Hybrid Approach of AF Treatment: Thoracoscopic and RF catheter ablation

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Atrial fibrillation is the most common cardiac arrhythmia requiring medical therapy.

Rhythm Control
- **Antiarrhythmic drugs (AADs)**
  - First-line therapy
  - Approximately double the rate of sinus rhythm compared with placebo
  - Various side effects
  - AF recurrence rate within 6 to 12 months reaches 50% with most AAD

*Lancet* 2012;380:238-146
*N Engl J med* 2007;357:987-999
Recurrence of Persistent Atrial Fibrillation after DC cardioversion
AF tends to progress over time. **AF begets AF.**

Progression of PAF to peAF: 8.6%/yr (Canadian Registry of AF)

Duration of AF

Relative Importance

- **Modulating factors**
  - APBs
  - Tachycardia
  - Bradycardia
  - Others

- **Reentrant Circuits**
  - Trigger/Initiation
  - Substrate/maintenance
• Rhythm Control
  – Radiofrequency Catheter Ablation (RFCA)
    ✓ Established therapeutic option, particularly in patients with symptomatic AF.
      Who have failure of or intolerance to AAD therapy
    ✓ Randomized trials showed superior clinical outcome compared to AAD therapy.
    ✓ RFCA is increasingly performed as a therapy for AF, but the high rate of arrhythmia recurrence is a limitation of the procedure.
    ✓ Also catheter ablation for persistent AF is more challenging compared to paroxysmal AF.

Circulation 2008;118:2498-2505
JAMA 2005;293:2634-2640
Heart Rhythm 2010;7:835-846
Curr Opin Cardiol 2010;25:1-7
AF ablation:
to eliminate AF triggers
to modify the susceptible substrates

Radiofrequency lesions
Schematic of Common Lesion Sets in AF Ablation
Scheme of stepwise ablation for chronic AF

Step 1. Extensive Encircling PV isolation
Step 2. LA roof line, LA bottom line
Step 3. LA septum anterior & posterior line
Step 4. Mitral annulus / isthmus line
Step 5. LAA base line
Step 6. RA septum / CT / RAA ablation
Step 7. SVC isolation, CTI ablation

Iesaka Y. J of Cardiology 2011;58:99
AF Recurrence after PVI±CTI

Log-rank
$P = 0.016$

Freedom from AF

Days

Paroxysmal AF
Persistent AF

SMC AF RFCA registry


**Surgical ablation of AF**

- **Cox maze**: cut-and-sew
- **Minimally invasive procedures**: alternative energy source to replace cut-and-sew procedure with similar lesion sets

<table>
<thead>
<tr>
<th></th>
<th>Cox maze</th>
<th>TTA</th>
</tr>
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<tbody>
<tr>
<td><strong>Energy source</strong></td>
<td>Cut-and-sew: more definite lesion</td>
<td>Bipolar RF energy: concern about recurrent ATa due to incomplete conduction block</td>
</tr>
<tr>
<td><strong>Lesion set</strong></td>
<td>RA incisional scar: recurrent ATa related to RA incision line</td>
<td>Similar with Cox maze, but mitral isthmus line (-)</td>
</tr>
</tbody>
</table>
Thoracoscopic ablation of AF
Thoracoscopic AF ablation

- Both pulmonary vein ablation
- Superior and inferior line ablation
- Ablation of ganglionated plexus
- Division of Marshall vein
- LAA exision
- SVC isolation ($\pm$)
- Intraoperative test
Hybrid Treatment

- **Antiarrhythmic drugs**

- **RFCA** *(radiofrequency catheter ablation): endocardial*

- **TTA** *(totally thoracoscopic ablation): epicardial*
Catheter ablation vs EP guided thoracoscopic surgical ablation in long-standing persistent AF: The CASA-AF Study

- To compare EP guided thoracoscopic surgical ablation with percutaneous RFCA as the first-line strategy in the treatment of LSPAF.
- 51 patients with de novo symptomatic LSPAF were recruited.
- 26 patients underwent EP guided thoracoscopic SA.
- The primary end point was single-procedure freedom from AF and AT lasting >30 seconds without antiarrhythmic drugs at 12 months.

Catheter ablation vs EP guided thoracoscopic surgical ablation in long-standing persistent AF: The CASA-AF Study

2-step conduction testing for the surgical ablation lesion set
Catheter ablation vs EP guided thoracoscopic surgical ablation in long-standing persistent AF: The CASA-AF Study

Single-procedure freedom from AF/AT at 12 mo

After a 3-month blanking period

Catheter ablation vs EP guided thoracoscopic surgical ablation in long-standing persistent AF: The CASA-AF Study

<table>
<thead>
<tr>
<th>Major Complications</th>
<th>Catheter ablation group (N = 25), n</th>
<th>Surgical ablation group (N = 26), n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Pulmonary vein stenosis</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Phrenic nerve palsy</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Vascular access complications</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acute pulmonary edema</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Cardiac tamponade</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sternotomy for complication</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stroke</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Death</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>
Hybrid vs Catheter Ablation in persistent and longstanding persistent AF

Key question
Is hybrid or catheter ablation more effective and safer in the treatment of persistent atrial fibrillation?

Key finding
More sinus rhythm (70.7% vs 49.9%, P<0.001) and slightly more complications after hybrid ablation were noted.

Take-home message
Hybrid ablation is more effective than catheter ablation in maintaining sinus rhythm but is associated with a slightly higher complication rate.
Hybrid approach in SMC

1. Early staged EPS at 5-7 days after TTA
   • Confirmation of PVI lines
   • Additional CTI ablation
   median 6 days
   2012년 2월부터 2015년 9월

2. Late staged EPS at 3-4 months after TTA
   median 123d[51-204]
   2013년 12월부터 2016년 6월

   When AF burden is zero
   • Confirmation of PVI lines
   • Additional CTI ablation

   When AF
   • Confirmation of PVI lines
   • 3D mapping and additional ablation
   • Additional CTI ablation

2. Selective staged EPS when AF(+) after TTA
## Baseline characteristics

<table>
<thead>
<tr>
<th></th>
<th>Early staged Hybrid (N=98)</th>
<th>Late staged Hybrid (N=48)</th>
<th>TTA only (N=184)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>81 (82.6%)</td>
<td>43 (89.5%)</td>
<td>153 (83.1%)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>54.5± 9.2</td>
<td>52.8 ± 7.8</td>
<td>53.8 ± 8.4</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>25.5± 3.4</td>
<td>25.3 ± 3.6</td>
<td>26.2 ± 3.2</td>
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<tr>
<td>Diabetes</td>
<td>11 (11.2%)</td>
<td>8 (16.6%)</td>
<td>23 (12.5%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>41 (47.1%)</td>
<td>23 (47.9%)</td>
<td>76 (42.3%)</td>
</tr>
<tr>
<td>Heart Failure</td>
<td>5 ( 5.7%)</td>
<td>2 (4.1%)</td>
<td>7 (3.9%)</td>
</tr>
<tr>
<td>Stroke/embolism</td>
<td>13 ( 13.3%)</td>
<td>8 ( 16.6%)</td>
<td>24 ( 13.1%)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>3 ( 3.1%)</td>
<td>1 ( 2.1%)</td>
<td>8 ( 4.3%)</td>
</tr>
<tr>
<td>Paroxysmal AF</td>
<td>4 ( 4.1%)</td>
<td>1 ( 2.1%)</td>
<td>32 (17.4%)</td>
</tr>
<tr>
<td>Persistent AF</td>
<td>28 ( 28.6%)</td>
<td>12 ( 25.0%)</td>
<td>71 (38.6%)</td>
</tr>
<tr>
<td>Longstanding persistent AF</td>
<td>66 ( 67.3%)</td>
<td>35 ( 72.9%)</td>
<td>81 (44.0%)</td>
</tr>
<tr>
<td>CHA2DS2VASc_score</td>
<td>1.3 ± 1.2</td>
<td>1.2 ± 1.1</td>
<td>1.3 ± 1.0</td>
</tr>
<tr>
<td>LV EF (%)</td>
<td>59.4 ± 6.7</td>
<td>60.2 ± 7.3</td>
<td>58.1 ± 8.1</td>
</tr>
<tr>
<td>LA diameter (mm)</td>
<td>47.1 ± 6.1</td>
<td>45.1± 7.2</td>
<td>46.8 ± 8.4</td>
</tr>
<tr>
<td>LA volume index (ml/m2)</td>
<td>48.2 ± 13.1</td>
<td>47.4 ± 11.8</td>
<td>49.8 ± 14.1</td>
</tr>
<tr>
<td>Pharmacologic Medication</td>
<td>Early staged Hybrid (N=98)</td>
<td>Late staged Hybrid (N=48)</td>
<td>TTA only (N=184)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Anti arrhythmic drugs</td>
<td>94 (95.9%)</td>
<td>46 (95.8%)</td>
<td>18 (97.8%)</td>
</tr>
<tr>
<td>Propafenone</td>
<td>7 (7.1%)</td>
<td>2 (4.1%)</td>
<td>17 (9.2%)</td>
</tr>
<tr>
<td>Flecainide</td>
<td>3 (3.1%)</td>
<td>3 (6.3%)</td>
<td>4 (2.1%)</td>
</tr>
<tr>
<td>Sotalol</td>
<td>1 (1.0%)</td>
<td>0 (0.0%)</td>
<td>3 (1.6%)</td>
</tr>
<tr>
<td>Amiodarone</td>
<td>81 (82.6%)</td>
<td>40 (83.3%)</td>
<td>146 (79.3%)</td>
</tr>
<tr>
<td>Dronedarone</td>
<td>2 (2.0%)</td>
<td>1 (2.1%)</td>
<td>8 (4.3%)</td>
</tr>
<tr>
<td>Beta blocker</td>
<td>7 (7.1%)</td>
<td>2 (4.2%)</td>
<td>11 (5.9%)</td>
</tr>
<tr>
<td>Calcium channel blocker</td>
<td>16 (16.3%)</td>
<td>10 (20.8%)</td>
<td>23 (15.5%)</td>
</tr>
<tr>
<td>ACEi/ARB</td>
<td>20 (20.4%)</td>
<td>11 (22.9%)</td>
<td>41 (22.3%)</td>
</tr>
<tr>
<td>Statin</td>
<td>21 (21.4%)</td>
<td>14 (29.1%)</td>
<td>62 (33.7%)</td>
</tr>
<tr>
<td>Antiplatelet agent</td>
<td>11 (11.2%)</td>
<td>7 (14.5%)</td>
<td>18 (9.8%)</td>
</tr>
<tr>
<td>Anticolaguation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warfarin</td>
<td>64 (65.3%)</td>
<td>16 (33.3%)</td>
<td>48 (26.1%)</td>
</tr>
<tr>
<td>Dabigatarn</td>
<td>24 (24.5%)</td>
<td>8 (16.7%)</td>
<td>41 (22.3%)</td>
</tr>
<tr>
<td>Rivaroxaban</td>
<td>10 (10.2%)</td>
<td>24 (50.0%)</td>
<td>12 (6.5%)</td>
</tr>
<tr>
<td>Apixaban</td>
<td>0</td>
<td>0</td>
<td>28 (15.2%)</td>
</tr>
<tr>
<td>Edoxaban</td>
<td>0</td>
<td>0</td>
<td>55 (29.9%)</td>
</tr>
</tbody>
</table>
AF/AT free survival

Kaplan-Meier Plot

Survival Probability

Only TTA
Early staged Hybrid
Late staged Hybrid

Time

0 1 yr 2 yr 3 yr 4 yr 5 yr 6 yr 7 yr

Survival Probability

0.0 0.4 0.6 0.8 1.0

$p = 0.651$

Numbers at risk

Only TTA 184 134 102 65 21 2 0 0
Early staged Hybrid 98 71 54 21 4 2 1 1
Late staged Hybrid 48 36 22 5 1 1 0 0
AF/AT free survival of TTA only group depending on AF type

Kaplan-Meier Plot

Survival Probability

Time

Paroxysmal AF
Persistent AF
Long persistent AF

Paroxysmal AF 32
Persistent AF 71
Long persistent AF 80

p < 0.0001
Signals at the right atrial lateral wall
Ablation at the right atrial lateral wall
Recurrent Tachyarrhythmia after Thoracoscopic Ablation for persistent AF

- The patients who underwent EPS and RFCA at least 3 months after TTA.
- A consecutive 154 TTA patients were evaluated.
- A total of 24 patients (15.6%) showed symptomatic recurrent ATa during a median of 17.8 months after TTA.
- 22 patients underwent RFA, and half of the patients (11/22, 50%) had AF as a form of recurrent ATa.
- Non-PV related mechanisms of ATa were noted in half of patients.
- PV gaps showed a characteristic distribution: most gaps in right PVs were located at the posterior ridge (71.4%).
- Post-RFA recurrence rate was 27.3% during a median follow-up of 9.1 months

Recurrent Tachyarrhythmia after Thoracoscopic Ablation for persistent AF

Distribution of pulmonary vein gaps

Staged vs Simultaneous Thoracoscopic Hybrid Ablation for Persistent AF


Typical thoracoscopic hybrid AF ablation lesion set:

Solid red lines: epicardial ablation, circular red tags: locations of typical endocardial ablation
Staged vs Simultaneous Thoracoscopic Hybrid Ablation for Persistent AF

- Retrospectively analyzed patients undergoing Totally Thoracoscopic (TT) staged vs simultaneous hybrid AF ablation.
- All subjects had continuous ILR or PM monitoring.
- 83 patients (52 same-day, 31 staged) underwent TT hybrid AF ablation.
- Recurrence was observed in 23 (29%) patients at a median time of 147 days.
- Longstanding persistent AF status predicted recurrence (HR 4, p = 0.01).
- Staged hybrid ablation of AF significantly increases the likelihood of discovering incomplete PVI at the time of endocardial mapping vs a same-day procedure.
- Staged vs Simultaneous Thoracoscopic Hybrid Ablation for persistent AF does not affect time to recurrence of atrial arrhythmia.

Staged vs Simultaneous Thoracoscopic Hybrid Ablation for Persistent AF

Recurrence-free survival versus time

any recurrence
a same-day : 25.8%
a staged : 28.8%

The Hybrid Maze procedure: Thoracoscopic and EP procedures

The completed thoracoscopic procedure

The Hybrid Maze procedure: Thoracoscopic and EP procedures

- A staged TS/CA hybrid procedure that creates a combination of lesions that adhere to the concept of a Maze pattern; a Hybrid Maze-IV procedure

Conclusions

- Hybrid approach of TTA and RFCA for AF was safe and showed excellent mid-term durability and may be an alternative treatment option for drug-refractory AF.
- Incidence of residual potentials around the pulmonary veins was not negligible in learning curve of TTA.
- The hybrid TTA and RFCA in the reduction of AF recurrence was prominent in patients with persistent AF.
- Ablation strategies are being developed and need to be properly evaluated.