Mapping of Atrial Tachycardia During/After AF Ablation

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Baseline AF
PV Isolation-RSPV

Baseline
During ABL
Post ABL
PV Isolation-RIPV

Baseline | During ABL | Post ABL
PV Isolation-LSPV
PV Isolation-LIPV

Baseline

Post ABL
Post 4PVs isolation
During LA CFAE ablation
- AF organized to AT
AT-TCL 320ms
During PMI ablation - AT termination
Post ablation SR
Baseline AF

Case#2 PeAF
Post 4PVs isolation
Post LA CFAE ablation
During RA CFAE ablation
AT-TCL 240ms
During LA Roof ablation - AT termination
Post ablation SR
The Spatial Distribution of Atrial Fibrillation Termination Sites in the Right Atrium During Complex Fractionated Atrial Electrograms-Guided Ablation in Patients with Persistent Atrial Fibrillation

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AF Termination Sites During RA CFAE Ablation. Background: The role of right atrial (RA) ablation guided by complex fractionated atrial electrograms (CFAE) in atrial fibrillation (AF) has been debated. This study evaluated the spatial distribution of RA CFAE, the critical sites, and the predictors of successful termination of longstanding persistent AF during RA ablation.

Methods: A total of 97 patients with persistent AF who received automated detection of CFAE mapping and ablation at the RA for sustained AF after pulmonary vein isolation and left atrial (LA) CFAE-guided ablation were analyzed. The AF termination patterns and CFAE areas were analyzed.

Results: Forty-eight (49%) patients successfully converted to atrial tachycardia (AT) or sinus rhythm (SR) during CFAE-guided ablation at the RA. Of these, 7 (15%) patients converted directly to SR, and 41 (85%) converted via AT. The crista terminalis (CT) was the most common site for AT conversion during RA CFAE ablation, followed by the RA appendage and RA septum. Patients with larger RA volumes (>145 mm³) had lower rates of SR or AT conversion during RA CFAE ablation. Patients with AF termination during RA CFAE ablation had less late recurrence than those without AF termination (P = 0.003).

Conclusions: A half of patients with persistent AF refractory to LA ablation successfully converted to AT or SR during automated CFAE-guided ablation at the RA. The most common critical sites for AF termination were the CT and RA appendage and septum. Patients with AF termination during procedure whether LA CFAE only or after RA CFAE ablation had better outcome with less late recurrence of atrial tachyarrhythmia compared to those without AF termination. (J Cardiovasc Electrophysiol, Vol. pp. 1-9)

atrial fibrillation, complex fractionated atrial electrograms, pulmonary vein isolation, right atrium, spatial distribution, catheter ablation
Persistent AF Ablation

Post 4PVs Isolation
- AF sustained

4PVs+ LA CFAE
- 44% converted AT or SR
  LA Vol. 119.9 ± 35.0
  RA Vol. 122.4 ± 37.9

4PVs+ LA CFAE + RA CFAE
- 56% AF sustained
  LA Vol. 127.1 ± 40.6
  RA Vol. 142.2 ± 50.2

49% converted AT or SR
51% AF sustained

≒72% converted AT or SR

Is Pursuit of Termination of Atrial Fibrillation During Catheter Ablation of Great Value in Patients with Longstanding Persistent Atrial Fibrillation?

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Termination of Atrial Fibrillation During Catheter Ablation Predicts Better Outcome. Background: The reliable endpoint for ablation of longstanding persistent atrial fibrillation (LPAPF) has not been clearly established.

Methods and Results: This study included 140 patients who underwent catheter ablation for drug-refractory LPAPF. A stepwise ablation approach included circumferential pulmonary vein isolation followed by left atrial and right atrial complex fractionated electrogram-guided ablation. Atrial fibrillation (AF) was terminated by radiofrequency application during catheter ablation in 95 patients (67.9%). Among them, 33 patients (23.6%) converted to sinus rhythm directly, whereas 62 patients (44.3%) via atrial tachycardias (ATs). Patients in whom AF terminated during the index procedure had a lower recurrence rate of atrial arrhythmia than patients in whom AF did not terminate (45.3% vs 68.9%; P = 0.009, follow-up 18.7 ± 7.6 months). Among patients in whom AF terminated, there was no significant difference in recurrence rate according to the termination mode, whether converted to AT or not (P = NS). However, patients who converted to AT had a higher recurrence rate of AT (54.8% vs 81%; P = 0.016). Multivariable logistic regression analysis demonstrated that termination of AF during ablation (HR 0.440; 95% CI: 0.200–0.969, P = 0.041) and structural heart disease (HR 2.633; 95% CI: 1.211–5.723; P = 0.015) were significant independent factors predicting the recurrence of atrial arrhythmia.

Conclusions: Termination of AF during catheter ablation is associated with a better clinical outcome in patients with LPAPF. (J Cardiovasc Electrophysiol, Vol. 23, pp. 1051-1058, October 2012)

atrial tachycardia, catheter ablation, complex fractionated atrial electrograms, left atrial flutter, persistent atrial fibrillation, pulmonary vein isolation
Termination of Atrial Fibrillation During Catheter Ablation Predicts Better Outcome

Termination of AF or AT during ablation is of great value in patients with LPAF.

Figure 1. Acute procedural results. Thirty-three of 140 patients (23.6%) achieved SR directly from AF. Eighty-two patients (58.6%) converted to AT. Of these, 62 patients (44.3%) converted to SR with further ablation, whereas the remaining 20 (14.2%) required cardioversion to achieve SR. In 25 patients (17.9%), AF remained during ablation, without converting to AT or SR.

AF = atrial fibrillation; AT = atrial tachycardia; SR = sinus rhythm.

Figure 2. There was a statistically significant difference in the recurrence rate in patients with AF termination during ablation and those without (45.3% [43/95] vs 68.9% [24/35]; P = 0.009). However, there was no significant difference in the recurrence rate between patients that did and did not convert to AT within each group (P = NS for both).

AF = atrial fibrillation; AT = atrial tachycardia.
The incidence of post-ablation ATs occurring during and after catheter ablation of AF varies significantly ranging from 4 up to 50%.

- Type and extent of the index ablation strategy,
- LA volume or diameter,
- Completeness of lesion lines.

- Carlo Pappone, JAFIB, 2012
Mechanisms of post-ablation ATs

- Macro-reentry
- Focal AT or Micro-reentry
- Macro-reentrant AT
- Micro-reentrant AT
- Focal AT
- PV Tachycardia
Mechanisms of AT

- **Macro-reentrant AT**
  - Most common (75~90%)
  - Reentry around a large central obstacle
  - Long P-wave duration & short diastolic interval
  - Well matched post pacing interval at least 2 opposite sites by entrainment mapping
  - Common circuit is LA anterior wall, PMI, LA Roof, Lt septum, Peri-pulmonary veins.
Mechanisms of AT

- **Micro-reentrant AT**
  - Around 10%
  - Reentry circuit is a small area and does not have a central obstacle
  - Short P-wave duration & long diastolic interval
  - Low amplitude of P-wave
  - Long duration of fractionated electrograms at the critical site
  - Common localized reentry circuit is LAA, LA Anterior wall, Lt. septum, PMI
P-wave duration of Macro vs. Micro-reentrant AT

Heart Rhythm 2013;10:469–476
Fractionated Electrogram at ABL site
Mechanisms of AT

- **Focal Tachycardia**
  - Rhythmic atrial activation in a small area with centrifugal activation from a point source.
  - Often tends to have cycle length variability
  - Inconsistent or variable responses after overdrive pacing
  - Originated from Atrial or Venous tissue (SVC, CS, Septum, Crista Terminalis)
Mechanisms of AT

- **PV tachycardia**
  - AT originates from incomplete lines of ablation and the focal mechanism of the AT is predominantly related to the reconnection of the conduction from PV to the LA.
  - Tachycardia activates the LA through a recovered conduction gap with 1-to-1 or Wenckebach conduction after the PV isolation.
Mapping of AT

- Activation sequence guided mapping
  - Activation sequence, TCL variability, Unipolar recording, Mid diastolic or fractionated potential

- Entrainment mapping
  - Response to overdrive pacing, Analysis of post pacing interval

- 3-d Electroanatomical mapping
  - Activation, Voltage
Activation sequence guided mapping

- Catheter position
  - 10 poles catheter
    : HRA to High septum
  - 20 poles catheter
    : CS to Lateral RA
Summary

LA lateral

LA lateral + CTI block
Summary

LA roof

LA septum

\[ \text{HRA}\_1 \times 10 \]
\[ \text{HRA}\_7.8 \]
\[ \text{HRA}\_4.5.6 \]
\[ \text{HRA}\_1.2 \]
\[ \text{HRA}\_9.20 \]
\[ \text{HRA}\_14.16 \]
\[ \text{HRA}\_16.11 \]
\[ \text{HRA}\_2.12 \]
\[ \text{HRA}\_0.12 \]
\[ \text{HRA}\_7.8 \]
\[ \text{HRA}\_2.4 \]
\[ \text{HRA}\_1.2 \]

\[ \text{HRA}\_1 \times 10 \]
\[ \text{HRA}\_7.8 \]
\[ \text{HRA}\_4.5.6 \]
\[ \text{HRA}\_1.2 \]
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\[ \text{HRA}\_2.12 \]
\[ \text{HRA}\_0.12 \]
\[ \text{HRA}\_7.8 \]
\[ \text{HRA}\_2.4 \]
\[ \text{HRA}\_1.2 \]

\( \text{ms} \)

\( = \text{median} \)
LA roof

CTI block(-)

CTI block(+)

HRA 9,10
HRA 7,8
HRA 5,6
HRA 3,4
HRA 1,2
H 19,20
H 17,18
H 15,16
H 13,14
H 11,12
H 9,10
H 7,8
H 5,6
H 3,4
H 1,2
LA septum

CTI block(-)

CTI block(+)
Activation sequence guided mapping

- Assessment of RA and CS activation patterns at a glance could facilitate mapping of ATs developed after AF ablation.

- This analysis does not replace detailed mapping of these ATs. However, it suggests a starting point and may help facilitate rapid identification of regions of interest.
Case #3

Baseline AT-TCL 345ms
Entrainment mapping

- CS ds ENT(+)  
- High septum ENT(+)  
- LA Ant. Roof ENT(+)  

HRA 9.10  
HRA 1.2  
H 19.20  
H 11.12  
H 9.10  
H 1.2  
HIS d  
HIS m  
HIS p
Split potential at Ant. Roof
Split potential at Ant. Roof
During LA Ant. Roof ABL - AT termination
LAT map

Macro vs. Focal AT

Earliest activation
AT after PVI+CTI+LA CFAE ablation
AT-TCL 260ms
LAT map
Lateral Ridge potential
ENT(+) Ridge
During ablation
LAT map

LAT map#1

 Earliest activation

LAT map#2

 Preferential conduction
Baseline
AT after PVI+LA CFAE
AT TCL 230 ms
AT termination

ABL catheter
AT termination during CFAE area ABL
AF converted to AT
AT termination
The areas of **CFAE** and their **border zones** were frequently associated with termination of ATs developed after AF ablation.
Baseline APC

Case#6
Spontaneous AT induction
LSPV AF during AT
AT termination during LSPV ABL
AF sustained inside LSPV
AF termination inside LSPV
PV Potentials

Case#7

LSPV PVP(-)  LIPV PVP(-)  RSPV PVP(-)  RIPV PVP(-)
AT induction after Isoproterenol IV
AT induction after Isoproterenol IV
Procedure summary

• 1\textsuperscript{st} procedure
  - Circumferential antral ablation with electrical isolation of 4 PVs including left carina, Roof line, CTI Block

• 2\textsuperscript{nd} procedure
  - PV potential reconnected all PVs,
  - Circumferential antral ablation with electrical isolation of PVs,
  - Multiple AT ablation(Lt septum, PMI, LA Roof)
3rd Ablation procedure

- Baseline AT
- No PV potential at all PVs
Baseline AT-TCL 360ms
PV Potentials

LSPV PVP

LIPV PVP

RSPV PVP

RIPV PVP
Entrainment Mapping

LAA base

PMI

PPI 360ms

LA Ant wall
ABL site – LA Appendage Base
During LA Appendage base ABL
ABL Site – LA Appendage Base

RAO 35°  

RAO 35°
Post ABL LA Appendage
Inducibility Test
Arrhythmogenic role of LAA


Left atrial appendage (LAA) is implicated in maintenance of atrial fibrillation (AF) and atrial tachycardia (AT) associated with persistent AF (PsAF) ablation.

- Heart Rhythm 2011;8:1853–1861
Figure 5  Mapping and ablation of localized reentry from the LAA. A: A long fractionated signal can be seen on bipolar C11-12, representing >70% of the tachycardia CL. The ablation catheter was then moved to this area (B), and ablation terminated the tachycardia within few seconds (C).
Left Atrial Appendage Potentials

AT - Split Double Potential
Summary

- Activation sequence guided Mapping
- Entrainment Mapping
- 3-D Electroanatomical Mapping
- Previous ablation region and presence of significant potentials
- Local activity as arrhythmogenic source
  - LA Appendage, Lateral Ridge and Septum
Conclusion

- Mapping and ablation of ATs has become the final frontier in the process of AF ablation and makes the difference between clinical success and failure.
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