How to Avoid Complications During AF Ablation

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Major Complications in the Overall Population

Updated Worldwide Survey on the Methods, Efficacy, and Safety of Catheter Ablation for Human Atrial Fibrillation

<table>
<thead>
<tr>
<th>Type of Complication</th>
<th>No. of Patients</th>
<th>Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>25</td>
<td>0.15</td>
</tr>
<tr>
<td>Tamponade</td>
<td>213</td>
<td>1.31</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>15</td>
<td>0.09</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>Sepsis, abscesses, or endocarditis</td>
<td>2</td>
<td>0.01</td>
</tr>
<tr>
<td>Permanent diaphragmatic paralysis</td>
<td>28</td>
<td>0.17</td>
</tr>
<tr>
<td>Total femoral pseudoaneurysm</td>
<td>152</td>
<td>0.93</td>
</tr>
<tr>
<td>Total artero-venous fistulae</td>
<td>88</td>
<td>0.54</td>
</tr>
<tr>
<td>Valve damage/requiring surgery</td>
<td>11/7</td>
<td>0.07</td>
</tr>
<tr>
<td>Atrium-esophageal fistulae</td>
<td>6</td>
<td>0.04</td>
</tr>
<tr>
<td>Stroke</td>
<td>37</td>
<td>0.23</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>115</td>
<td>0.71</td>
</tr>
<tr>
<td>PV stenoses requiring intervention</td>
<td>48</td>
<td>0.29</td>
</tr>
<tr>
<td>Total</td>
<td>741</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Cardiac tamponade
Cardiac tamponade

• incidence of cardiac tamponade
  – 1.2% and a 1.3%

• Risk factors
  – Linear ablation lesions
  – higher ablation power
Cardiac tamponade

- most common causes of cardiac perforation
  - misdirected transseptal punctures either with punctures performed too posteriorly exiting the right atrium into the pericardium before entering the LA or punctures exiting the LA via the roof, LA appendage, or the lateral LA wall,
  - direct mechanical trauma, especially through the LA appendage,
  - overheating during radiofrequency energy delivery, with or without the development of a “pop.”
Cardiac tamponade

Cardiac tamponade

Invagination in the roof of LA
Detection

• abrupt dramatic fall in blood pressure or more insidiously, a gradual decrease in blood pressure.

• An early sign of cardiac tamponade
  – reduction in the excursion of the cardiac silhouette on fluoroscopy
  – ICE
Recognition of Cardiac tamponade

Medical intervention

- **Step 1: BP support**
  Volume, Atropine and pressors

- **Step 2: Reversal of anticoagulation**
  Heparin → Protamine
  1.5 mg/1000 units of heparin given
  Max dose 50 mg,
  High INR → recombinant factor VII, FFP
  Typing and crossmatching for blood

- **Step 3: Control of pericardial pain and inflammation**
  Intrapericardial steroid
  IV narcotics

Procedural intervention

- **Step 1: pericardiocentesis**
- **Step 2: Evacuation of fluid**
- **Resolution of hypotension**

Preparation

- Bleeding resolved
  Observation (12-24hrs)

- Active bleeding

Step 3: Removal of drain

Step 3: surgical repair

Shoei Huang Catheter Ablation of Cardiac Arrhythmias
Injury to the esophagus
Anatomy

Circulation. 2005;112:1400-1405
Anatomy

- Relations between the esophagus and posterior wall of the LA are variable because of displacement of the esophagus by the aortic arch.

*Circulation. 2005;112:1400-1405*
Anatomy

Transmural Thickness (Endocardium-Epicardium) and Muscular Thickness of the Posterior Atrial Wall in 3 Different Regions:

<table>
<thead>
<tr>
<th></th>
<th>R V-A, mm</th>
<th>MPW, mm</th>
<th>L V-A, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epi-Endo</td>
<td>2.3±0.5 (1.1–4.8)</td>
<td>2.5±0.5 (1.1–5.3)</td>
<td>2.2±0.3 (1.2–4.5)</td>
</tr>
<tr>
<td>Myocardium</td>
<td>1.7±0.3 (0.3–3.1)</td>
<td>1.9±0.7 (0.6–3.2)</td>
<td>1.8±0.6 (0.3–3.3)</td>
</tr>
<tr>
<td>Middle level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epi-Endo</td>
<td>2.8±0.5 (1.5–5)</td>
<td>3.8±0.6 (3.1–5)</td>
<td>3.5±1.2 (1.7–5)</td>
</tr>
<tr>
<td>Myocardium</td>
<td>2.5±0.5 (0.5–4)</td>
<td>2.9±0.5 (0.6–4.2)</td>
<td>2.8±0.5 (0.4–3.5)</td>
</tr>
<tr>
<td>Inferior level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epi-Endo</td>
<td>5.7±2.5 (2.7–10)</td>
<td>6.5±2.5 (2.8–12)</td>
<td>5.3±2 (2.5–9)</td>
</tr>
<tr>
<td>Myocardium</td>
<td>4.2±1 (1.1–5.3)</td>
<td>4.3±0.8 (1.3–5.3)</td>
<td>4.1±0.5 (1.1–5)</td>
</tr>
</tbody>
</table>

* Circulation. 2005;112:1400-1405
Anatomy

- The mean thickness of the esophageal wall (from mucosa to adventitia) adjacent to the LA was 2.5 ±1 mm (range, 1.5 to 4.5 mm).
- The minimal distance of the closest contact varied from 3.3 to 13.5 mm.
- The fat pad was thinnest at the level between the orifices of the inferior PV, measuring 0.5 ± 0.2 mm (range, 0.2 to 1.2 mm).

Circulation. 2005;112:1400-1405
Esophageal injury

• Esophageal ulceration
  – 17% (Di Biase L J Cardiovasc Electrophysiol 2010;21:839-44.)

• Perforation

• atrial-esophageal fistula
Esophageal injury

- Esophageal ulceration
  - 17% (Di Biase L J Cardiovasc Electrophysiol 2010;21:839-44.)
- Esophageal mucosal injury has been shown to lead to progressive ulceration ultimately resulting in the development of AEF
Atrioesophageal fistulae

- A 63-year-old man presented to the emergency department (ED) with history of high-grade fever associated with chills and rigours for 4 days. While being evaluated in the ED he had massive hematemesis leading to circulatory collapse and death. He had complained of retrosternal pain, aggravated while swallowing food, for a week before the presentation. Six weeks before the event he had undergone a catheter ablation for AF.

Figure 1. Autopsy specimen of the left atrium from a patient with atrioesophageal fistula after atrial fibrillation ablation. The location of the atrioesophageal fistula is at the ablation site in the posterosuperior aspect of the antrum of the left common pulmonary vein. Image courtesy of Jennifer Walsh, MD, FRCPC, Chief, Laboratory Medicine, Halton Healthcare Services, Oakville, ON, Canada.
Atrioesophageal fistulae

- A 62-year-old woman presented to the ED with confusion, weakness of the left half of the body, and high-grade fever with chills and rigours. The patient had catheter ablation for AF 4 weeks before presentation.
Atrioesophageal fistulae

• less than 0.25%
• Presentation
  – 2 to 4 weeks following the ablation
  – dysphagia, odynophagia, massive gastrointestinal bleeding, a persistent fever and chills, recurrent neurologic events, and septic shock
Atrioesophageal fistulae

• Injury mechanism
  – direct thermal injury,
  – ischemic injury through thermal occlusion of end-arterioles
  – Acid reflux,
  – infection from the lumen
Atrioesophageal fistulae

• Diagnosis
  – CT or MRI
  – barium swallow is not sensitive
  – Endoscopy should be avoided
Atrioesophageal fistulae: prevention

• Imaging the esophagus before ablation
  – Imaging the esophagus (CT/MRI scans)
  – cine-fluoroscopic images during swallowed barium contrast
  – Three-dimensional rotational CT or MRI
Atrioesophageal fistulae: prevention
Atrioesophageal fistulae: prevention

- LET (Luminal esophageal temperature) monitoring
  - the LET might not be reliable if the temperature catheter is not close to the ablation site or if the esophagus is large
  - LET might be significantly lower than esophageal mural temperature and esophageal mucosal injury might occur even after temperature monitoring, resulting in AEF
  - The esophageal temperature might continue to increase in most patients even after RF delivery is interrupted

  - very effective in reducing esophageal mucosal injury, might not be sufficient to eliminate esophageal injury
Atrioesophageal fistulae: prevention

- Esophageal mucosal protection
  - routinely prescribe either proton pump inhibitors or H2 blockers for one to four weeks following ablation
Atrioesophageal fistulae: prevention

- Limiting energy delivery on the posterior LA wall.
  - to 25-30W on the posterior LA
  - avoiding excess tissue contact pressure,
  - moving the ablation catheter every 15 to 20 seconds during ablation anywhere on the LA posterior wall.
- Esophageal mucosal protection
  - routinely prescribe either proton pump inhibitors or H2 blockers for one to four weeks following ablation.
Peri-Esophageal vagal nerve injury
Vagus nerve

Ho SY, J Cardiovasc Electrophysiol. Mar 2006;17(3):330 –331
Peri-Esophageal vagal nerve injury

- Injury to the vagal anterior esophageal plexus
- Caused by RF ablation to the posterior wall
- Common symptoms
  - pyloric spasm and gastric hypomotility
  - nausea, vomiting, bloating and abdominal pain
  - developing within a few hours to a few weeks after the ablation procedure
  - recover within two weeks
- Tx
  - Small low-fat and low-fiber meals
  - Metoclopramide
  - Botulinum injections or surgery
Phrenic nerve injury
Phrenic nerve

- Distance
  - RSPV 2.1 ± 0.4mm
  - RIPV 3.2 ± 0.9mm

Heart Rhythm, Vol 11, No 10, October 2014
Phrenic nerve injury

• common scenario
  – cryoballoon ablation of the right sided PVs
    • incidence of 4.7%.
  – electrical isolation of the SVC with RF energy
• Sx
  – dyspnea, hiccups, atelectasis, pleural effusion, cough, and thoracic pain.
Phrenic nerve injury

A

B

Am Coll Cardiol 2006;47: 2498–503
Prevention:

Electroanatomic map

- The 3-dimensional display of PN position
- Pacing with Max output (10 V x 2.9 ms) with a cycle length of 800 ms

Heart Rhythm 2008;5:1120 – 1126
Prevention:
Pacing the phrenic nerve

- Right PN function monitoring
  - capturing the PN at twice the capture threshold during ablation
  - at cycle lengths ranging from 1500 to 1000 ms.
Phrenic nerve monitoring strategies

- Fluoroscopy
- Palpation
- Electromyography
- Auditory cardiotocography
- Intracardiac echocardiography (ICE)
Phrenic nerve monitoring strategies

ICE

Fetal heart monitor

Heart Rhythm, Vol 11, No 10, October 2014
Phrenic nerve monitoring strategies

- Diaphragmatic compound motor action potential (CMAP)

*Decrease in CMAP amplitude by 35% from baseline predicted and prevented PNI*

Heart Rhythm, Vol 11, No 10, October 2014
Phrenic nerve monitoring strategies

- Different method of CMAP recording
Recommendations to prevent phrenic nerve injury

• Early detection of PNI and immediate termination of ablation
• RF ablation
  – the ablation catheter can be paced at high outputs (10 mA at 2 ms) at putative ablation sites to discern phrenic capture.
  – Capture of PN with high output indicates higher risk of PNI at that particular site, and RFA should be performed more proximally (antrally).
Stroke, TIA, and silent microemboli
Stroke

- A number of potential explanations
  - thrombi on or within stationary sheaths or ablation catheters positioned within the LA,
  - char formation at the tip of the ablation catheter and at the site of ablation,
  - disruption of a thrombus located in the atrium prior to the ablation procedure,
  - electrical cardioversion during procedures.
Peri-procedural Anticoagulation

• Warfarin (INR 2-3) or NOAC
  – All patient for 3 weeks
  – Irrespective of CHADS-VASC score or Sinus rhythm

• TEE
  – all patients in whom there is a doubt about the appropriate anticoagulation
Peri-procedural Anticoagulation

• TEE

  – A TEE should be performed in all patients in whom there is a doubt about the appropriate anticoagulation in the 3 weeks before the intervention
  – Indeed, studies have shown that 1.6–2.1% of patients who have been fully anticoagulated undergoing PVI demonstrate a left atrial thrombus or sludge (Europace 2010;12:927–32.)
  – Although there is no consensus among the Task Force as to whether a TEE should be performed in the subset of patients who have received four weeks of systemic anticoagulation, many in the group perform TEEs in all patients undergoing AF ablation.
## Peri-procedural Anticoagulation

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Before Ablation</th>
<th>During Ablation</th>
<th>After Ablation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninterrupted warfarin</td>
<td>Continue warfarin</td>
<td>Give heparin to achieve an ACT &gt;300 s</td>
<td>Stop heparin and consider protamine; remove sheath when ACT is &lt;250 s; continue warfarin and re-evaluate at 3 mo</td>
</tr>
<tr>
<td>Minimally interrupted or uninterrupted NOAC</td>
<td>Stop NOAC 12–24 h before procedure</td>
<td>Give heparin to achieve an ACT &gt;300 s</td>
<td>Stop heparin and consider protamine; remove sheath when ACT is &lt;250 s; resume NOAC 6–8 h after sheath removal; re-evaluate at 3 mo</td>
</tr>
</tbody>
</table>

*Yonsei University, Wonju College of Medicine*  
*Circulation. 2014;129:1688-1694*
Peri-procedural Anticoagulation

IF INR <2.0,

- Increase VKA dose
- Use UFH (±LMWH) 6-hr after sheath removal until INR is ≥2.0.

LMWH = low-molecular weight heparine; UFH = unfractionated heparin; VKA = vitamin K antagonist
Peri-procedural Anticoagulation

LMWH = low-molecular weight heparin; NOACs = new oral anticoagulants; UFH = unfractionated heparin.

NOACs, once-a-day

NOACs, twice-a-day

UFH or LMWH

Courtesy of The Korea University Dr Jin-Seok Kim 2017 KSC & KHRS
53F Lt Lower lobectomy 11’
Recurred PAF
AF ablation 4PVI/CTI
FU echo
FU echo

2017-04-29

2017-05-01
CT

Se: 402
Im: 133

Study Date: 2017-05-01
Study Time: 오후 11:17:44
MRN:

Se: 401
Im: 176

Study Date: 2017-05-01
Study Time: 오후 11:17:44
MRN:
Left Atrial Intramural Hematoma

FU echo

017-04-29

05-01

05-11

06-08
Take Home message

• Complications are not only related to anticoagulation but also dependent on operator experience and technique.

• For now, periprocedural anticoagulation with NOACs should be tailored based on the patient’s bleeding and thromboembolic risk, comorbidities, as well as the center’s and operator’s experience with the medication and the procedure.
Take Home message

• It must be remembered that the publications from which these data are derived originate from large volume centers where complications would be expected less frequently than in lower volume centers.

• Although these data might be regarded as providing more representative complication rates, it must be recognized that the data were from voluntary surveys and likely underestimated the true complication rates.
How to Avoid Complications During AF Ablation