How to Distinguish Focal Atrial Tachycardia from Small Circuits and Reentry

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IHU LIRYC ANR-10-IAHU-04
Equipex MUSIC imaging platform ANR-11-EQPX-0030
Eutraf HEALTH-F2-2010-261057

HRS May 2014
Conflict of interest

• Consulting fees/honoraria (modest):
  – Biosense Webster
  – Bard
  – Philips
  – ST Jude Medical

• Stock holder Cardio Insight
Surgery for congenital Heart Disease is arrhythmogenic: incomplete linear atrial lesions!!

- **ASD, VSD**: Atrial incisions
- **Mustard, Senning**: Atrial incisions
  (Switch arterial? Canulations!)
- **Fallot**: canulations
- **Fontan**: Atrial incisions
- **Any Heart surgery with atrial incisions**
Surgery for ASD and Atrial Arrhythmias

• Vernant (1980) 9% (200 pts)

• Bink-Boelkens (1983) 18% (204 pts)

• Gatzoulis (1999) 213 pts 19% before, 13% after (AF or Flutter)

• Berger (1999) 211 pts 10% before and after! (AF or flutter)

• Mantovan, Europace 2003 (5:133) 9% before and 12% after
Fontan, Mustard and Senning are more complex substrate to map and ablate

SMALL RA REENTRY FOLLOWING TRICUSPID SURGERY

Dominant loop
Passive activation
Figure 1. Ideograms to illustrate the concept of IART circuit. a., b. and c. illustrate the wave morphology and the role of a central obstacle. IART may be mediated by a short latency current to the central obstacle as well as by additional delay to establish an effective stimulus to induce reentrant activity. Pacing from within a protected corridor or outside the circuit may result in a short latency and orthodromic activation; and c, between stimuli and the protected corridor, pacing in our model may result in a short latency between stimulations. Triedman (Circ 2001)
Ablation for Persistent/Permanent AF using a combination of strategies

1. PVI
2. Defragmentation
3. Linear lesions

84% AF termination

13% SR
71% AT

JCE 2005
Atrial Flutter After AF Ablation - Incidence

- < 5% after PVI (Oral Circ 01, Pace 03, Gerstenfeld Circ 04)
- 18% after CPVA (Karch Circ 05)
- 10 to 20% persistent AF Ablation (Oral, Circ 07; Matsuo HR 07)
- Up to 50% acutely after stepwise approach for long standing AF (Haissaguerre JCE 05, Jais JCE 09)
Atrial Flutter After AF Ablation - Mechanisms

- Dipen Shah, JCE 06
- 15 pts 15 AT after AF ablation
- 11 localized Reentry
- 4 macro Reentry
Narrow, Slow-Conducting Isthmus Dependent Left Atrial Reentry Developing After Ablation for Atrial Fibrillation: ECG Characterization and …

Figure 1. Examples of narrow isthmus dependent left atrial tachycardia (LAT) ECGs with isoelectric intervals on all 12 leads.

Shah et al, JCE 2006 17; 508-515
Small reentry:
Circuit limited to 1 (or 2 adjacent) LA segments:
PVs, Ant, post, sept, lateral (+ LAA)
EP criteria for reentry
PPI-TCL > 100 ms is color coded in purple

Esato et al, HR 2009;6:349 –358

78% macroreentry
22% focal
Focal Atrial Tachycardia vs Reentrant

• Dynamic behavior:
  – Frequent initiations
  – Variable cycle length

• Activation spread from the earliest site (origin) to the rest of the cavity (passive activation)
- Centrifugal tachycardia
- Focal
- Localized reentry
- Macroreentrant tachycardia
Repeating entrainment checking for consistency

1\textsuperscript{st} PPI mapping; ATCL250ms, PPI +0ms
This results suggest focal AT
Three Deductive Steps

STEP 1 CL Irregularity

$> 15\%$

Yes

No

STEP 2 Diagnose or exclude macroreentry

Activation and PPI compatible with:
- Perimital
- Roof dependant
- Pericuspid

Yes

No

STEP 3 Locate centrifugal arrhythmia

Linear ablation

Activation and PPI Focal ablation
1. **Centrifugal activation**
2. > 75% of CL is recorded
3. PPI increases with increasing distance from the source
4. Good PPI in only one segment

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**Macreentrant tachycardia**
1. Circuit involving 3 or more segments
2. > 75% of the CL is mapped along the circuit
3. Good PPI in 2 opposite segments

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**Localized reentry**
1. Centrifugal activation
2. > 75% of CL is recorded
3. PPI increases with increasing distance from the source
4. Good PPI in 2 opposite segments

---

**Focal**
1. Centrifugal activation
2. < 75% of CL is recorded
3. PPI increases with increasing distance from the source
4. Good PPI in only one segment
A  
PPI Septal: TCL+ 136 ms

B  
PPI lateral: TCL+ 16 ms
PPI Anteroseptal LA: TCL + 40 ms
PPI: + 12 ms
PPI: + 20 ms
14 ms before CS ref
82 ms before CS ref
Focus superior to a complete Mitral isthmus line

Activation mapping only may be misleading!!!
Entrainment mapping only may be misleading !!!
Atrial Tach After AF Ablation – Are they always man made?

- Jaïs et al, JCE 06
- 275 pts 14 anterior LA AT after AF ablation
- localized Reentry
Boston AF Live Case: AT2 was successfully ablated at ant LA, the 3rd most active region according to phase mapping

- Persistent AF 3-4mths
- No CEE
- No structural heart disease
- LAA CL 145
238 ATs were identified in 128 pts: 1.8±1.2 per pt

**Macro-reentry:** 109 (46%):  
- @ Peri Mitral 26%  
- @ Cavo tricuspid isthmus 7%  
- @ Peri R veins 13%

**Non macro reentrant:** 129 (54%)  
- focal AT, n=34;  
- Localized Reentry, n=95

Mean diagnostic time per tachycardia: 10±5 min

128 pts: 97% mapped and ablated conventionally
## Results

<table>
<thead>
<tr>
<th></th>
<th>Focal (F)</th>
<th>Localized R</th>
<th>Macro reentry (MR)</th>
<th>P Focal / localized</th>
<th>P Localized / MR</th>
<th>P F / MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>n =</td>
<td>34</td>
<td>95</td>
<td>109</td>
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<tr>
<td>Cycle Length</td>
<td>341 ± 115</td>
<td>278 ± 85</td>
<td>269 ± 67</td>
<td>&lt; 0,001</td>
<td>NS</td>
<td>&lt; 0,001</td>
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<tr>
<td>Cycle length Irregularity (%)</td>
<td>9,6 ± 9,4</td>
<td>5 ± 3,8</td>
<td>3,8 ± 3,2</td>
<td>&lt; 0,001</td>
<td>0,02</td>
<td>&lt; 0,001</td>
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<tr>
<td>Diagnostic time (min)</td>
<td>16 ± 12</td>
<td>10 ± 5</td>
<td>7 ± 6</td>
<td>0,005</td>
<td>0,001</td>
<td>0,005</td>
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<tr>
<td>Duration EGM Ablation site (min)</td>
<td>76 ± 31</td>
<td>256 ± 74</td>
<td></td>
<td>&lt; 0,001</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>PPI – TCL (ms)</td>
<td>10 ± 8</td>
<td>8 ± 13</td>
<td>6 ± 9</td>
<td>NS</td>
<td>NS</td>
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</tbody>
</table>
Conclusion

• Combining Activation and Entrainment mapping is best

• The diagnosis can be made without mapping 3D system

• Localized reentries are always associated with very slow conduction and fractionated electrograms

• Good PPI in 2 opposite segments is always associated with macroreentry
Preferential distribution of localized reentry circuits
Conclusion

• Macroreentries are frequently observed after persistent AF ablation

• Centrifugal tachycardia involve focal and localized reentries, a newly described mechanism, possibly more frequent in the context of CAFE ablation?

• 3D mapping systems are effective but there are practical and cost effective alternatives
### Table IV.

Association between SR Restoration and Outcome of a Single Ablation

<table>
<thead>
<tr>
<th></th>
<th>Success</th>
<th>Failure</th>
<th>P Value</th>
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</thead>
<tbody>
<tr>
<td>L-L persistent AF</td>
<td>29/50 (58%)</td>
<td>9/50 (18%)</td>
<td>0.009</td>
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<tr>
<td>S-L persistent AF</td>
<td>18/22 (82%)</td>
<td>11/13 (85%)</td>
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<tr>
<td>Paroxysmal AF</td>
<td>38/39 (97%)</td>
<td>19/20 (95%)</td>
<td>1.0</td>
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</table>

**Comparison of the Modes and Ablation Sites in Patients with Restored SR**

<table>
<thead>
<tr>
<th></th>
<th>N=59 (Paroxysmal n=57)</th>
<th>N=35 (S-L Persistent n=29)</th>
<th>N=100 (L-L Persistent n=38)</th>
<th>P Value</th>
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</thead>
<tbody>
<tr>
<td>Via LAT</td>
<td>2 (4%)</td>
<td>15 (52%)</td>
<td>30 (79%)</td>
<td>&lt;0.001</td>
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<tr>
<td>PV ablation</td>
<td>53 (93%)</td>
<td>7 (24%)</td>
<td>3 (8%)</td>
<td>&lt;0.01</td>
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<tr>
<td>Sept-Ant-CS ablation</td>
<td>1 (2%)</td>
<td>13 (45%)</td>
<td>25 (66%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Atrial Flutter After AF Ablation - Mechanisms

- Dipen Shah, JCE 06
- 15 pts 15 AT after AF ablation
- 11 localized Reentry
- 4 macro Reentry
Atrial Flutter After AF Ablation - Mechanisms

- Esato/Hindricks, HR 09
- 26 pts 29 AT after AF ablation- carto- NavX
- 9 localized Reentry
- 20 macro Reentry
Atrial Flutter After AF Ablation - Mechanisms

- Zheng/Kadish, JCE 09
- 80 pts 146 AT after AF ablation in 200 pts
- 4 Focal- CL 225 ms
- 142 macro Reentry
- CL 205 ms
Atrial Flutter After AF Ablation - Mechanisms

- Satomi/Kuck, HR 08
- 45 pts/AT after PVI in 850 pts
- 8 localized Reentry CL 297 ms
A: mapping with the multipolar catheter

B: mapping with the RF catheter

RF dist

RF prox
• Left atrial tachycardia are frequently observed during AF ablation, particularly in persistent AF.

• 3 D mapping is time consuming and impractical especially after many hours of AF ablation and situations of multiple atrial tachycardia.

• We developed a diagnostic approach based on conventional mapping strategies.
Localized reentry: Spiral is covering all the ATCL
LA Dynamic Isochrone Sequence During AT
Atrial Flutter After AF Ablation - Mechanisms

- Jaïs et al, JCE 06
- 275 pts 14 anterior LA AT after AF ablation
- localized Reentry
LA activation during peri mitral flutter
Gerstenfeld et al, (Heart Rhythm 2007;4:1136–1143)
P wave morphology to localize the origin of the tachycardia:

Except after surgery
For congenital HD!

Kalman et al, (J Am Coll Cardiol 1998;31:451–9)

<table>
<thead>
<tr>
<th>Tachycardia Location</th>
<th>ECG Lead</th>
<th>I</th>
<th>aVL</th>
<th>V_1</th>
<th>II</th>
<th>III</th>
<th>aVF</th>
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<td><strong>Mid-CT</strong></td>
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<td><strong>Low CT</strong></td>
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Biph/iso = biphasic/isoelectric; CS = coronary sinus; CT = crista terminalis; ECG = electrocardiographic; RUPV = right upper pulmonary vein; TA = tricuspid annulus.
Electroanatomic Mapping of Entrained and Exit Zones in Patients With Repaired Congenital Heart Disease and Intra-Atrial Reentrant Tachycardia

Triedman et al, Circ 2001;103:2060-2065
Patient Population

• 128 patients, 238/246 atrial tachycardia successfully mapped (97%)
  – 109 male; 58 11 Years
  – 25/128 20% paroxysmal AF;
  – 80% persistent/permanent
  – SHD in 30%
    • Dilated: 18 (14%)
    • Hypertrophic: 9 (7%)
    • Ischemic: 5 (4%)
    • Valvular: 5 (4%)