TYPICAL AND ATYPICAL ATRIAL FLUTTER
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12th ASIA PACIFIC HEART RHYTHM SOCIETY SCIENTIFIC SESSION
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• 57y/o man long persistent AF 2 years
• not much symptoms, but really wants SR
• CHA2DS2 VASc=0
• LAA thrombus
• Dabigatran for 3 months
55 y/o man

- Post CFAE AF RFA with recurrent AT
RA propagation
LA propagation
CS Propagation
3 Map All Together
FAT vs. MAT

- Blue shading shows the portion of the tachycardia cycle covered by the activation; <50% in focal atrial tachycardia and 100% in atrial flutter.

FAT vs. MAT

RIGHT ATRIUM
Entrainment mapping for rapid distinction of left and right atrial tachycardias

Miyazaki H. Heart Rhythm 2006;3:516–523
Typical AFL

Reverse Typical AFL

AFL conduction through CT

Macro-reentrant AT of the RA

Macroreentrant AT with a nonsurgical low-voltage unexcitable area

Scar macroreentrant AT without including the SVC

Macroreentrant AT with two scars including SVC

Macroreentrant AT around septal patch

García-Cosío F; Pastor Fuentes A; Núñez Angulo A. Revista Española de Cardiología. 65(4):363–75, 2012 Apr
TV-IVC Isthmus Dependent Atrial Flutter
Typical AFL vs. Atypical AFL

Activation of Typical Atrial Flutter

- Craniocaudal in the anterior wall
- Caudocranial in the septum
- Line of functional block inscribing double EGMs in the posterolateral wall extending cranially from the IVC
- Fragmented and/or double EGMs were recorded from low or mid posteroseptal
- Slow conduction in the low posteroseptal area

Cosio FG: Circulation 89(5). May 194. 2117–
Induction of CCW Flutter

Lin JL. Heart 1999;81:73-81
Induction of CW Flutter

Lin JL. Heart 1999;81:73-81
End point of Atrial flutter ablation

- Initial reports targeting mid isthmus, exit site of the isthmus has high success rate
- Using AFL termination and inability to induce as an endpoint, 10-44% recurrence during follow up
- Bidirectional isthmus conduction block significantly reduced the recurrence rate
Identification of the isthmus conduction block

- Conduction time
- Activation sequence around the TV annulus
- Negative initial polarity of EGMs recorded just lateral to the ablation line during CS pacing
- DPs along the entire ablation line
- Positive Unipolar EGM
- Bipolar EGM polarity
- At baseline and on isoproterenol at 2mcg/min
# Conduction Time

<table>
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<tr>
<th></th>
<th>Preablation 20 Patients</th>
<th>P</th>
<th>Postablation 20 Patients</th>
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<tbody>
<tr>
<td><strong>Low lateral RA pacing</strong></td>
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<tr>
<td>S-His</td>
<td>108±19</td>
<td>NS</td>
<td>112±19</td>
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<tr>
<td>S-PCS</td>
<td>101±19</td>
<td>.0001</td>
<td>141±18*</td>
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<td>S-Low Sept</td>
<td>79±20</td>
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<td>134±31*</td>
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<td>His to PCS</td>
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<td>29±18</td>
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<td><strong>PCS pacing</strong></td>
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<tr>
<td>S-High Lat</td>
<td>119±23</td>
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<td>High-to-Low Lat</td>
<td>-14±15</td>
<td>.0001</td>
<td>24±17</td>
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Abbreviations as in Table 1. Conduction times are measured on basic cycle lengths of 600 ms.

*After exclusion from the data of the three patients with no or incomplete modification in “anterograde” conduction and of three patients with modification occurring at a cycle length shorter than 600 ms, conduction time becomes 144±19 ms to PCS and 147±19 ms to lower septum, without change in statistical results.

†After exclusion of the patient with no modification in “retrograde” conduction and of five patients with modification occurring at critical cycle length, conduction time to low lateral RA becomes 143±17 ms.
Activation sequence during CS pacing

Poty H. Circulation 94(12) 1996. 3204-13

- Baseline
- Incomplete CW block
- Complete CW block

Using PCS- H1-2>160ms all has complete block, but only 55% of complete block has conduction time 160 ms
Activation sequence

LRA pacing

Proximal CS pacing

Poty H. Circulation 94(12) 1996. 3204-13
Activation Sequence and Double Potential

Poty H. Circulation 94(12) 1996. 3204-13
Double potentials

<table>
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<tr>
<th>criteria</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV</th>
<th>NPV</th>
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<td>DP1-2≥90ms+negative DP2</td>
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<tr>
<td>DP1-2≥90ms+isoelectric interval+negative DP2</td>
<td>77</td>
<td>100</td>
<td>100</td>
<td>78</td>
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</tbody>
</table>

Tada, H. JACC 2001;38:750
High density mapping of activation through an incomplete ablation line

- Conduction velocity as low as 0.08 could sustained AFL

Shah D. Circulation 1999;99:211
Unipolar EGMs after ablation of AFL
Approach to typical AFL ablation
Anatomy for TV–IVC Isthmus Ablation

- The cavotricuspid isthmus is not a flat structure
Anatomy for TV–IVC Isthmus Ablation

- difficulty with ablation when a prominent sub–Eustachian pouch
Anatomy for TV–IVC Isthmus Ablation

- difficulty with ablation with the pectinates encroach onto the cavotricuspid isthmus and can be found medial to the crista terminalis as well
Anatomy for TV–IVC Isthmus Ablation

- On the “hills” of the pectinates the thickness of the myocardium makes transmural ablation lesion creation difficult.

- Whereas in the “valley” the catheter is wedged between two pectinates and energy delivery is limited by impedance rise and increased local tissue heating.
Anatomy for TV–IVC Isthmus Ablation

- Problem with obtaining the desired catheter position and contact when a prominent Eustachian ridge is present.
Isthmus dependent atrial flutter

- Length of the cavo-tricuspid isthmus: shorter ‘central isthmus’

- Endocardial geometry of the isthmus: deeper pouches (sub-Thebesian recess)

- Obstacles such as a large Eustachian valve/ridge

- Variable content of myocardial and fibro-fatty tissues at the ablation zone

- Proximity of the AV nodal artery and right coronary artery

Prophylactic pulmonary vein isolation during isthmus ablation for atrial flutter: The PReVENT AF Study I

- N=55 AFL without AF
- 25 randomised to have PVI
- More patients in the isthmus ablation–only group experienced new–onset AF during follow–up (52% vs 12%; P=.003)
- 1 year AF burden CTI only vs. combine (8.3% vs 4.0%; P=.034)
- 8 (32%) patients subsequently underwent another ablation for AF

Steinberg JS. Heart Rhythm 2014;11:1567–1572
LEFT ATRIUM
Macro-reentrant Tachycardia Mechanisms in the Left Atrium

LA anterior view

LA posterior view

MV
Atrial fibrillation and left atrial flutter

- Variant anatomy of the PVs: length of the common pulmonary trunk–PVs myocardial connections (some epicardially located)

- Endocardial ridges: the left atrial ridge and the interpulmonary isthmus (PV carina)

- Extra-appendicular pectinate muscles (mitral isthmus and vestibule)

- Cooling effect by the intramyocardial atrial arteries

- Autonomic nervous system on the epicardial surface of the LA wall

- Fibrous tissue around the mitral annulus

- Proximity with phrenic nerves, oesophagus, vagus nerve and left circumflex artery

A Deductive Mapping Strategy for Atrial Tachycardia Following Atrial Fibrillation Ablation

Three Deductive Steps

- 128 consecutive patients presenting 246 AT in the context of prior AF ablation was investigated.

- Using activation and entrainment mapping and applying the consensus definition of AT

- deductive diagnostic approach based on up to three steps
  - (1) cycle length regularity
  - (2) search for macroreentry (i.e., involving >2 separate atrial segments)
  - (3) if macroreentry excluded, search for focal origin giving a centrifugal activation of the atria.

- A total of 238/246 (97%) sustained AT (mean cycle length [CL] 284 ± 87 ms) were successfully mapped (single AT, 51 pts; multiple AT, 77 pts) with a diagnostic time time of 10 ± 8 min per tachycardia.
A Deductive Mapping Strategy for Atrial Tachycardia Following Atrial Fibrillation Ablation

- A total of 238/246 (97%) sustained AT (mean cycle length [CL] 284 ± 87 ms) were successfully mapped (single AT, 51 pts; multiple AT, 77 pts) with a diagnostic time time of 10 ± 8 min per tachycardia.

- Of the latter, only 34 focal AT originated from a discrete point site fulfilling the consensus criteria, while a distinct mechanism, localized reentry (AT that was neither macro reentry nor focal), was identified in 95.

- Localized reentry was defined by
  - (1) electrograms covering ≥75% of the cycle length of AT within an area covering a single or 2 contiguous segments,
  - (2) postpacing interval (PPI) < 30 ms at the site,
  - (3) an identifiable zone of slow conduction, and
  - (4) centrifugal activation of the atrium from the area.
A Deductive Mapping Strategy for Atrial Tachycardia Following Atrial Fibrillation Ablation

• The number of potential macroreentry circuits is in fact limited.

• perimitral and roof–dependent (around the right or left PVs). & peri TV

• To minimize the risk to transform or interrupt AT, entrainment maneuvers were guided by the initial activation mapping and were only performed in two opposite segments
  • from septal and mitral isthmus sites for perimitral
  • from anterior and posterior wall for roof–dependent macroreentry

• to confirm the diagnosis. In cases of postpacing interval (PPI) exceeding the CL by no more than 30 ms in two opposite segments, the only possibility was macroreentry.

• PPI exceeding the CL by more than 30 ms in the previously mentioned locations (two opposite atrial segments), a left atrial macroreentry was ruled out.
A Deductive Mapping Strategy for Atrial Tachycardia Following Atrial Fibrillation Ablation

A Deductive Mapping Strategy for AT Following AFRFA: Localized reentry
Linear AF Ablation

Hocini M. Circulation 2005;112:3688-96
Linear ablation
Technique and Results of Linear Ablation at the Mitral Isthmus

- n=100 (13 women; age 55 ± 10 years) with drug-refractory, symptomatic paroxysmal AF underwent PVI and linear ablation of the TV–IVC isthmus and the mitral isthmus (lateral mitral annulus to the left inferior PV).

- 1 year after the last procedure, 87 patients with mitral isthmus ablation and 69 without (P = 0.002) were arrhythmia free without antiarrhythmic drugs, mitral isthmus ablation being the only factor associated with long-term success (RR for AF recurrence, 0.2; CI, 0.1 to 0.4; P = 0.001).

Jaïs P. Circulation. 2004;110:2996-3002
The Importance of the Marshall Bundle Epicardial Connections
Schematic diagram of the cross section along the mitral isthmus from the mitral valve annulus to the left inferior pulmonary vein

- Complications
  - cardiac tamponade
  - circumflex artery damage
  - atrio–esophageal fistula

Wong KCK. Indian Pacing and Electrophysiology Journal (ISSN 0972-6292), 12 (4): 152-170 (2012)
Alternative Isthmus

- septal/medial left atrial isthmus
  - longer isthmus
  - greater percentage of ridges
  - myocardial thickness increases at a more medial mitral isthmus
- anterior line
  - very effective in terminating perimitral flutters (>95%)
  - bi-directional block was only achieved in 86% of cases.
  - Inadvertent isolation of the LAA
Comparison of voltage map–guided left atrial anterior wall ablation versus left lateral mitral isthmus ablation in patients with persistent atrial fibrillation

- n= 29 patients with persistent AF and determined the area of low voltage.

- In the multicenter prospective study, clinical outcomes of LAAW (n = 100) and LLMI ablations (n = 100) were compared in patients with persistent AF (79.4% male, 59.4 ± 10.6 years)

- The low-voltage area consistently existed on LAAW and had a correlation with the LA-aorta contact area (R = 0.921, P <.0001).

- Mean voltage of LAAW was significantly lower than that of LLMI (P <.0001). (2)

- The length of LAAW ablation (37.9 ± 3.4 mm vs 26.6 ± 3.2 mm, P <.0001) was longer

- achievement of bidirectional block was higher (68.0% vs 32.0%, P = .0001) than in LLMI ablation.

Pak HN. Heart Rhythm. 2011 Feb;8(2):199-206
Critical Isthmus Block Can Prevent Atrial Tachycardia Recurrence

- n=28 patients with LAMRT, including 4 patients with ablated typical atrial flutter (AFL), underwent electroanatomic mapping of the LA
- LA maps were performed during LAMRT in 26 patients and during sinus rhythm in 2 patients
- Of 25 patients with identified isthmuses, 20 patients were without atrial arrhythmia and 5 had only atrial fibrillation during a median follow-up of 14 months.
- the reentry circuit of LAMRT can be identified in 89% patients. It presents as dual loop in 74% tachycardias and single loop in 26% tachycardias, with a protected isthmus between 2 anatomic barriers.

High-Resolution Mapping of Scar-Related Atrial Arrhythmias Using Smaller Electrodes with Closer Interelectrode Spacing

- LA bipolar voltage maps (0.10–0.50mV) in the PA view recorded with a standard linear catheter (panel A) and a multielectrode catheter (Panel B) in a patient with structurally normal left atria.

- In contrast, in a patient with scar-related atrial tachycardia, the bipolar voltage amplitude measured with the linear catheter (Panel C) was significantly lower than the one measured with the multielectrode (Panel D)

Elad Anter, DOI: 10.1161/CIRCEP.114.002737
High-Resolution Mapping of Scar-Related Atrial Arrhythmias Using Smaller Electrodes with Closer Interelectrode Spacing

- In a patient with macroreentrant left atrial flutter, the multielectrode linear catheter were placed at a similar position at the area of “early meet late”. The linear catheter was positioned in a perpendicular orientation to the tissue with its distal electrode applying 9gr of tissue contact force. The multielectrode catheter was positioned parallel to the tissue (panel A). While the linear catheter recorded low, far-field, signal with amplitude of 0.12 mV. The multielectrode recorded EGM range of 0.18–0.28mV that allowed both local time annotation and pacing with capture (Panel B)

Elad Anter, DOI: 10.1161/CIRCEP.114.002737
A Prospective Study of Ripple Mapping in Atrial Tachycardias

- RM-guided ablation interrupted the tachycardia in 19 of 20 cases with the 1st ablation set.
Thank You Very Much

For Your Attention

The End
Thank you very much for your attention

See you in Bangkok
October 24-27, 2019

THE END