrant ATs) and non-sustained in 7 (4 focal ATs, 3 macroreentrant ATs), while pre-ablation AT was sustained in 5 (5 macroreentrant ATs) and non-sustained in 4 (1 focal AT, 3 macroreentrant ATs).

Distribution of Ongoing AT and Timing of Initiation and Termination Mode Relative to AF Ablation Procedure

The mechanism and distribution of pre-ablation AT and ongoing AT are shown in Table and the representative activation and isochrone maps of ongoing ATs are shown in Figure 2. Among the 46 ongoing ATs, 44 were converted from AF or changed from another AT during RF application, and 2 were induced by atrial pacing after AF termination.

The timing of AT occurrence was classified into 3 categories: during PVAI; during LA linear ablation; and during CFAE ablation; and the types of AT are described according to the timing in Figure 3. Although there was no significant difference in the occurrence rate at each timing between focal and macroreentrant AT, macroreentrant AT tended to occur more frequently than focal AT during LA linear ablation ($P=0.15$).

The termination mode of AT was classified into 4 categories: during RF ablation; spontaneous termination; by pacing; and by cardioversion (Figure 4). Twenty-four ATs (52%) were terminated by RF ablation, 11 (24%) terminated spontaneously, and 6 (13%) were terminated by pacing. The remain-

ing 5 ATs (11%) were not terminated by RF ablation or pacing, and were restored to SR by cardioversion.

Focal AT in Ongoing AT

Of the 19 focal ongoing ATs, 8 originated from PV (PV AT), 3 from the LA roof (LA roof AT), 1 from LAA (LAA AT), 1 from the LA septum (LA septal AT), 1 from the LA inferior wall (LA inferior AT), 1 from the CS ostium (CS ostium AT), and 1 from the superior vena cava (SVC; SVC AT). The remaining 3 ATs (in which EA showed focal activation with an rS morphology in the virtual unipolar electrogram at the earliest activation site in the LA and which were not terminated by RF ablation) were classified as being of unknown origin. These ATs were restored to SR by cardioversion.

For 8 focal PV ATs the site of origin was the left superior pulmonary vein (LSPV) in 3, the right superior pulmonary vein (RSPV) in 3, and the left inferior pulmonary vein (LIPV) in 2. Two examples of an activation map of focal ATs originating from LSPV and LIPV are shown in Figure 5. All instances of focal PV AT were related to incomplete isolation of the PV antrum region or reconnection of LA–PV conduction, which included AT initiation during PVAI in 4, and during LA linear ablation with reconnected LA–PV conduction after PVAI in 4. The termination mode was RF ablation in 5, spontaneous termination in 2, and pacing in 1. Of the 5 focal PV ATs, which were terminated by RF ablation, 4 developed during PVAI and converted to SR on completion of PVAI. The remaining 1 AT originating from RSPV developed during LA linear ablation. We found that LA–PV was reconnected, and AT was terminated by completion of

Figure 5. Two cases of focal AT originating from the pulmonary vein converted from AF in the course of pulmonary vein antrum isolation. Red arrows, direction of local conduction. (A) Activation map constructed by EnSite Array (EA) during AT, which originated from LSPV. (B) EA recordings of virtual unipolar electrograms. White arrow, activation of this LSPV AT. (C) Activation map constructed using EA during AT that originated from LIPV. (D) EA recordings of virtual unipolar electrograms. The white arrow indicates the activation of this LIPV AT. Abbreviations as in Figure 2.

RSPV isolation.

Three focal LA roof ATs were terminated by RF ablation, pacing, and spontaneous termination. The termination mode of LA septum AT and LAA AT was spontaneous termination and that of the LA inferior wall AT was pacing. The focal AT of SVC and that of CS ostium were terminated by RF ablation; the method used was SVC isolation in SVC AT and focal RF ablation in CS ostium AT.

Of all 19 focal ATs, 4 (PV AT, LA roof AT, LA inferior AT, and AT of unknown origin) had an atrial activation time that accounted for >75% of the AT cycle length, which suggests microreentrant AT.⁸ These 4 ATs, however, were terminated by methods other than RF ablation and, therefore,

PPI or prolonged fractionated potentials, which suggest a slow conduction zone within the microreentrant circuit, were not evaluated.

Macroreentrant AT in Ongoing AT

Of the 27 macroreentrant ATs, 10 were peri-mitral ATs involving the mitral isthmus, 10 were c-AFLs, 3 were macroreentry involving the LA roof (LA roof reentrant AT), and the others consisted of macroreentry involving the LAA (peri-LAA AT) in 2 and the LA anterior wall (LA anterior localized AT) in 1. The remaining 1 AT was a double-loop reentry involving the mitral isthmus and the LA roof (double-loop reentrant AT).

Figure 6. Peri-mitral AT rotating around the mitral annulus converted from AF during LA roof linear ablation. Red arrows, direction of the local conduction. (A) Activation map constructed using EnSite Array (EA) during AT. (B) EA recordings of virtual unipolar electrograms. White arrow, activation of this AT. Abbreviations as in Figure 2.

Two examples of peri-mitral AT and LA roof reentrant AT are given in Figures 6,7. Among the 10 peri-mitral ATs, 3 terminated after completion of the ablation line at the mitral isthmus, 3 terminated during pacing, and 3 terminated spontaneously. One peri-mitral AT failed to terminate after creation of the ablation line at the mitral isthmus and was restored to SR by cardioversion. Of the 10 c-AFLs, 8 were terminated by CTI ablation. The remaining 2 c-AFLs converted to AF spontaneously and CTI ablation was performed at the end of AF ablation.

All 3 LA roof reentrant ATs were gap-related ATs due to incomplete line creation at the LA roof and were eliminated by completion of LA roof line creation. Of 2 peri-LAA ATs, 1 was initiated during PVAI and terminated by linear ablation between LAA and LSPV, and the other was initiated during LA linear ablation in association with an incomplete LA roof line, and terminated by RF ablation at the roof portion near LSPV. In both peri-LAA ATs, the virtual activation map showed that local conduction markedly slowed in the region between the posterior portion of the LAA base and the anterior portion of the left PVAI line.

One AT localized at the LA anterior wall occurred during PVAI and terminated spontaneously. One double-loop reen-

trant AT, consisting of a peri-mitral AT with counterclockwise rotation and roof reentry with activation going up in the posterior LA wall, was initiated during LA linear ablation. RF ablation was performed to create the LA bottom and mitral isthmus lines; AT was not terminated by this ablation method but was terminated by cardioversion.

Pre-Ablation AT

Pre-ablation AT consisted of 1 focal AT (11%; 1 PV AT) and 8 macroreentrant ATs (89%; 3 peri-mitral ATs, 3 c-AFLs, 1 roof reentrant AT, and 1 double-loop reentrant AT). Three ATs (33%; 2 c-AFLs and 1 roof reentrant AT) were terminated by RF ablation and 4 ATs (45%; 2 peri-mitral ATs, 1 c-AFL, and 1 PV AT) terminated spontaneously. Cardioversion was performed in the remaining 2 ATs (22%; 1 peri-mitral AT and 1 double-loop reentrant AT), 1 of which was a double-loop reentrant AT observed as a pre-ablation AT as well as an ongoing AT in the same patient. This AT changed into AF after beginning AF ablation, but AF converted into an almost identical double-loop reentrant AT again during LA linear ablation.

Figure 7. LA roof reentrant AT rotating through the LA roof converted from AF during complex fractionated atrial electrogram ablation. Red arrows, direction of the local conduction. (A) Activation map constructed using EnSite Array (EA) during AT. (B) EA recordings of virtual unipolar electrograms. White arrow, activation of this AT. Abbreviations as in Figure 2.

Acute Effects of Ablation of Ongoing AT

Among the 33 patients with 46 ATs, 28 patients (85%) with 41 ATs, which were terminated by RF ablation or pacing or terminated spontaneously, were finally rendered non-inducible directly or indirectly by AT ablation or completion of AF ablation.

Procedure Time and Complications

The total procedure time was 230 ± 44 min in 33 patients who underwent the ablation of early secondary AT in addition to AF, while it was 220 ± 42 min in 67 patients who underwent AF ablation alone ($P=NS$). A complication occurred in 1 patient (3%) with the early secondary AT, who developed femoral arteriovenous fistula at the puncture site. The arteriovenous fistula disappeared spontaneously.

Follow-up

During a mean follow-up period of 21 ± 8 months (range: 9–37 months), AT or AF (AF in 1, AT in 2) recurred in 3 of the 33 patients (9%). Two patients underwent repeat ablation (AF in 1, AT in 1). AT observed at the repeated session was different from that at the first session. Ablation was successful in these 2 patients at the second session.

Discussion

Previous Studies on Secondary AT

The incidence of early secondary AT was reported to be 10–75%,^{9–12} and that of late secondary AT was 16–31%^{2,3,5} depending on the ablation procedures used. Studies dealing with early secondary AT are limited in number, although there are many studies on late secondary AT. Scharf et al reported that among 144 patients with drug-refractory AF, 6 patients (4%) converted to left AT and 6 (4%) to LA flutter during PVAI followed by LA linear ablation.⁹ Haïssaguerre et al observed 87 early secondary ATs in 45 (75%) of 60 patients with PeAF during AF ablation.¹⁰ Some patients had multiple ATs with a focal or macroreentrant mechanism, a result similar to that of the present study. Zheng et al reported that most ATs that developed during stepwise linear ablation were of LA origin and resulted from macroreentrant AT related to conduction gaps, especially at the LAA and LSPV ridge.¹¹ Nam et al observed 110 induced or converted ATs in 42 (40%) of 105 patients during PVAI and/or CFAE ablation, the mechanisms of which were focal, roof dependent, perimitral or CTI dependent, which is also consistent with the present results.¹²

Mechanism of Pre-Ablation AT

Pre-ablation AT is not associated with RF energy delivery, and can be considered to be a spontaneous AT. In the present study, the main mechanisms of pre-ablation AT were peri-mitral AT, c-AFL, and roof-reentrant AT, which were observed as ongoing AT as well. Yoshida et al reported a dominant frequency with a lower frequency in the periodogram of AF during AF ablation, manifested as ongoing AT after AF termination by the elimination of higher-frequency components of atrial electrograms that resulted from rapid activation of AF.²⁰

These results might support the idea that some ATs coexist with AF and the elimination of AF unmasks this type of AT, which might occur as ongoing AT. Therefore, this type of AT has a potential to recur as late secondary AT and should be ablated irrespective of the sustainability or mechanism.

Mechanism of Ongoing AT

In the present study, macroreentrant AT was the main mechanism of ongoing AT, and focal AT was the second most frequent mechanism. The virtual activation map showed focal AT originating from the PV, LA roof, LA septum, LA inferior wall, LAA, CS ostium, and SVC, all of which are known as origins of focal idiopathic AT.²¹ The most frequent focal AT occurring after AF ablation was reported to be PV AT related to reconnected LA–PV conduction in several studies.^{2,7} In the present study, 4 of 8 focal PV ATs were transformed from AF during PVAI and eliminated by completion of PVAI. These ATs were defined as transient AT because they could be eliminated by standard PVAI. This finding is consistent with a previous report by Huang et al.²²

As for macroreentrant AT, this type of AT can be further divided into 2 categories: gap-related AT and non-gap-related AT. Gap-related macroreentrant AT is a man-made tachycardia relating to the gap in prior incomplete ablation lesions and includes mainly PV reentrant AT, peri-mitral AT, and LA roof reentrant AT. In the present study, a conduction gap was observed at the LA roof line in all 3 roof reentrant ATs and between the posterior portion of the LAA base and the anterior portion of the left PVAI line in 2 peri-LAA ATs. Additional ablation targeting this region resulted in termination of these ATs. Gap-related AT is a main mechanism of late secondary AT. Therefore the incompleteness of the ablation line should be avoided for future recurrence, which is easily seen on 1-beat EA analysis. When a gap-related AT appears, it should be ablated.

In contrast, non-gap-related macroreentrant AT is a secondary consequence of AF termination and includes c-AFL, peri-mitral AT, LA roof reentrant AT, septal AT and LA anterior localized AT. It is accepted that CTI ablation for spontaneous or induced c-AFL during AF ablation should be performed in the index session because the recurrence rate is high.²³ Chang et al reported a macroreentrant AT rotating around the antero-septal muscular bundle.²⁴ We also found a similar LA anterior localized AT confined to the anterior LA irrelevant to the previous ablation line.

Relationship Between Early and Late Secondary AT

The relationship between early and late secondary AT has been the focus of discussion. Chugh et al reported that early secondary AT was associated with late secondary AT,³ but Daoud et al reported no relationship between early and late secondary AT.⁴

Peri-mitral AT and LA roof reentrant AT can result from

either a gap-related or non-gap-related mechanism.^{1,5,6,13}

Gap-related mechanisms are most common, but non-gap-related peri-mitral AT and LA roof reentrant AT also have been reported to occur as both early secondary AT¹³ and late secondary AT.^{1,5,6} These ATs should be ablated only when they occur as gap-related ATs. When they occur as non-gap-related ATs, however, it is difficult to determine during the first session whether these ATs are byproducts of AF termination (transient arrhythmias without a long-term meaning) or spontaneous arrhythmias coexisting with AF or relating to the initiation or maintenance of AF (clinically significant arrhythmia). The discrepancy between the incidence of early secondary AT and the recurrence of late secondary AT might be due to that of non-gap-related peri-mitral AT or LA roof reentrant AT, which has limited meaning during the follow-up period, especially in those with AF that has been cured with RF ablation.

As for ongoing AT due to focal discharge mechanism, there has been no study that has clarified the etiology so far. Most focal AT seems to result from abnormal cellular mechanisms without relating to RF energy delivery. Therefore this type of AT should be ablated as well.

In summary, early secondary AT should be ablated when it presents as a pre-ablation AT or an ongoing AT resulting from a focal or gap-related macroreentrant mechanism, but ongoing ATs resulting from non-gap-related macroreentry (except for c-AFL) can be monitored. Further study, however, is needed to confirm this hypothesis. It is also difficult to determine whether septal AT, which results from either a focal or non-gap-related macroreentrant mechanism, is a spontaneous one or a byproduct of AF termination. Despite the very low incidence rate, the recurrence of this AT has been reported.⁶ Therefore, septal AT should be ablated.

One thing of note in the present study is the lower recurrence rate of late secondary AT (6%) than in the previous studies (16–31%),^{2,3,5} which seems to be due to our positive attitude toward eliminating all early secondary ATs. Moreover, ablation of early secondary AT seems to be involved in the modification of possible atrial substrate of late secondary AT. Ablation of non-sustained AT may contribute to the lower recurrence rate of AT as well.

Study Limitations

The present study had 4 limitations. First, some ATs terminated after the use of methods other than RF ablation, although AT became non-inducible after RF application to the critical site maintaining ATs. Second, EA was placed in the LA and therefore there was difficulty in analysis of the RA. In the present study, 3 ATs with the virtual activation electrogram morphology of an rS pattern at the earliest activation site in the LA, which were not terminated by RF ablation, might have been of RA origin. Conventional mapping is needed for tachycardia with RA origin in such a case. Third, analysis of the atrial substrate by methods such as voltage mapping was not performed. Therefore, the background condition of early secondary AT remains unclear. Fourth, the evaluation of microreentrant AT, which might be identified as focal AT on virtual activation mapping, was sometimes suggested by a wide atrial electrogram covering most of the AT cycle length. No such AT, however, was found in the present study. It is possible that microreentrant AT was not evaluated. Finally, the procedure time should not be prolonged even if secondary AT is observed, because it may increase the chance of adverse complications.

Conclusion

AT occurred in 37% of the patients during ongoing AF ablation. ATs resulted from either a focal or reentrant mechanism with diverse locations: peri-mitral AT, c-AFL, and PV-AT being frequently observed. They were eliminated by EA-guided RF ablation in many cases.

Disclosure

Dr Tsuchiya has served as a speaker and consultant for Nihon Kohden and St Jude Medical.

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