Current Surgical Treatment for Atrial Fibrillation

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Introduction

- Detrimental sequelae of AF
  - Discomfort and anxiety
  - Compromise cardiac hemodynamics
  - Stasis of blood flow in the left atrium: vulnerability to thromboembolism
Objectives of rhythm control in patients with AF

- Relieve of symptoms such as palpitation, fatigue, and dyspnea
- Prevention of tachycardia-induced myocardial remodeling and HF
- Prevention of thromboembolism
**Goals of Curative Procedure for AF**

- Restore sinus rhythm
  *Without drugs, if possible*

- Restore atrial transport function
  *Synchronized contraction*

- Reduce the risk of thromboembolism
  *Remove areas of clot formation*

- Safe and efficacious
Merits: Surgical AF ablation

- Left atrium auricle manipulation
- LA size reduction
- Transmural lesions
- Operation for associated lesion
Essentials of AF ablation

- **Clinical**
  - Long, linear lesions
  - Various shape lesions
  - Continuous lesions
  - Transmural lesions

- **Surgical**
  - Off-Pump
  - Minimally invasive
  - Directed Lesions
  - Short, Stand-Alone procedure
Lesion set of AF surgery

- To simplify and less complications
  - Less ischemic time
  - Less bleeding chance
  - Minimize adjacent organ damage
  - Easy to apply
Lesion set of AF surgery

Cox Maze III

- Left Atrial Appendage Lesion
- Pulmonary Vein Isolation Lesion
- Septal Lesion
- Left Atrial “Isthmus” Lesion
- Cryolesion on Coronary Sinus
Common Left Atrial Lesion Set

Left auricle

Mitral valve

Pulmonary vv.
# Energy Sources for Surgical AF Ablation

<table>
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<tr>
<th>Energy type</th>
<th>Endo</th>
<th>Epi</th>
<th>Flexible</th>
<th>TM</th>
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<td>Surgi-Frost</td>
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Principal electrophysiological mechanisms of AF

(a) Focal activation

(b) Multi-wavelet reentry
Paroxysmal AF

Trigger

Substrate

Chronic AF
Lesion set of AF surgery

- Pulmonary vein isolation

- *Left atrium act as electrical driving chamber for chronic atrial fibrillation*; Harada, 2000, Ann Thorac Surg

- *Pulmonary vein orifice isolation was effective in treatment of chronic atrial fibrillation*; Sueda, 2001, Ann Thorac Surg
The Ideal AF Procedure

Adaptability vs. Complexity

% Freedom from AF

0 20 40 60 80 100

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The Ideal AF Procedure

Adaptability

% Freedom from AF

Complexity

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The Surgical Maze--III Procedure

Adaptability

Complexity

% Freedom from AF
Pulmonary Vein Isolation

Adaptability Complexity

% Freedom from AF

PV Isolation (RF, MW, CS, Laser)

Maze-III
The Mini-Maze Procedure

- PV Isolation (RF, MW, CS, Laser)
- Mini-Maze (RF, MW, CS, Laser)
- Maze-III

Adaptability Complexity

% Freedom from AF

0 20 40 60 80 100

0 1 2 3 4 5 6 8 9 10

0 10

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Mini-Maze Procedure with HIFU

Adaptability

PV Isolation with HIFU
(PV Isolation with RF, MW, CS, Laser)

Mini-Maze
(PV Isolation with RF, MW, CS, Laser)

Maze-III

% Freedom from AF

Complexity

0 1 2 3 4 5 6 7 8 9 10

Mini-Maze Procedure with HIFU

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Methods used to conduction block

- Surgical Incisions
- Cryolesions
- Radiofrequency Lesions
- Microwave Lesions
- Laser Lesions
- High-Intensity Focused Ultrasound
Surgical 'Maze' operation

- Cox-Maze III operation: gold standard for surgical treatment of AF
- Cut and Sew
- Best initial overall results
- Technical difficulty and complexity
- Cure rate: more than 96% at 10 years
  Washington university, Damiano

- Problem
  - Postoperative pacemaker insertion
  - Reduced LA contraction
Alternative Energy Sources

“The object of these new technology is to replace the surgical incision with the lines of transmural ablation to creat conduction block”

Energy Sources

- Safety and effective
- **TRULY** less invasive
  - minimal invasive surgery
  - epicardial ablation
Energy Sources

- **Transmurality**
  - Production of histological transmural line
  - Thickness of atrial wall may vary tenfold in one ablation line
  - Fat tissue and Trabeculation
    : inter or intraindividual variability
Cryoablation

- Inexpensive, reasonable results
- N₂O-based Frigitronics© cryoprobe
- Lateral diffusion damage
- Successful ablation of AF
- 2min, -60°C
- Bulky, sometimes unreliable cooling
Cryoablation

Transmural set: 2 min at -60 °C
SurgiFrost

- 160 °C
- Tailoring ablation lines: flexible
- Rapid, efficient transmurality
- Off-pump, epicardial ablation
Radiofrequency

- More incisive than cryotherapy
- Current of 350 kHz to 1MHz
- Adjacent tissue injuries
- Saline irrigation
- Successful AF ablation
Radiofrequency

- Bipolar probe
- Atricure, Cardioblate
- Transmurality
- Epicardial/endocardial ablation
Microwave

- High-frequency electromagnetic radiation
  - Oscillation of water molecules in tissue
  - Converting electromagnetic energy into kinetic energy (heat)

- Minimal invasive
  - Epicardial/ Endocardial approach
  - On/Off-pump ablation
Epicardial Beating Heart Ablation

- **Lesion set**
  - Single encircling lesion around PVs
  - Line from PV circle to LA appendage
  - LA appendage amputated or stapled off
  - Line from SVC to IVS (crista terminalis)
  - Line from CT to RA appendage

- **FLEX 4 Microwave Ablation Probe**

- **Ablation times and power**
  - Epicardial: 65 watts @ 90 sec
Microwave
AMC results

- Period: Jul. 1997 ~ Sep. 2005
- Prospective cohort study of 422 patients
- Echocardiogram follow up
  - immediate postop, 3, 6, 12, 18, 24, 36 and 48 Mo
AMC results

- **Sex (M/F):** 184/238 (43.6:56.4)
- **Age (yrs):** 51.2±12.7 (11~80)
- **Mean follow up (months):** 32.1±23.1 (0.1~89.3)
Mortality

- Early mortality: 3 (1.2)
- Late mortality: 2 (0.8)
Morbidity

- Minor stroke: 2 (0.8)
- PPM: 3 (1.2)
LA diameter & EF

EF (%)

LA diameter (mm)

- Preop
- Immediate
- 3 months
- 6 months
- 12 months
- 18 months
- 24 months
- 36 months
- 4 yrs

LA diameter & EFLA diameter & EF

- LA diameter (mm)
A wave
AF recurrence free rate

![Graph showing AF recurrence free rate over years]

- AF recurrence free survival (%) at various years:
  - Year 1: 91.7%
  - Year 2: 89.9%
  - Year 3: 87.7%
  - Year 4: 87.7%
  - Year 5: 80.7%
  - Year 6: 80.7%

- Number of subjects at each year:
  - 19 subjects at year 1
  - 21 subjects at year 2
  - 22 subjects at year 3
  - 24 subjects at year 4
  - 24 subjects at year 5
  - 2 subjects at year 6

- Most recent data points at years 4 and 5 show a 2% decrease compared to the previous year.
AF recurrence free rate; Giant LA

Giant LA

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<td>39</td>
<td>20</td>
<td>9</td>
<td>5</td>
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</table>

Arrhythmia free survival (%)

P = 0.34

85.5%

72.5%
AF recurrence free rate; Sustained AF vs. Paroxysmal AF

Sustained AF vs. Paroxysmal AF

27 Paroxysmal AF 92.4%
P = 0.0014

207 Sustained AF 78.8%

14 16 17 19
125 64 29 6

2 19
Warfarin; arrhythmia related use

![Graph showing usage over months]

- Immediate: 131
- 6 months: 164
- 12 months: 136
- 24 months: 77
- 36 months: 38
- 48 months: 12

- Percentage:
  - Immediate: 45.9%
  - 6 months: 23.0%
  - 12 months: 13.9%
  - 24 months: 9.4%
  - 36 months: 7.3%
  - 48 months: 0.0%

Legend:
- Purple: not use
- Red: use
- Green: rate %
Amiodarone
Freedom from AF: MVR vs MVP

Years after Operation

Freedom from Permanent AF %

- None
  24/25
  96.0%
  cum 95.5%
- MVR
  103/106
  97.2%
  cum 96.0%
- MVP
  145/149
  97.3%
  cum 97.1%
Freedom from AF: Rheumatic vs Degenerative

<table>
<thead>
<tr>
<th>Type</th>
<th>Events</th>
<th>Freedom from AF %</th>
<th>Cumulative Survival</th>
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<tbody>
<tr>
<td>Rheumatic</td>
<td>172/178</td>
<td>96.6%</td>
<td>95.9%</td>
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<tr>
<td>Degenerative</td>
<td>71/71</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td>Other</td>
<td>29/31</td>
<td>93.6%</td>
<td>92.7%</td>
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p = 0.129
AMC results

AF without mitral valve disease
(on-pump beating, epicardial MW)

![Graph showing AMC results over time]

- AF: 83% at 4 years
- AFL: 89% at 4 years
- Sinus: 0% at 4 years
- Junctional: 75% at 4 years
- SSS: 0% at 4 years
Summary

- Modified Maze is a safe procedure, Mx 1.2%
- Sinus: 79% in OR, 86% on discharge, and > 95% up to 5 yrs
- Atrial transport (a wave): 71% on discharge, > 90% after 6 mos
- Minimal use of warfarin and amiodarone in the long-term
- No differences in giant LA, rheumatic MV
- Good result in lone AF with MICS approach
Surgical Conclusion

The long-term results of Maze operation are stable up to 5 years without increased need for medications.
Recurrence of AF/AFL

- Postoperative supraventricular tachycardias (mostly AFL) : 3% to 11%
- Mechanism of atrial tachyarrhythmias
  - predominantly left-sided origin
- Need for EPS for recurred cases

*Ann Thorac Surg 2005*
Conclusion

- Collaboration between surgery and EPS
- Postoperative AF/AFL → EPS
- AF/AFL surgical ablation after EPS failure