Atrial Fibrillation and Anesthesia Considerations from an EP Perspective

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Disclosures

Speaker has no conflict of interest

I also hope that I don’t put you to sleep...

Because that’s your job!
Objectives

1. Indications and special patient populations in atrial fibrillation ablation

2. Mechanisms of atrial fibrillation and evolving techniques and technologies in ablation

3. Anesthetic considerations and techniques during ablation
   - Improved ablation lesion formation
   - EP medications
   - Esophageal considerations
In patients with paroxysmal AF, the vast majority of atrial premature beats originate in the pulmonary veins (94% of all triggers).
Figure 2. Angiogram of a Left Inferior Pulmonary Vein Depicting the Source and Exit of Ectopic Activity.

The electrogram showed characteristic changes in timing depending on the position of the recording catheter in the specific pulmonary vein. With an increasingly distal catheter position (toward the source), the spike was recorded progressively later during sinus rhythm (left-hand panel, arrows) and correspondingly earlier during ectopic activity (arrowhead). Conversely, in a proximal position at its exit into the left atrium (right-hand panel), the spike was not as delayed during sinus rhythm (arrows) nor as precipitous during ectopic activity (arrowhead). The application of radio-frequency energy at the source of ectopic activity eliminated the local spike during sinus rhythm and ectopic beats and atrial fibrillation on a short-term basis. The dotted lines mark the onset of the ectopic P wave, and 1–2 and 3–4 are bipolar recordings from the distal and proximal poles of the mapping catheter. A indicates near-field atrial activity. The radiograph (center panel) shows the position of electrographic recordings inside the pulmonary vein at the source and exit.
Other AF triggers outside the pulmonary veins
Hypotheses regarding mechanisms of atrial fibrillation

(a) Multiple wavelets
(b) Rapidly discharging automatic foci
(c) Single reentrant circuit with fibrillatory conduction
(d) Functional reentry from rotors or spiral waves
(e) AF maintenance due to dissociation between epicardium and epicardium
Atrial Fibrosis: AF is a progressive disease

Electroanatomic mapping allows direct contact with endocardial tissue and can reveal presence of scar (low voltage areas), not detectable by any imaging method.

In contrast to paroxysmal AF, an important proportion of patients with persistent AF have regional increase in atrial fibrosis that is associated with greater frequency of AF.

Patient Populations: Who is at Risk for AF?

REVEAL-AF study: 385 patients with no history of AF (CHADS2 score of $\geq 3$ or 2 with 1 extra risk factor) underwent LINQ monitor implant

- 29% detection rate of AF lasting $\geq 6$ min. AF would have gone undetected in most pts had monitoring been limited to 30 days. AF incidence was higher in older and more obese patients.

Reiffel et al. *JAMA Cardiol.* 2017;2(10):1120-1127
Special Patient Populations Undergoing AF Ablation

CASTLE-AF: 398 heart failure pts with ICDs were enrolled
Randomized to medical therapy vs ablation

**Table 1. Characteristics of the Patients at Baseline.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ablation (N=179)</th>
<th>Medical Therapy (N=184)</th>
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</thead>
<tbody>
<tr>
<td>Age — yr</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Range</td>
<td>56–71</td>
<td>56–73.5</td>
</tr>
<tr>
<td>Male sex — no. (%)</td>
<td>156 (87)</td>
<td>155 (84)</td>
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<tr>
<td>Body-mass index†</td>
<td>29.0</td>
<td>29.1</td>
</tr>
<tr>
<td>Range</td>
<td>25.9–32.2</td>
<td>25.9–32.3</td>
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<tr>
<td>New York Heart Association class — no./total no. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>20/174 (11)</td>
<td>19/179 (11)</td>
</tr>
<tr>
<td>II</td>
<td>101/174 (58)</td>
<td>109/179 (61)</td>
</tr>
<tr>
<td>III</td>
<td>50/174 (29)</td>
<td>49/179 (27)</td>
</tr>
<tr>
<td>IV</td>
<td>3/174 (2)</td>
<td>2/179 (1)</td>
</tr>
<tr>
<td>Cause of heart failure — no. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic</td>
<td>72 (40)</td>
<td>96 (52)</td>
</tr>
<tr>
<td>Nonischemic</td>
<td>107 (60)</td>
<td>88 (48)</td>
</tr>
<tr>
<td>Type of atrial fibrillation — no. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>54 (30)</td>
<td>64 (35)</td>
</tr>
<tr>
<td>Persistent</td>
<td>125 (70)</td>
<td>129 (65)</td>
</tr>
<tr>
<td>Long-standing persistent (duration &gt;1 year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left atrial diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total no. of patients evaluated</td>
<td>162</td>
<td>172</td>
</tr>
<tr>
<td>Median — mm</td>
<td>48.0</td>
<td>49.5</td>
</tr>
<tr>
<td>Interquartile range — mm</td>
<td>45.0–54.0</td>
<td>5.0–55.0</td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total no. of patients evaluated</td>
<td>164</td>
<td>172</td>
</tr>
<tr>
<td>Median — %</td>
<td>32.5</td>
<td>31.5</td>
</tr>
<tr>
<td>Interquartile range — %</td>
<td>25.0–38.0</td>
<td>27.0–37.0</td>
</tr>
<tr>
<td>CRT-D implanted — no. (%)</td>
<td>48 (27)</td>
<td>52 (28)</td>
</tr>
<tr>
<td>ICD implanted — no. (%)</td>
<td>131 (73)</td>
<td>132 (72)</td>
</tr>
</tbody>
</table>

**Significant reduction in composite outcome of death and hospitalization for heart failure and in all-cause mortality alone**
4 Pillars of AF Management

1. Risk Factor Modification
2. Rate control: resting HR < 100bpm
3. Anticoagulation
4. Rhythm Control

- Flecainide/propafenone: class Ic (Na channel blockers)
- Sotalol: class III (K+ ch blocker + BB)
- Amiodarone: class III – reserved for pts with significant HF/systolic dysf' n EF <35%
- Dronedarone: class III

“CCS algorithm” (“CHADS65”) for OAC therapy in AF

- Age ≥ 65
  - YES → OAC
  - NO
    - Stroke / TIA / peripheral embolism or Hypertension or Heart Failure or Diabetes Mellitus (CHADS2 risk factors)
      - YES → OAC
      - NO → CAD or Arterial vascular disease (coronary, aortic, peripheral)
        - YES → ASA
        - NO → No antithrombotic therapy

Consider and modify (if possible) all factors influencing risk of bleeding during OAC treatment (hypertension, antiplatelet drugs, NSAIDs, corticosteroids, excessive alcohol, labile INRs) and specifically bleeding risks for NOACs (low creatinine clearance, age ≥ 75, low body weight)

*A NOAC is preferred over warfarin for non-valvular AF

Oral anticoagulant therapy is justified when the annual risk of stroke exceeds 1.5%
OAC for patients age ≥ 65 (even without other criteria)
ASA for patients with vascular disease (questions remain)
Modifiable Risk Factors: Weight loss

**FIGURE 2** Atrial Fibrillation Freedom Outcome According to Group

(A) Kaplan-Meier curve for AF-free survival without the use of rhythm control strategies. (B) Kaplan-Meier curve for AF-free survival for total AF-free survival (multiple ablation procedures with and without drugs). Abbreviations as in Figure 1.

Indications for AF ablation

**Paroxysmal:**
AF terminates with intervention or spontaneously within 7 days of onset

**Persistent:**
AF that is sustained beyond 7 days but < 3 months

**Longstanding persistent:**
Continuous AF > 12 months duration

Success rate in maintaining sinus rhythm:
catheter ablation: 66-89%
antiarrhythmics: 9-58%

Contemporary AF management. Andrade et al. CJC 33 (2017) 965-976
AF Ablation Procedure
Site-Specific Transseptal Puncture for Various Intracardiac Interventions

- AF ablation
- LAA closure
- MitraClip
- PFO closure
- Perc LVAD

1. Fluoroscopy with catheter location
2. Hemodynamics
3. TEE
4. Intracardiac echo (ICE)

Coronary sinus catheter

Alhouli et al. JACC Volume 9, 24 (2016), 2465-2480
Intracardiac echo. FO = fossa ovalis
Intraprocedural Anticoagulation

Typically 5-10,000 units of heparin is bolused before transseptal ACT during procedure = target 300-350 seconds

Heparin given in boluses or continuously IV

Protamine may be given at termination of procedure

Periprocedural OAC varies between operator.
- coumadin will typically not be stopped
- NOAC held for 1 or 2 doses, and heparin IV or a NOAC will be restarted 6 hours post sheath removal
Why is Anticoagulation Given Even Prior to Transseptal Puncture?

and restarted so soon post procedure?
Intracardiac echo

A single linear mobile thrombus (8x4mm) attached at the sheath of the lasso catheter, pulling the sheath/lasso with thrombus back into the right atrium.

In 50%, LA thrombi occurred before RF energy application.
Char formation on the tip of the radiofrequency ablation catheter

A. Transthoracic echo (apical 4-ch) demonstrating posterior LA thrombus 3 days post AF ablation

B. TEE

Thrombogenic milieu post abl with increased D-dimers and slow flow due to stunning
AF Ablation Procedure: Mapping

A left atrial electroanatomic map is created using a multielectrode mapping catheter (lasso or pentaray).

Coronary sinus catheter
AF Ablation Procedure: importance of being still

Once the mapping catheters have been introduced into the LA after transseptal, and the electroanatomic map has been started, it is essential that the patient does not move.

The mapping and ablation catheters have magnetic sensors that link to patches on the patient’s front and back with a reference under the table/at torso level.

Mapping is usually started 30 minutes after achieving femoral access... typically at times when induction paralytic agent starts to wear off.
Radiofrequency

Contact Sensing RF catheters since 2014 = more efficacious lesions and safer procedure

Cryoablation
Different lesion sets are created depending on location of scar, persistent vs paroxysmal AF, recurrent atrial tachycardias/flutters (red=scar, purple=healthy)
Right inferior pulmonary vein electrograms: AF continues despite sinus rhythm in the atrium.

Left atrial electrograms

Normal sinus
Lesion Creation and Stability

Achieving durable pulmonary vein isolation necessitates the creation of transmural, contiguous ablation lesions encircling the veins.

Requires the ablation catheter to maintain adequate contact with the endocardial surface to have sufficient contact force and time-duration to create a transmural lesion.

3 things have been demonstrated to improve AF ablation outcomes:

1. Incorporation of cardiac imaging (CT or MRI)
2. Use of a steerable sheath
3. ....
Anesthesia saves the day!
Jet Ventilation

**Conventional Ventilation**
- Gas flow is slow, bidirectional, and sequential.
- Dead space can be an issue.
- Airway sealing is mandatory.

**High Frequency Jet Ventilation**
- High velocity insufflation of gas through a narrow nozzle into the open airway.
- Gas flow is fast, coaxial, partially simultaneous, inward only.
- Dead space is less relevant.
- Airway sealing contraindicated.
Thumbs up for Jet

-Dr. David Bracco
Efforts to enhance catheter stability improve atrial fibrillation ablation outcome

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Table 1 Demographic data

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Group 2 (I-EAM, SI)</th>
<th>Group 3 (I-EAM, SI, HFJV)</th>
<th>P</th>
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<tbody>
<tr>
<td>Sex: Man</td>
<td></td>
<td></td>
<td></td>
<td>.008</td>
</tr>
<tr>
<td>Age (y)</td>
<td>57 ± 11</td>
<td>60 ± 10</td>
<td>59 ± 10</td>
<td>.03</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>28.5 ± 5.8</td>
<td>29.1 ± 4.8</td>
<td>31.2 ± 5.4</td>
<td>&lt;.001</td>
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<tr>
<td>CAD</td>
<td>13%</td>
<td>16%</td>
<td>16%</td>
<td>.79</td>
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<tr>
<td>Hypertension</td>
<td>48%</td>
<td>64%</td>
<td>64%</td>
<td>.03</td>
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<tr>
<td>Diabetes mellitus</td>
<td>9%</td>
<td>10%</td>
<td>15%</td>
<td>.36</td>
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<td>TIA/CVA</td>
<td>5%</td>
<td>3%</td>
<td>4%</td>
<td>.78</td>
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<tr>
<td>MR (≥ moderate)</td>
<td>1%</td>
<td>4%</td>
<td>6%</td>
<td>.17</td>
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<tr>
<td>CM</td>
<td>6%</td>
<td>14%</td>
<td>15%</td>
<td>.09</td>
</tr>
<tr>
<td>CHF</td>
<td>2%</td>
<td>2%</td>
<td>6%</td>
<td>.19</td>
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<tr>
<td>OSA</td>
<td>12%</td>
<td>16%</td>
<td>20%</td>
<td>.30</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>62 ± 8</td>
<td>60 ± 10</td>
<td>59 ± 10</td>
<td>.22</td>
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<tr>
<td>LA diameter (cm)</td>
<td>4.2 ± 0.8</td>
<td>4.4 ± 0.7</td>
<td>4.5 ± 0.8</td>
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<tr>
<td>AF type</td>
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<tr>
<td>Paroxysmal</td>
<td>83</td>
<td>70</td>
<td>61</td>
<td></td>
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<tr>
<td>Persistent</td>
<td>6</td>
<td>26</td>
<td>28</td>
<td></td>
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<tr>
<td>Permanent</td>
<td>11</td>
<td>4</td>
<td>11</td>
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</table>

AF = atrial fibrillation; BMI = body mass index; CAD = coronary artery disease; CHF = congestive heart failure; HFJV = high-frequency jet ventilation; I-EAM = 3-dimensional image integration; LA = left atrium; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; OSA = obstructive sleep apnea; SI = steerable introducer; TIA/CVA = transient ischemic attack/cerebrovascular accident.
300 patients undergoing AF ablation

Despite a sicker population, Jet ventilation added significant improvement to 1-year freedom from AF (52% vs 66% vs 74%)

JET ventilation also cuts down on procedure time (45min-1hour in my experience)
Apnea

EP may request apnea be performed where difficulty with catheter stability is encountered:

-typically left atrial roof, Marshall ridge (anterior to the left pulmonary veins), and at the anterior aspect of the right superior pulmonary vein

-apnea significantly improves catheter stability and lesion formation
During Ablation: Fluctuations in HR and BP

**Adenosine** is frequently given post pulmonary vein isolation to confirm isolation.

Adenosine acts to hyperpolarize cells, thereby increasing conduction times and uncovering potentially dormant conduction/Afib.

A brief period of bradycardia and heart block is observed with resultant brief period of hypotension.

**Isoproterenol** (non-selective β adrenoreceptor agonist) is given post ablation in attempts to induce atrial tachycardias or atrial fibrillation.

Hypotension may be caused with isoproterenol alone or when atrial pacing is performed at the same time.
Potential Complications of AF Ablation
<table>
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<tr>
<th>Signs and symptoms of complications within a month postablation</th>
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<tbody>
<tr>
<td>Back pain</td>
</tr>
<tr>
<td>Chest pain</td>
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<tr>
<td>Cough</td>
</tr>
<tr>
<td>Dysphagia</td>
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<tr>
<td>Early satiety, nausea</td>
</tr>
<tr>
<td>Fever</td>
</tr>
<tr>
<td>Fever, dysphagia, neurological symptoms</td>
</tr>
<tr>
<td>Groin pain at site of access</td>
</tr>
<tr>
<td>Headache</td>
</tr>
<tr>
<td>Hypotension</td>
</tr>
<tr>
<td>Hemoptysis</td>
</tr>
<tr>
<td>Neurological symptoms</td>
</tr>
<tr>
<td>Shortness of breath</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signs and symptoms of complications more than a month postablation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever, dysphagia, neurological symptoms</td>
</tr>
<tr>
<td>Persistent cough, atypical chest pain</td>
</tr>
<tr>
<td>Neurological symptoms</td>
</tr>
<tr>
<td>Hemoptysis</td>
</tr>
</tbody>
</table>
Phrenic nerve paralysis:

Typically resolves but may be permanent. Occurs during radiofrequency ablation at the right superior pulmonary vein and during cryoablation of the right-sided veins.

Diaphragmatic pacing is performed with a catheter at the SVC/RA

Catheter pacing the diaphragm

No paralytic agents should be on board during cryoablation of the right-sided pulmonary veins
Esophageal Injury:
Not only does the esophagus have a variable position within the thoracic cavity, but can also vary temporally and based on patient position.
Can an esophageal temperature probe help to prevent fistulas?

Esophageal heating is a mechanism for injury, but fistulas do occur in cryoablation as well.

lesions occurred in pts with esophageal temp > 41°C (every 1°C increase in esophageal temperature = 1.36 increased odds of esophageal lesion)

**Is there harm associated with temperature probes?**
30% vs 2.5% incidence of esophageal injury in the temperature probe group (n=80 patients)

- Some harm has been associated with the type of temperature probe: temp probes with noninsulated metal thermistors may function as lightning rods, attracting electric current form the ablation catheter and potentiating heat transfer to the esophagus.

- Others suggest that use of a temp probe with insulated thermocouples was as safe compared with ablations performed without a temperature probe
If a patient presents with fever, chest pain, GI or neuro sx within 6 weeks of AF ablation: NO TEE, NO ENDOSCOPY. DO CT SCAN, DIAGNOSE ESOPHAGEAL FISTULA AND SURGERY (NOT STENTING)

Pericarditis

Most patients experience pleuritic chest pain post procedure as a result of transmural ablation lesions, lasting up to 48-72 hours

**Significant improvement with Ketorolac** given at time of procedure, prior to leaving the operating room
Conclusions

1. Early atrial fibrillation originates at the muscular sleeves of the pulmonary veins. With time, scarring in the left atrium can occur resulting in a more complex ablation procedure.

2. New techniques in atrial fibrillation, including contact force sensing catheters, new-generation cryo-balloons, and mapping software have translated into higher success rates with reduced complications. Sicker patients are being ablated.

3. Importance of Anesthesia and EP communication during ablation: issues with paralysis, patient movement, improved catheter stability (JET ventilation/apnea).

4. Esophageal considerations to reduce complications.

5. Specific EP medications used during ablation.

6. And…
Big thank you to all our EP anesthesia teams across Canada, and our team here at McGill

Dr. Bondi, Dr. Bracco, Dr. Predescu, Dr. Owen, Dr. Guzzo, Dr. Donatelli, Dr. Ah-kye, and Dr. Baldini, and the rest of the EP anesthesia team