When Do We Have to Consider Linear Lesion in Patients Without Macroeentry

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Disclosure

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- **Advisory board**: Boryung, Medtronic Inc.
~ Our Story ~

❖ 58/Female

❖ She presented for the evaluation of **persistent AF of unknown duration**. She noted that she had several episodes of intermittent palpitation for the last year and dyspnea on exertion developed recently which was getting worse.

❖ Echo (2015-12-16): EF 28%, LA 94.64ml, type III moderate MR
ECG of Tachycardia

Keimyung University Dongsan Medical Center
~ Our Story ~

- She had been treated with NOAC and beta blocker as a rate control strategy. After fully anticoagulated, amiodarone challenge was tried.
- Her rhythm converted to sinus rhythm, and LV function recovered to normal.
- Echo (2016-05-27): EF 65%, LA 117.07 ml, mild Mr.
- Follow up Holter monitor showed recurrent episodes of AF despite amiodarone.
Baseline Intracardiac EGM
RSPV isolation

[Diagram showing various leads including Lasso-20, Lasso-1, HRA-p, HRA-d, His-p, His-d, CS-p, and CS-d]
RIPV isolation

Lasso-20

Lasso-1
HRA-p
HRA-d
His-p
His-d
CS-p
CS-d
Abl-p
Abl-d
F
V
LSPV isolation
LIPV isolation

1 F

Abl-d
Abl-p

Lasso-20

Lasso-1
HRA-p

HRA-d
His-p

His-d
CS-p

CS-d
Biantral Ablation
Spontaneous AT/AF after adenosine injection
Internal Cardioversion

Line graph showing various medical tracings labeled as follows:

- HRA-p
- HRA-d
- His-p
- His-d
- CS-p
- CS-d

Each tracing is labeled with letters such as F, V1, etc., indicating different measurement points or leads.
Spontaneous AT/AF with the same activation
Internal Cardioversion
Spontaneous AT/AF with different activation
Multiple triggers with degenerating to AF immediately

What’s your option?
Maze Procedure

Dr. Cox and colleagues’ work

- Mapping the atria with 250 bipolar electrodes experimentally and 156 electrodes clinically during AF

- Characteristics of AF
  - Multiple large *constantly shifting macroreentrant circuit* in the atria
  - Macro-reentrant circuits often *remained in one location for only 200 ms*
  - Macro-reentrant *circuits were more than 5 to 6 cm in diameter in the LA* & much larger than that in the RA
Maze Procedure

Pattern & Principle of a Maze: One entrance, one exit, one true route between the two and multiple blind alleys
Cox Maze III

On Sep 25th, 1987
Cox Maze IV

- Left Appendage
- Right Appendage
- LAA Amputated
- SVC
- Left Atriotomy
- Mitral Annulus
- Coronary Sinus
- Circumflex Coronary Artery
- Tricuspid Annulus
- Right Coronary Artery
- Right Atriotomy
- IVC
- Cryoablation
- Surgical Incision
- Bipolar RF
The Cox-Maze Procedure for Lone Atrial Fibrillation
A Single-Center Experience Over 2 Decades

- 53.5±10.4 years; 78% male
- PAF (48%) vs. PeAF (52%)
- CM-III (112) vs. CMP IV (100): duration of perop AF – 6 years

**Follow-up:**
- Office visits at 3, 6, & 12 months and annually thereafter
- With the ECG, & 24-hour Holter monitoring or pacemaker interrogation was obtained in 95% (62/65) of patients, since 2006, when new follow-up guidelines were established
# The Cox-Maze Procedure for Lone Atrial Fibrillation

## A Single-Center Experience Over 2 Decades

<table>
<thead>
<tr>
<th>Variable</th>
<th>CMP III (n=112)</th>
<th>CMP IV (n=100)</th>
<th>CMP III+IV (N=212)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up, median (IQR), y</td>
<td>5.9 (2.5–7.8)</td>
<td>1.0 (0.74–1.9)</td>
<td>2.2 (0.9–6.2)</td>
</tr>
<tr>
<td>Freedom from AF*</td>
<td>96 (86–98)</td>
<td>90 (81–95)</td>
<td>93 (87–96)</td>
</tr>
<tr>
<td>Freedom from AF off antiarrhythmics*</td>
<td>83 (68–88)</td>
<td>82 (71–89)</td>
<td>82 (75–87)</td>
</tr>
<tr>
<td>Freedom from warfarin*</td>
<td>86 (75–92)</td>
<td>74 (62–83)</td>
<td>80 (72–86)</td>
</tr>
<tr>
<td>Late stroke (&gt;30 d), no. (%)</td>
<td>1 (0.8)</td>
<td>0</td>
<td>1 (0.4)</td>
</tr>
</tbody>
</table>

*Data are given as mean (95% CI).*
The Cox-Maze Procedure for Lone Atrial Fibrillation
A Single-Center Experience Over 2 Decades

Kaplan-Meier estimate for freedom from AF @ 10 years:
85% (95% CI, 70%–92%)
Conclusions—The **Cox-Maze Procedure**, although simplified and shortened by alternative energy sources, has excellent results, even with improved follow-up and stricter definition of failure.
### Perioperative variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>CMP III (n=112)</th>
<th>CMP IV (n=100)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time, median (IQR), min</td>
<td>163 (145–183)</td>
<td>129 (113–150)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CCT, mean (95% CI), min</td>
<td>90 (73.5–105)</td>
<td>39 (33.2–46.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>30-d Mortality</td>
<td>2 (2)</td>
<td>1 (1)</td>
<td>0.625</td>
</tr>
<tr>
<td>Early ATAs</td>
<td>38 (34)</td>
<td>40 (40)</td>
<td>0.732</td>
</tr>
<tr>
<td>Pacemaker implantation ≤90 d</td>
<td>9 (8)</td>
<td>7 (7)</td>
<td>0.776</td>
</tr>
<tr>
<td>Major complication rate</td>
<td>11 (10)</td>
<td>1 (1)</td>
<td>0.003</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>3 (3)</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>Early stroke ≤30 d</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>...</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2 (2)</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>Mediastinitis</td>
<td>1 (1)</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>4 (4)</td>
<td>0</td>
<td>...</td>
</tr>
</tbody>
</table>

Data are given as number (percentage) of each group unless otherwise indicated.

CPB indicates cardiopulmonary bypass; CCT, aortic cross-clamp time.
Start Linear ablation @ roof
Termination of AF while ablating @ roof
Roving catheter @ CS7,8 from LA
On & Off tachycardia while ablating MB
CV to restore sinus rhythm after MB ablation
Final Lesion Sets
Bidirectional block @ MI

Lasso-20

Abl-d
Abl-p

HRA-d
His-p
His-d
CS-p
CS-d

Lasso-1
HRA-p

F

1

√
Bidirectional block @ Roof

Lasso-20

Abl-d
Abl-p

HRA-d
HRA-p

His-d
His-p

CS-d
CS-p

Lasso-1

115
105

106
96
589 patients with PeAF: 18 months FU

**Open irrigated ablation catheter**: ~40W with ~ 30cc/min

To compare the ablation strategies with *Ensite NavX* System

Primary endpoint: freedom from recurrence of AF lasting longer than 30 seconds after a single ablation procedure

67 patients

263 patients

259 patients
Approaches to Catheter Ablation for Persistent Atrial Fibrillation

There were also *no significant differences* among the three groups for the primary end points.
Stand alone PVI vs. PVI with additional substrate modification as an index procedures in patients with PeAF & LSPeAF

- Prospective randomized single center study
- Stand-alone PVI vs. stepwise approach of PVI followed by CAFÉ & linear ablation
- 118 patients
- Primary end point: freedom from recurrence of any atrial tachyarrhythmia, outside a 90-day blanking period, at 12 months
Stand alone PVI vs. PVI with additional substrate modification as an index procedures in patients with PeAF & LSPeAF

- LA, RA, CS for up to 2 hours
- fractionated electrograms with $\geq 1$ continuous deflections of a prolonged atrial activation complex or atrial electrograms with a cycle length $<120$ ms over a period of at least 5 s
Stand alone PVI vs. PVI with additional substrate modification as an index procedures in patients with PeAF & LSPeAF

Freedom from recurrence of atrial tachyarrhythmias after a single procedure

P=0.86

Freedom from atrial tachyarrhythmia

Time (days)

61
57
61
57
48
43
40
35
34
32
0.0
0.2
0.4
0.6
0.8
1.0

PVI-only
Substrate-mod

54%
57%
Stand alone PVI vs. PVI with additional substrate modification as an index procedures in patients with PeAF & LSPeAF

Freedom from recurrence of atrial tachyarrhythmias after a multiple procedure

- PVI-only: 69%
- Substrate-mod.: 86%

P = 0.09

Fink T, et al. CIRCEP 2017;10:e005114
Conclusions — In patients with persistent and long-standing persistent atrial fibrillation, no significant difference was observed in 12-month freedom from atrial tachyarrhythmias between an index ablative approach of stand-alone PVI and a stepwise approach of PVI plus complex fractionated atrial electrogram and linear ablation.
120 patients with PeAF (2005~2009)
- Linear ablation only without CPVI
- Ablation using Ensite system (multiple electrode array)
  - Ω like lesion set: Lateral MI – LLR – Roof – anterior part of RPV – medial MI
  - Additional ablation to the GAP by noncontact mapping
  - CTI ablation
  - Conduction block was verified by noncontact mapping
  - Ablation: temperature-control, 4-mm irrigated-tip ablation catheter or 8-mm-tip ablation catheter
Long-Term Follow-Up of Pure Linear Ablation for Persistent Atrial Fibrillation Without Circumferential Pulmonary Vein Isolation

Median FU: 5.1 year after single procedure

During the 1st procedure  
\[ n = 120 \text{ pts} \]

62.5%  
AF terminated by ablation  
\[ n = 75 \text{ pts} \]

37.5%  
AF terminated by cardioversion  
\[ n = 45 \text{ pts} \]

End of follow-up

49.3%  
SR  
\[ n = 37 \text{ pts} \]

24.4%  
SR  
\[ n = 11 \text{ pts} \]

Recurrent ATa  
\[ n = 72 \text{ pts} \]

Persistent AF  
\[ n = 20 \text{ pts} \]

Paroxysmal ATa  
\[ n = 52 \text{ pts} \]
Long-Term Follow-Up of Pure Linear Ablation for Persistent Atrial Fibrillation Without Circumferential Pulmonary Vein Isolation

SR was maintained in 48 (40.0%) patients without AAA after a single procedure.

AF termination 24.4% No termination

P=0.007
Conclusion: *Linear catheter ablation without CPVI is effective for persistent AF*. Patients with AF terminated by ablation were associated with a better long-term outcome than those requiring cardioversion.
The impact of lesion tag size of 3D mapping systems to improve the clinical outcome in patients undergo contact-force guided ablation of atrial fibrillation: POSITIVE study
The impact of lesion tag size of 3D mapping systems to improve the clinical outcome in patients undergo contact-force guided ablation of atrial fibrillation: **POSITIVE** study

- ThermoCool® SMARTTOUCH® Catheter with Vistag™ module
- Multicenter, Randomized to size 2 or size 1 for the PeAF
- Biventricular ablation & linear ablation @ roof, MI, CTI

Unpublished data
The impact of lesion tag size of 3D mapping systems to improve the clinical outcome in patients undergo contact-force guided ablation of atrial fibrillation: POSITIVE study

Bidirectional block rate after single pass

- Roof: 80% (size 1), 80% (size 2)
- MI: 68% (size 1), 60% (size 2)
### Ablation strategies to be considered for use in conjunction with PVI

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>LOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>If a patient has a <em>history of typical AFL or typical AFL is induced</em> at the time of AF ablation, delivery of a CTI linear lesion is recommended</td>
<td>I</td>
<td>B-R</td>
</tr>
<tr>
<td>If linear ablation lesions are applied, operators should use mapping and pacing maneuvers to assess for line completeness</td>
<td>I</td>
<td>C-LD</td>
</tr>
<tr>
<td>If a reproducible <em>focal trigger</em> that initiates AF is identified outside the PV ostia at the time of an AF ablation procedure, ablation of the focal trigger should be considered</td>
<td>IIa</td>
<td>C-LD</td>
</tr>
<tr>
<td>When performing AF ablation with a force-sensing RF ablation catheter, a minimal <em>targeted contact force of 5 to 10 grams</em> is reasonable</td>
<td>IIa</td>
<td>C-LD</td>
</tr>
<tr>
<td><strong>Posterior wall isolation</strong> might be considered for <em>initial or repeat ablation of persistent or longstanding persistent AF</em></td>
<td>IIb</td>
<td>C-LD</td>
</tr>
</tbody>
</table>
## 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter & surgical ablation of AF

### Ablation strategies to be considered for use in conjunction with PVI

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<td>Administration of <strong>high-dose isoproterenol</strong> to screen for and then ablate non-PV triggers may be considered during initial or repeat AF ablation procedures in patients with paroxysmal, persistent, or long-standing persistent AF</td>
<td>IIb</td>
<td>C-LD</td>
</tr>
<tr>
<td><strong>DF-based ablation strategy</strong> is of unknown usefulness for AF ablation</td>
<td>IIb</td>
<td>C-LD</td>
</tr>
<tr>
<td>The usefulness of creating linear ablation lesions in the right or left atrium as an initial or repeat ablation strategy for persistent or long-standing persistent AF is <strong>not well established</strong></td>
<td>IIb</td>
<td>B-NR</td>
</tr>
<tr>
<td>The usefulness of linear ablation lesions in the absence of macroreentrant atrial flutter is <strong>not well established</strong></td>
<td>IIb</td>
<td>C-LD</td>
</tr>
<tr>
<td>The usefulness of mapping and ablation of areas of abnormal myocardial tissue identified with voltage mapping or MRI as an initial or repeat ablation strategy for persistent or longstanding persistent AF is <strong>not well established</strong></td>
<td>IIb</td>
<td>B-R</td>
</tr>
</tbody>
</table>
Pulmonary vein isolation is a reasonable and often sufficiently effective ablation strategy in patients undergoing a first catheter ablation of persistent AF.

Additional ablation targets should in our view not routinely be pursued in the first procedure.
Summary

✓ Linear lesion sets by **Cox-Maze III or IV** seem to work well

✓ Linear lesions by the catheter ablation can be affected by several factors such as *laboratory circumstances* (general anesthesia, jet ventilator, etc.), *catheter technology*, and *energy sources* etc.

✓ Inability to make constant transmural linear lesion with current point-by-point technique & energy modality may be the leading cause of lack of efficacy

✓ In case of multiple unmappable triggers with a certain amount of substrate, linear ablation may be the treatment option
Thank You for Your Attention!

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