Mitral Valve and MAZE

Vinay Badhwar, MD
Gordon F. Murray Professor and Chair
Department of Cardiovascular and Thoracic Surgery
Executive Chair, WVU Cardiovascular Services
West Virginia University
Morgantown, WV
Disclosures

No Relevant Financial Disclosures

Chair, STS Council on Quality, Research, and Patient Safety

Co-Chair Program Executive Committee Tendyne (uncompensated)

Writing committee:
2017 ACC Expert Consensus on Management of Mitral Regurgitation
2017 STS Clinical Practice Guidelines on Surgical Ablation of AF
2017 AATS Expert Consensus Guidelines on Surgical Ablation of AF
2017 HRS Expert Consensus Statement on Catheter and Surgical AF
2019 ACC Expert Consensus Transcatheter Therapy for Mitral Disease
Mitral Valve
Objectives

• Understanding fundamentals of mitral valve anatomy and physiology

• Principles behind surgical decision making

• Review v2.9 Mitral Section for data abstraction
The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2018 Update on Research: Outcomes Analysis, Quality Improvement, and Patient Safety
Association Between Early Surgical Intervention vs Watchful Waiting and Outcomes for Mitral Regurgitation Due to Flail Mitral Valve Leaflets

Figure 1. Survival After Diagnosis of Mitral Regurgitation Due to Flail Mitral Leaflet According to Initial Treatment Strategy

A Overall population

B Propensity score-matched cohort

<table>
<thead>
<tr>
<th>Follow-up, y</th>
<th>Medical management</th>
<th>Early surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>575</td>
<td>446</td>
</tr>
<tr>
<td>5</td>
<td>477</td>
<td>412</td>
</tr>
<tr>
<td>10</td>
<td>296</td>
<td>203</td>
</tr>
<tr>
<td>15</td>
<td>126</td>
<td>41</td>
</tr>
<tr>
<td>20</td>
<td>42</td>
<td>10</td>
</tr>
</tbody>
</table>

Log-rank P < .001

<table>
<thead>
<tr>
<th>Follow-up, y</th>
<th>Medical management</th>
<th>Early surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>5</td>
<td>276</td>
<td>295</td>
</tr>
<tr>
<td>10</td>
<td>157</td>
<td>160</td>
</tr>
<tr>
<td>15</td>
<td>53</td>
<td>35</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

Log-rank P = .002

Long-term survival following early surgery vs initial medical management overall population (A) and in the propensity score-matched cohort (B).
• Etiology often predicts surgical management
• Primary MR – myxomatous degeneration
• Secondary MR – functional (ischemic or non-ischemic)
• Mixed MR – degenerative with rheumatic or calcific features
Physiologic Principles

Isovolumetric Relaxation

Passive ventricular filling

LVP increases
Valve to intermediary closing position
Atrial Contraction
Active ventricular filling

LAP > LVP
Mitral valve opens

LAP = LVP
No significant trans-mitral flow

Atrial Contraction

FLOW

TIME

Diastole

Systole
Surgical Exposure
Mitral Stenosis
Lesion and its severity determines feasibility and type of repair

More complex disease, less likely to repair
  - Calcification, leaflet tethering, retraction, mitral annular calcification (MAC)
Functional Carpentier Classification of MR

Type I

Type II

Type IIIa

Type IIIb
Severe MR  
(See Figure 7)  
Classification of MR  
(See Figure 2)

Primary MR

Define Leaflet Motion

Secondary (functional) MR

Consider restrictive annuloplasty ring with adjunctive techniques or chord-sparing valve replacement for severe functional MR if indicated (see text)

Carpentier Type I

Normal
Endocarditis, perforation, congenital abnormality

If not repairable, proceed with MVR

Repair if:
- Limited leaflet destruction
- No annulus destruction
- Cleft

If complex repair is required, consider referring to an experienced mitral valve surgeon

Carpentier Type II

Consider approach to determine feasibility and complexity of repair as outlined in Table 5

Repair is ideal if anatomy appropriate (See Table 5)

If not repairable, proceed with MVR

Carpentier Type IIIA

Restricted in both systole and diastole

If not repairable, proceed with MVR

Mixed MR

Consider repair based on principal findings

If not repairable, proceed with MVR
<table>
<thead>
<tr>
<th>Grade</th>
<th>R Vol (ml)</th>
<th>RF(%)</th>
<th>ERO (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;20</td>
</tr>
<tr>
<td>2+</td>
<td>30-44</td>
<td>30-39</td>
<td>20-29</td>
</tr>
<tr>
<td>3+</td>
<td>45-59</td>
<td>40-49</td>
<td>30-39</td>
</tr>
<tr>
<td>4+</td>
<td>≥60</td>
<td>≥50</td>
<td>≥40</td>
</tr>
</tbody>
</table>
The main 4 principles of mitral valve repair:

1. the restoration of the depth of coaptation of the anterior and posterior leaflets to > 5mm
2. the stabilization and surgical remodelling of the mitral annulus
3. the restoration of normal leaflet motion
4. the achievement of a repair that cause no more than mild regurgitation observed on the immediate postoperative echocardiogram
Pathoanatomic Continuum of Primary MR

- FED
- FED+
- Forme fruste
- Barlow's

Leaflet tissue
Resection or chords are largely used in degenerative etiology (primary MR).
• Triangular Resection
  • Focal P2 or isolated disease

• Quadrangular Resection
  • P2 with annular compression
- **PTFE** “polytetrafluoroethylene” a.k.a. “Gor-Tex”
- Placed often in the leading edge of the leaflet to provide support
Chordal relocation are often from secondary position to a primary position (body of leaflet to tip of leaflet) and often used in primary degenerative MR.
Folding Plasty: ☐ Yes ☐ No
VSMitRFold (3565)
Sliding Plasty: ☐ Yes ☐ No
VSMitRSlidP (3566)
Annular decalcification/debridement: ☐ Yes ☐ No
VSMitRADecalc (3567)
Leaflet extension/replacement patch: ☐ Yes ☐ No
VSMitRLeafERP (3568)
(If Yes→) Patch Location: ☐ Anterior ☐ Posterior ☐ Both ☐ Not Documented
VSMitRLeafERPLoc (3569)
Edge to edge repair: ☐ Yes ☐ No
VSMitREdge (3570)
Mitral commissuotomy: ☐ Yes ☐ No
VSMitRMittComm (3580)
Mitral commissuroplasty: ☐ Yes ☐ No
VSMitRMittCplasty (3585)
Mitral cleft repair: (scallop closure): ☐ Yes ☐ No
VSMitRMittCleft (3590)
Mitral paraprosthetic leak repair: ☐ Yes ☐ No
VSMitParaprosLeak (3591)
- Replacement (If Replacement ↓)
  Mitral repair attempted prior to replacement: □ Yes  □ No
  MitralIntent (3600)
  Mitral chords preserved: □ Anterior □ Posterior □ Both □ None
  VSChorPres (3605)
  Transcatheter replacement: □ Yes  □ No
  VSTCVMit (3610)

  Implant type: □ Mechanical valve  □ Bioprosthetic valve  □ Annuloplasty device  □ Mitral Leaflet clip  □ Transcatheter device
  MitralImplantTy (3620) □ Surgically implanted transcatheter device  □ Other
Summary

• Fundamentals of Mitral Pathophysiology

• Pathoanatomic Basis for Mitral Surgery
  • Importance of detail of pathology and repair methods

• Data collection v 2.9 mitral section
  • Value of accurate capture and reporting
MV Lesion Choose PRIMARY Lesion (one):
VDMiPrimLes (1746)

Carpentier Class – Valve Dysfunction Type (see Training Manual)

☐ Carpentier Class I – Normal Leaflet Mobility
☐ Carpentier Class II – Increased Leaflet Mobility
☐ Carpentier Class III A – Restricted Leaflet Mobility (systole and diastole)
☐ Carpentier Class III B – Restricted Leaflet Mobility (systole only)
☐ Mixed Lesion (Type II and Type IIIA)
☐ Acute Papillary muscle rupture
☐ Other
☐ Not Documented
<table>
<thead>
<tr>
<th>MV Lesion</th>
<th>Choose PRIMARY Lesion (one):</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDMiPrimLes (1746)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carpentier Class – Valve Dysfunction Type (see Training Manual)</th>
<th>MV Disease Etiology/Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Carpentier Class I – Normal Leaflet Mobility</td>
<td>Pure Annular Dilatation, Endocarditis native valve, Perforation</td>
</tr>
<tr>
<td>☐ Carpentier Class II – Increased Leaflet Mobility</td>
<td>Myxomatous degenerative prolapse/flail, Endocarditis</td>
</tr>
<tr>
<td>☐ Carpentier Class III A – Restricted Leaflet Mobility (systole and diastole)</td>
<td>Rheumatic, Carcinoid, Tumor, Radiation Induced heart disease, MAC</td>
</tr>
<tr>
<td>☐ Carpentier Class III B – Restricted Leaflet Mobility (systole only)</td>
<td>Ischemic (acute/chronic), Non-ischemic Cardiomyopathy, HCM</td>
</tr>
<tr>
<td>☐ Mixed Lesion (Type II and Type IIIA)</td>
<td>Mixed etiology (flail and restriction), Congenital, MAC, Failed repair</td>
</tr>
<tr>
<td>☐ Acute Papillary muscle rupture</td>
<td></td>
</tr>
<tr>
<td>☐ Other</td>
<td>Reoperation-Failure of previous MV repair or replacement</td>
</tr>
<tr>
<td>☐ Not Documented</td>
<td></td>
</tr>
</tbody>
</table>

Coming in 2020
### K. 2. Mitral Valve Procedure

If Mitral Valve Procedure Performed = Yes ↓

**Procedure Performed:**
- [ ] Repair (If Repair)
  - Repair Approach: [ ] Surgical  [ ] Transcatheter
  - If Surgical (Select all that apply):
    - [ ] Annuloplasty
    - [ ] Annular decalcification/debridement
    - [ ] Mitral commissurotomy
    - [ ] Leaflet resection
    - [ ] Leaflet extension/replacement patch
    - [ ] Mitral commissuroplasty
    - [ ] Neochords (PTFE)
    - [ ] Chordal Transfer

**If Surgical (Select all that apply):**
- [ ] Annuloplasty
- [ ] Leaflet resection
- [ ] Leaflet extension/replacement patch
- [ ] Edge to edge repair
- [ ] Mitral cleft repair:
  - [ ] Mitral commissuroplasty
  - [ ] Pannus/Thrombus Removal (Native Valve)

**Resection Location(s):**
- [ ] Anterior Resection
- [ ] Posterior Resection
- [ ] Both

**Resection Method (select all that apply):**
- [ ] Triangular Alone
- [ ] Quadrangular Alone
- [ ] Resection with Sliding Valvulopasty
- [ ] Resection with Folding Valvuloplasty
- [ ] Other

**Surgical Prosthetic Valve Intervention (Not Explant of Valve):**
- [ ] No
- [ ] Repair of periprosthetic leak
- [ ] Removal of Pannus
- [ ] Removal of Clot
- [ ] Other

**Replacement (If Replacement ↓)**
- Mitral repair attempted prior to replacement: [ ] Yes  [ ] No
- Mitral chords preserved: [ ] Anterior  [ ] Posterior  [ ] Both  [ ] None
- Transcatheter replacement: [ ] Yes  [ ] No

**Implant:**
- [ ] Yes  [ ] No  (If Yes
  - [ ] Mechanical valve
  - [ ] Bioprosthetic valve
  - [ ] Annuloplasty Ring
  - [ ] Annuloplasty without ring (pericardial or suture)
  - [ ] Transcatheter device implanted open heart
  - [ ] Transcatheter Replacement Device (Transapical)
  - [ ] Transcatheter Replacement Device (Trans-septal)
  - [ ] Annuloplasty Ring Transcatheter
  - [ ] Mitral Leaflet clip
  - [ ] Other

**Implant Model Number:** ___________________________  **Implant Size:** ___________________________

**Unique Device identifier (UDI):** ______________________________________________________
Surgical Ablation of Atrial Fibrillation

The MAZE Procedure
Objectives

- Understanding classification of Atrial Fibrillation
- Review the Guidelines for Surgical Ablation
- Understanding types and methods of surgical ablation: partial ablation to the Cox Maze IV
- Reviewing the v2.9 AF Procedure Section
  - A step by step review of variables and lesions
**Historical AF Definitions**

**Paroxysmal**
AF that terminates spontaneously or within 7 d

**Persistent**
Continuous AF sustained > 7d

**LS Persistent**
Continuous AF sustained > 12m

**Permanent**
Joint decision, no effort to maintain SR
**Current AF Definitions**

**Paroxysmal**  AF that terminates spontaneously or with intervention within 7 d

**Persistent**  Continuous AF sustained beyond 7d

  **Early Persistent**  AF that is sustained > 7 days but < 3 months

  **LS Persistent**  Continuous AF sustained > 12m

**Permanent**  Should no longer be used
Why Perform Surgical Ablation?
Surgical Ablation of Atrial Fibrillation in the United States: Trends and Propensity Matched Outcomes

Vinay Badhwar, MD, J. Scott Rankin, MD, Niv Ad, MD, Maria Grau-Sepulveda, MD, MPH, Ralph J. Damiano, MD, A. Marc Gillinov, MD, Patrick M. McCarthy, MD, Vinod H. Thourani, MD, Rakesh M. Suri, MD, DPhil, Jeffrey P. Jacobs, MD, and James L. Cox, MD

Department of Cardiovascular and Thoracic Surgery, West Virginia University, Morgantown, West Virginia; Duke Clinical Research Institute, Durham, North Carolina; Division of Cardiothoracic Surgery, Washington University, St. Louis, Missouri; Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic, Cleveland, Ohio; Division of Cardiac Surgery, Northwestern University Feinberg School of Medicine, Chicago, Illinois; Division of Cardiothoracic Surgery, Emory University, Atlanta, Georgia; and Division of Cardiac Surgery, Johns Hopkins University School of Medicine, Baltimore, Maryland
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Overall (N=57,478)</th>
<th>No Ablation (N=28,739)</th>
<th>Ablation (N=28,739)</th>
<th>Relative Risk (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>4.31%</td>
<td>4.50%</td>
<td>4.13%</td>
<td>0.92 (0.85-1.00)</td>
<td>0.0422</td>
</tr>
<tr>
<td>Reoperation for Bleeding</td>
<td>3.61%</td>
<td>3.73%</td>
<td>3.49%</td>
<td>0.93 (0.86-1.02)</td>
<td>0.1195</td>
</tr>
<tr>
<td>Permanent Stroke</td>
<td>1.96%</td>
<td>2.13%</td>
<td>1.78%</td>
<td>0.84 (0.74-0.94)</td>
<td>0.0028</td>
</tr>
<tr>
<td>Transient Ischemic Attack</td>
<td>0.38%</td>
<td>0.42%</td>
<td>0.34%</td>
<td>0.80 (0.61-1.05)</td>
<td>0.1064</td>
</tr>
<tr>
<td>Prolonged Ventilation</td>
<td>16.31%</td>
<td>16.75%</td>
<td>15.87%</td>
<td>0.95 (0.90-0.99)</td>
<td>0.0224</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>4.62%</td>
<td>4.35%</td>
<td>4.88%</td>
<td>1.12 (1.03-1.22)</td>
<td>0.0107</td>
</tr>
<tr>
<td>Pacemaker</td>
<td>6.87%</td>
<td>5.89%</td>
<td>7.84%</td>
<td>1.33 (1.24-1.43)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Phrenic Nerve Injury</td>
<td>0.06%</td>
<td>0.06%</td>
<td>0.06%</td>
<td>1.06 (0.53-2.14)</td>
<td>0.8655</td>
</tr>
<tr>
<td>Readmission 30-days</td>
<td>13.36%</td>
<td>12.79%</td>
<td>13.92%</td>
<td>1.09 (1.03-1.15)</td>
<td>0.0011</td>
</tr>
</tbody>
</table>
Surgical Ablation Trends By Operative Procedure

- MVRR±CABG
- CABG
- AVR±CABG
- OTHER
- STAND ALONE
- AVR+MVR

# of Surgical Ablations

Six Month Intervals

Ann Thorac Surg 2017;104:493–500
Clinical Practice Guidelines

2014 ACC AHA HRS Guideline  
COR IIa, LOE C

• Grouped all cardiac operations as a whole
• Utilized early surgical ablation data acquired from cases performed between 1998-2005
• Classified recommendations by AF symptoms and presence of antiarrhythmic therapy
• Essentially a catheter based ablation guideline
Clinical Practice Guidelines

2017 STS Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation

• Distinct from 2014 HRS and 2016 ESC guidelines:
  • Recommendations by specific operative procedures: Mitral Valve, Aortic Valve, CABG
  • Weight and relevance of AF symptoms at the time of planned symptomatic cardiac operation
  • Complimentary to AATS recommendations

• Evidence based options for surgeons in typical clinical scenarios based on mortality, morbidity and 1-year outcome

Ann Thorac Surg 2017;103:329-341
2017 STS Clinical Practice Guidelines

Mitral Valve Operations

- Multiple populations studied: 11 RCTs, 4 Meta-analyses, Several Institutional experiences

Recommendation:

- Surgical ablation for AF can be performed without additional risk of operative mortality or major morbidity, and is recommended at the time of concomitant mitral operations to restore sinus rhythm. (COR: I, LOE: A)
**2017 STS Clinical Practice Guidelines**

**AVR, isolated CABG, AVR+CABG Operations**

- Limited populations studied: 2 RCTs, 2 Meta-analyses, limited Institutional experiences

**Recommendation:**

- Surgical ablation for AF can be performed without additional risk operative of mortality or major morbidity, and is recommended at the time of concomitant isolated AVR, isolated CABG, and AVR+CABG operations to restore sinus rhythm.

(COR: I, LOE: B-NR)

*Ann Thorac Surg 2017;103:329-341*
2017 STS Clinical Practice Guidelines

All Operations

Recommendation:

- Surgical ablation for symptomatic AF in the setting of left atrial enlargement (≥ 4.5 cm) or more than moderate mitral regurgitation by pulmonary vein isolation alone is not recommended.

(COR: III - No Benefit, LOE: C-EO)
2017 STS Clinical Practice Guidelines

All Operations

Recommendation:

- It is reasonable to perform LA appendage excision or exclusion in conjunction with surgical ablation for AF for longitudinal thromboembolic morbidity prevention.

(COR: IIA, LOE: C-LD)

Ann Thorac Surg 2017;103:329-341
### Preoperative Arrhythmia Section

- Preoperative arrhythmia section permits notation of AF history at the time of operation as well as *remote* history.
- Permits documentation of type of AF and AF with and without previous pacemaker.

<table>
<thead>
<tr>
<th>Arrhythmia: ☐ Yes ☐ No</th>
<th>Permanently Paced Rhythm: ☐ Yes ☐ No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arrhythmia (945)</strong></td>
<td><strong>ArrhythmPPaced (947)</strong></td>
</tr>
<tr>
<td>(If Arrhythmia = Yes →)</td>
<td></td>
</tr>
<tr>
<td>(If Yes, choose one response below for each rhythm →)</td>
<td>(If AFibrillation not ‘None’ →)</td>
</tr>
<tr>
<td>VTach/VFib ArrhythmVV (950)</td>
<td>Sick Sinus Syndrome ArrhythmSSS (955)</td>
</tr>
<tr>
<td>AFiblatter ArrhythmAFlutter (960)</td>
<td>AFibrillation ArrhythmAtrFib (961)</td>
</tr>
<tr>
<td>Second Degree Heart Block ArrhythmSecond (965)</td>
<td>Third Degree Heart Block ArrhythmThird (970)</td>
</tr>
<tr>
<td>Atrial Fibrillation Type: ☐ Paroxysmal ☐ Persistent ☐ Longstanding Persistent ☐ Permanent</td>
<td></td>
</tr>
<tr>
<td>ArrhythmAFib (962)</td>
<td></td>
</tr>
</tbody>
</table>
**M.I. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures**

(If Other Cardiac Procedure, AFib = Yes ↓)

**Lesion location:**
- [ ] Primarily epicardial
- [ ] Primarily Intracardiac

**Lesions Documented:**
- [ ] Yes
- [ ] No
  (If Yes ↓)

**Method of Lesion Creation:**
- [ ] Radiofrequency
- [ ] Yes
- [ ] No
  (If Yes →)
- [ ] Bipolar
- [ ] Yes
- [ ] No

**Lesions:**
- [ ] 1 Bilateral Pulmonary Vein Isolation
- [ ] 2 Box Lesion Only
- [ ] 3a Inferior Pulmonary Vein Connecting Lesion
- [ ] 3b Superior Pulmonary Vein Connecting Lesion
- [ ] 4 Posterior Mitral Annular Line Lesion
- [ ] 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
- [ ] 6 Mitral Valve Annular Lesion
- [ ] 7 LAA /Removal/Obliteration
- [ ] 8 Pulmonary Vein to LAA Lesion
- [ ] 9 Intercaval Line to Tricuspid Annulus (“T” lesion)
- [ ] 10 Tricuspid Cryo Lesion, Medial
- [ ] 11 Intercaval Line (SVC and IVC)
- [ ] 12 Tricuspid Annular Line to RAA
- [ ] 13 Tricuspid Cryo Lesion
- [ ] 14 RAA Ligation/Removal
- [ ] 15a RAA Lateral Wall (Short)
- [ ] 15b RAA Lateral Wall to “T” Lesion
- [ ] 16 Coronary Sinus Lesion

---

**Epicardial Left Sided Lesions**

![Epicardial Left Sided Lesions Diagram](image-url)
Pathoetiologic Basis for the Surgical Treatment of Atrial Fibrillation

Paroxysmal AF

- Based on focal triggers
- PVI may be adequate but may miss triggers in concomitant cases of structural heart disease

Non-paroxysmal (Persistent and LSP AF)

- Macro-reentrant circuits in the atria
- More than PVI is needed
- Cox Maze operation
The Cox-MAZE
1987
The Toolbox of Energy Sources
Lesions for Surgical Ablation
Prevailing Surgical Treatment Paradigm of AF

**Paroxysmal AF**
- Left atrial surgical ablation
- For isolated CABG or AVR, bilateral paired or posteriorly encircled pulmonary vein isolation

**Persistent AF**
- Bi-Atrial Cox-MAZE III/IV procedure
- Better outcomes with bi-atrial lesions in Mitral operations
Prevailing Surgical Treatment Paradigm of AF

**Epicardial Surgical Ablation (PVI)**

- Minimum 2 but up to 4 applications of clamp
- Testing for Exit Block from Pulmonary Veins
- Energy Source Options: Caution on use of unipolar RF for epicardial use

**Endocardial Surgical Ablation**

- Bi-Atrial Cox-MAZE IV procedure
  1. Importance of the Coronary Sinus Lesion, Box, Mitral and LAA Connection
  2. Energy Source options (Depth and Breadth)
     - Cryo > Bipolar RF > Unipolar RF
The Cox-MAZE IV Procedure
Left Atrial Lesion Set

Sternotomy

Right Mini-thoracotomy
The Cox-Maze IV Procedure

Semin Thorac Cardiovasc Surg 2019 Feb 27 [Epub ahead of print]
Lesion location:  
- Primarily epicardial  
- Primarily Intracardiac

Lesions Documented:  
- Yes  
- No

Method of Lesion Creation:  
- Select all that apply:
  - Radiofrequency
  - Cut-and-sew
  - Cryo

Lesions:
- 1 Bilateral Pulmonary Vein Isolation
- 2 Box Lesion Only
- 3a Inferior Pulmonary Vein Connecting Lesion
- 3b Superior Pulmonary Vein Connecting Lesion
- 4 Posterior Mitral Annular Line Lesion
- 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
- 6 Mitral Valve Annular Lesion
- 7 LAA / Removal / Obliteration
- 8 Pulmonary Vein to LAA Lesion
- 9 Intercaval Line to Tricuspid Annulus (“T” lesion)
- 10 Tricuspid Cryo Lesion, Medial
- 11 Intercaval Line (SVC and IVC)
- 12 Tricuspid Annular Line to RAA
- 13 Tricuspid Cryo Lesion
- 14 RAA Ligation / Removal
- 15a RAA Lateral Wall (Short)
- 15b RAA Lateral Wall to “T” Lesion
- 16 Coronary Sinus Lesion
<table>
<thead>
<tr>
<th>Lesion Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bilateral Pulmonary Vein Isolation</td>
</tr>
<tr>
<td>2</td>
<td>Box Lesion Only</td>
</tr>
<tr>
<td>3a</td>
<td>Inferior Pulmonary Vein Connecting Lesion</td>
</tr>
<tr>
<td>3b</td>
<td>Superior Pulmonary Vein Connecting Lesion</td>
</tr>
<tr>
<td>4</td>
<td>Posterior Mitral Annular Line Lesion</td>
</tr>
<tr>
<td>5</td>
<td>Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus</td>
</tr>
<tr>
<td>6</td>
<td>Mitral Valve Annular Lesion</td>
</tr>
<tr>
<td>7</td>
<td>LAA /Removal/Obliteration</td>
</tr>
<tr>
<td>8</td>
<td>Pulmonary Vein to LAA Lesion</td>
</tr>
<tr>
<td>9</td>
<td>Intercaval Line to Tricuspid Annulus (“T” lesion)</td>
</tr>
<tr>
<td>10</td>
<td>Tricuspid Cryo Lesion, Medial</td>
</tr>
<tr>
<td>11</td>
<td>Intercaval Line (SVC and IVC)</td>
</tr>
<tr>
<td>12</td>
<td>Tricuspid Annular Line to RAA</td>
</tr>
<tr>
<td>13</td>
<td>Tricuspid Cryo Lesion</td>
</tr>
<tr>
<td>14</td>
<td>RAA Ligation/Removal</td>
</tr>
<tr>
<td>15a</td>
<td>RAA Lateral Wall (Short)</td>
</tr>
<tr>
<td>15b</td>
<td>RAA Lateral Wall to “T” Lesion</td>
</tr>
<tr>
<td>16</td>
<td>Coronary Sinus Lesion</td>
</tr>
</tbody>
</table>

**M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures** (If Other Cardiac Procedure, AFib = Yes ↓)

**Lesion location:**
- Primarily epicardial
- Primarily Intracardiac

**Lesions Documented:**
- Yes
- No

**Method of Lesion Creation:**
- Radiofrequency: Yes
- Bipolar: Yes
- Cut-and-sew: Yes
- Cryo: Yes

**Epicardial Left Sided Lesions**
**M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures** (If Other Cardiac Procedure, AFib = Yes ↓)

<table>
<thead>
<tr>
<th>Lesion location:</th>
<th>☐ Primarily epicardial</th>
<th>☑ Primarily Intracardiac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesions Documented:</td>
<td>☐ Yes</td>
<td>☑ No</td>
</tr>
<tr>
<td>Method of Lesion Creation:</td>
<td>☐ Yes</td>
<td>☑ No</td>
</tr>
<tr>
<td>Radiofrequency</td>
<td>☐ Yes</td>
<td>☑ No</td>
</tr>
<tr>
<td>Cut-and-sew</td>
<td>☐ Yes</td>
<td>☑ No</td>
</tr>
<tr>
<td>Cryo</td>
<td>☐ Yes</td>
<td>☑ No</td>
</tr>
</tbody>
</table>

**Lesions: (check all that apply ↓)**

- ☐ 1 Bilateral Pulmonary Vein Isolation
- ☑ 2 Box Lesion Only
- ☐ 3a Inferior Pulmonary Vein Connecting Lesion
- ☐ 3b Superior Pulmonary Vein Connecting Lesion
- ☐ 4 Posterior Mitral Annular Line Lesion
- ☐ 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
- ☐ 6 Mitral Valve Annular Lesion
- ☐ 7 LAA /Removal/Obliteration
- ☐ 8 Pulmonary Vein to LAA Lesion
- ☐ 9 Intercaval Line to Tricuspid Annulus (“T” lesion)
- ☐ 10 Tricuspid Cryo Lesion, Medial
- ☐ 11 Intercaval Line (SVC and IVC)
- ☐ 12 Tricuspid Annular Line to RAA
- ☐ 13 Tricuspid Cryo Lesion
- ☐ 14 RAA Ligation/Removal
- ☐ 15a RAA Lateral Wall (Short)
- ☐ 15b RAA Lateral Wall to “T” Lesion
- ☐ 16 Coronary Sinus Lesion

---

**Epicardial Left Sided Lesions**
Lesions By the Numbers Step by Step

1. Bilateral PV Isolation can be performed by any technique but is most commonly done by epicardial RF bipolar clamp.
2. Box lesion can be performed as the only procedure on the left atrium in isolation. However if the operative report says “completion box lesion” and involves #1, #3a, and #3b, and then they should record these 3 sections and not #2.
3. (a) Inferior connecting lesion connects the right inferior pulmonary vein to the left inferior pulmonary vein; often called the “LA floor line”, (b) Superior connecting lesion connects the right superior pulmonary vein to the left superior pulmonary vein; often called the “LA roof line”.
4. This important lesion can be performed solely with cryo and when it does it encompasses lesion #6. If performed with bipolar RF or cut-and-sew, then a cryo #6 lesion is required. If performed by unipolar RF, both #4 and #6 may be completed. It should be noted, that this endocardial mitral annular lesion is often accompanied by an epicardial coronary sinus lesion performed with cryo (#16) and thus the two may appear contiguously in the operative report.
5. This is an epicardial only lesion, and may often be accompanied by a reference to the “Dallas Lesion Set”.
6. As noted above, most commonly performed with Cryo.
7. This may be performed by resection, epicardial stapling with or without resection, epicardial commercially available clip, or endocardial suture closure (usually double layer longitudinal mattress prolene).
8. This completion line connects the left inferior pulmonary vein to the LAA and it is most often performed together with lesion 3a or the inferior pulmonary vein connecting lesion.
The Right Atrial Lesions

- Objective to interrupt the macro-reentrant circuit traversing the base of the right atrial appendage and crossing the crista terminalis and the cavotricuspid isthmus
  
  I. SVC-IVC or intercaval lesion
  II. “T” lesion or right atrial free wall lesion to the tricuspid annulus
  III. Lateral right atrial lesion from the T to the right atrial appendage or tricuspid annulus
The Right Atrial Lesions

J Thorac Cardiovasc Surg 1996;110:485-95
The Right Atrial Lesions of Cox-MAZE IV
The Cox-Maze IV Procedure
An Effective Modification to Simplify the Right Atrial Lesion Set of the Cox-Cryomaze

Faisal H. Cheema, MD, Muhammad J. Younus, MD, Arham Pasha, James L. Cox, MD, and Harold G. Roberts, Jr, MD
M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures (If Other Cardiac Procedure, AFib = Yes ↓)

Lesion location: ☐ Primarily epicardial  ☑ Primarily Intracardiac
Lesions Documented:  ☑ Yes  ☐ No (If Yes ↓)

Method of Lesion Creation:  (Select all that apply ↓)
  - Radiofrequency  ☑ Yes  ☐ No (If Yes →)
  - Bipolar  ☑ Yes  ☐ No
  - Cut-and-sew  ☑ Yes  ☐ No
  - Cryo  ☑ Yes  ☐ No

Lesions: (check all that apply ↓)

☐ 1  Bilateral Pulmonary Vein Isolation
☐ 2  Box Lesion Only
☐ 3a Inferior Pulmonary Vein Connecting Lesion
☐ 3b Superior Pulmonary Vein Connecting Lesion
☐ 4  Posterior Mitral Annular Line Lesion
☐ 5  Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
☐ 6  Mitral Valve Annular Lesion
☐ 7  LAA /Removal/Obliteration
☐ 8  Pulmonary Vein to LAA Lesion
☐ 9  Intercaval Line to Tricuspid Annulus (“T” lesion)
☐ 10 Tricuspid Cryo Lesion, Medial
☐ 11 Intercaval Line (SVC and IVC)
☐ 12 Tricuspid Annular Line to RAA
☐ 13 Tricuspid Cryo Lesion
☐ 14 RAA Ligation/Removal
☐ 15a RAA Lateral Wall (Short)
☐ 15b RAA Lateral Wall to “T” Lesion
☐ 16 Coronary Sinus Lesion

Epicardial Left Sided Lesions
M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures

(If Other Cardiac Procedure, AFib = Yes ↓)

Lesion location:
- [ ] Primarily epicardial
- [ ] Primarily Intracardiac

Lesions Documented:
- [ ] Yes
- [ ] No

(If Yes ↓)

Method of Lesion Creation:
- (Select all that apply ↓)
  - Radiofrequency
    - [ ] Yes
    - [ ] No
  - Bipolar
    - [ ] Yes
    - [ ] No
  - Cut-and-sew
    - [ ] Yes
    - [ ] No
  - Cryo
    - [ ] Yes
    - [ ] No

Lesions:
(check all that apply ↓)

- [ ] 1 Bilateral Pulmonary Vein Isolation
- [ ] 2 Box Lesion Only
- [ ] 3a Inferior Pulmonary Vein Connecting Lesion
- [ ] 3b Superior Pulmonary Vein Connecting Lesion
- [ ] 4 Posterior Mitral Annular Line Lesion
- [ ] 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
- [ ] 6 Mitral Valve Annular Lesion
- [ ] 7 LAA /Removal/Obliteration
- [ ] 8 Pulmonary Vein to LAA Lesion
- [ ] 9 Intercaval Line to Tricuspid Annulus (“T” lesion)
- [ ] 10 Tricuspid Cryo Lesion, Medial
- [ ] 11 Intercaval Line (SVC and IVC)
- [ ] 12 Tricuspid Annular Line to RAA
- [ ] 13 Tricuspid Cryo Lesion
- [ ] 14 RAA Ligation/Removal
- [ ] 15a RAA Lateral Wall (Short)
- [ ] 15b RAA Lateral Wall to “T” Lesion
- [ ] 16 Coronary Sinus Lesion

Epicardial Left Sided Lesions
M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures (If Other Cardiac Procedure, AFib = Yes ↓)

Lesion location: ☐ Primarily epicardial ☐ Primarily Intracardiac
Lesions Documented: ☐ Yes ☐ No (If Yes ↓)

Method of Lesion Creation: (Select all that apply ↓)

Radiofrequency ☐ Yes ☐ No (If Yes →) Bipolar ☐ Yes ☐ No
Cut-and-sew ☐ Yes ☐ No
Cryo ☐ Yes ☐ No

Lesions: (check all that apply ↓)

☐ 1 Bilateral Pulmonary Vein Isolation
☐ 2 Box Lesion Only
☐ 3a Inferior Pulmonary Vein Connecting Lesion
☐ 3b Superior Pulmonary Vein Connecting Lesion
☐ 4 Posterior Mitral Annular Line Lesion
☐ 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
☐ 6 Mitral Valve Annular Lesion
☐ 7 LAA/Removal/Obliteration
☐ 8 Pulmonary Vein to LAA Lesion
☐ 9 Intercaval Line to Tricuspid Annulus (“T” lesion)
☐ 10 Tricuspid Cryo Lesion, Medial
☐ 11 Intercaval Line (SVC and IVC)
☐ 12 Tricuspid Annular Line to RAA
☐ 13 Tricuspid Cryo Lesion
☐ 14 RAA Ligation/Removal
☐ 15a RAA Lateral Wall (Short)
☐ 15b RAA Lateral Wall to “T” Lesion
☐ 16 Coronary Sinus Lesion
M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures (If Other Cardiac Procedure, AFib = Yes ↓)

Lesion location: □ Primarily epicardial □ Primarily Intracardiac

Lesions Documented: □ Yes □ No (If Yes ↓)

Method of Lesion Creation: (Select all that apply ↓)
- Radiofrequency □ Yes □ No (If Yes →)
- Bipolar □ Yes □ No
- Cut-and-sew □ Yes □ No
- Cryo □ Yes □ No

Lesions: (check all that apply ↓)

□ 1 Bilateral Pulmonary Vein Isolation
□ 2 Box Lesion Only
□ 3a Inferior Pulmonary Vein Connecting Lesion
□ 3b Superior Pulmonary Vein Connecting Lesion
□ 4 Posterior Mitral Annular Line Lesion
□ 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
□ 6 Mitral Valve Annular Lesion
□ 7 LAA Removal/Obliteration
□ 8 Pulmonary Vein to LAA Lesion
□ 9 Intercavalline to Tricuspid Annulus ("T" lesion)
□ 10 Tricuspid Cryo Lesion, Medial
□ 11 Intercaval Line (SVC and IVC)
□ 12 Tricuspid Annular Line to RAA
□ 13 Tricuspid Cryo Lesion
□ 14 RAA Ligation/Removal
□ 15a RAA Lateral Wall (Short)
□ 15b RAA Lateral Wall to "T" Lesion
□ 16 Coronary Sinus Lesion

Epicardial Left Sided Lesions
M.1. Complete for Epicardial and Intracardiac Atrial Fibrillation Procedures (If Other Cardiac Procedure, AFib = Yes ↓)

Lesion location: □ Primarily epicardial □ Primarily Intracardiac
Lesions Documented: □ Yes □ No (If Yes ↓)

Method of Lesion Creation: (Select all that apply ↓)
- Radiofrequency □ Yes □ No (If Yes →)
- Bipolar □ Yes □ No
- Cut-and-sew □ Yes □ No
- Cryo □ Yes □ No

Lesions: (check all that apply ↓)
- □ 1 Bilateral Pulmonary Vein Isolation
- □ 2 Box Lesion Only
- □ 3a Inferior Pulmonary Vein Connecting Lesion
- □ 3b Superior Pulmonary Vein Connecting Lesion
- □ 4 Posterior Mitral Annular Line Lesion
- □ 5 Pulmonary Vein Connecting Lesion to Anterior Mitral Annulus
- □ 6 Mitral Valve Annular Lesion
- □ 7 LAA /Removal/Obliteration
- □ 8 Pulmonary Vein to LAA Lesion
- □ 9 Intercaval Line to Tricuspid Annulus ("T" lesion)
- □ 10 Tricuspid Cryo Lesion, Medial
- □ 11 Intercaval Line (SVC and IVC)
- □ 12 Tricuspid Annular Line to RAA
- □ 13 Tricuspid Cryo Lesion
- □ 14 RAA Ligation/Removal
- □ 15a RAA Lateral Wall (Short)
- □ 15b RAA Lateral Wall to "T" Lesion
- □ 16 Coronary Sinus Lesion

Epicardial Left Sided Lesions
Lesions By the Numbers Step by Step

9. The T-lesion is vertical line or incision is on the lateral wall of the RA and may be completed with cryo or RF but it is most often performed by a surgical incision.

10. Since incision number 9 cannot cross into the tricuspid annulus without injuring the tricuspid, this is often completed with cryo, often also worded as the “medial tricuspid annular completion line”.

11. The inter-caval line is a very important lesion and it can be completed by any of the methods. It is done by a single incision with the full cut-and-sew technique. Most commonly, this is performed separately by the bipolar RF clamp or cryo device as two separate lesions: the “SVC” lesion and “IVC” lesion performed from the bottom of the vertical atriotomy lesion #9.

12. This is a variant of lesion #15b. Usually 12 and 15b are not performed together as they do the same thing.

13. This is the variant of lesion #10 and should not be performed together. In other words, lesion and 12 and 13 are a pair, as lesion 9 and 10 are a pair.

14. This is an optional maneuver and not considered part of the contemporary Cox-MAZE IV lesion set. This is often performed as part of the traditional full cut-and-sew Cox-MAZE procedure.

15. (a) this lesion often is performed epicardially or with a bipolar RF clamp inserted in the RAA and combined with lesion 12, (b) this lesion is often performed with a bipolar RF clamp or cryo and extends into the tip of the RAA.

16. This is an epicardial lesion only and is most often performed with cryo and it often accompanies lesion 4.
<table>
<thead>
<tr>
<th>Operation</th>
<th>AF Type</th>
<th>Lesion Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG</td>
<td>Paroxysmal</td>
<td>PVI or Box</td>
</tr>
<tr>
<td>CABG</td>
<td>Persistent</td>
<td>PVI – not sufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LA only, anecdotal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bi-Atrial – best</td>
</tr>
<tr>
<td>AVR</td>
<td>Paroxysmal</td>
<td>PVI or Box</td>
</tr>
<tr>
<td>MVR/r</td>
<td>Paroxysmal</td>
<td>PVI – not sufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LA CMIV lesion set may be ok</td>
</tr>
<tr>
<td>but…</td>
<td></td>
<td>Bi-Atrial – curative</td>
</tr>
<tr>
<td></td>
<td>Persistent</td>
<td>LA CMIV lesion set may be ok</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bi-Atrial – best</td>
</tr>
</tbody>
</table>
AQO AF Summary

• Understand why AF is so important and how surgical ablation can impact survival.

• You can now help your team with understanding surgical ablation and the Cox Maze procedure

• Perhaps you finally understand the DCF, the lesions and why they are performed!
## M.1. Atrial Fibrillation Procedures

(If Other Cardiac Procedure, AFib = Yes ↓)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Atrial Appendage Obliteration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epicardially applied occlusion device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epicardial Staple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epicardial Suture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocardial Suture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Transcathe ter Device In Existence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If epicardially applied occlusion device →  UDI: ___________________

Left Atrial Appendage Amputation:  □ Yes  □ No

Lesion location:  □ Primarily epicardial  □ Primarily Intracardiac  □ Both  □ None

(If not None, select all that apply) → □ Radiofrequency  □ Cut-and-sew  □ Cryo

(If Radiofrequency →)  Bipolar  □ Yes  □ No  □ Not Documented

Lesions Documented:  □ Yes  □ No  (If Yes – select all that apply)

<table>
<thead>
<tr>
<th>Location</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Atrial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (If Yes, select all that apply)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Bilateral Pulmonary Vein Isolation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Posterior Box Lesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Mitral Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Left atrial appendage line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Epicardial Coronary Sinus Lesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Epicardial Posterior Wall Other (i.e. Convergent procedure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Atrial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (If Yes, select all that apply)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ SVC Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ IVC Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Tricuspid Completion Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Ventricle Right Atrial Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Right Atrial Appendage Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>