Atrial Fibrillation

- Most common clinically significant cardiac arrhythmia
- Prevalence 1%
- Affects ~ 2.3 million US adults
- Projected to increase to > 5.6 million by 2050
- Important risk factor for stroke (5X increase)
Role of echo in AF

- Assessing cardiac sizes
- Assessing atrial contribution to LV filling
- Assessing valve function
- Assessing pericardium
- Assessing risk for recurrence after cardioversion
- Hemodynamic benefits of maintaining SR
- Identifying pts at risk for thrombo-embolism before cardioversion or in chronic AF
- Guiding interventions of the LA appendage

Appropriate Use Criteria
JASE 2011;24:229-67

<table>
<thead>
<tr>
<th>Arhythmias With TTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Infrequent APCs or infrequent VPCs without other evidence of heart disease</td>
</tr>
<tr>
<td>4. Frequent VPCs or exercise-induced VPCs</td>
</tr>
<tr>
<td>5. Sustained or nonsustained atrial fibrillation, SVT, or VT</td>
</tr>
<tr>
<td>6. Asymptomatic isolated sinoatrial bradycardia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEE as Initial Test—Atrial Fibrillation/Flutter</th>
</tr>
</thead>
<tbody>
<tr>
<td>112. Evaluation to facilitate clinical decision making with regard to anticoagulation, cardioversion, and/or radiofrequency ablation</td>
</tr>
<tr>
<td>113. Evaluation when a decision has been made to anticoagulate and not to perform cardioversion</td>
</tr>
</tbody>
</table>
New AF: role of TTE

- LA size
- LV function
- MV morphology and function

**TTE for LA size**


*2D guided linear measurement of anteroposterior dimension*

- AP dimension nl < 4 cm (< 2 cm/m²)
  Most reproducible measure of LA size

- LA volume nl < 34 ml/m²
  may still be underestimation
echo for LA size

- LA enlargement
  - common in AF but also AF leads to increased LA size (reversible with maintenance of SR)
  - Prognostic value
    - LA greater than 6 cm greater risk for recurrent AF
    - CV attempt regardless of LA size (?)
- Assessment of LA clot, imaging LA/RA appendage
  - TEE better

Echocardiographic predictors of nonrheumatic AF: Framingham Heart Study
Vaziri et al, Circ 1994:89:724-730
Atrial remodeling in AF
LA and RA enlargement as a consequence of AF
Sanfilippo et al, Circ 1990;82:792-797

Table 1. Change in Atrial Dimensions Between Initial and Follow-up Studies

<table>
<thead>
<tr>
<th></th>
<th>Study 1</th>
<th>Study 2</th>
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</thead>
<tbody>
<tr>
<td>LA measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anteroposterior (mm)</td>
<td>38.6±4.9</td>
<td>42.4±4.6</td>
<td>0.0078</td>
</tr>
<tr>
<td>Mediolateral (mm)</td>
<td>40.6±3.7</td>
<td>46.1±5.2</td>
<td>0.0051</td>
</tr>
<tr>
<td>Superoinferior (mm)</td>
<td>54.6±7.8</td>
<td>62.4±6.2</td>
<td>0.0013</td>
</tr>
<tr>
<td>Volume (cm³)</td>
<td>45.2±11.0</td>
<td>64.1±13.5</td>
<td>0.0001</td>
</tr>
<tr>
<td>RA measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediolateral (mm)</td>
<td>40.7±7.1</td>
<td>46.0±5.7</td>
<td>0.0002</td>
</tr>
<tr>
<td>Superoinferior (mm)</td>
<td>53.5±7.2</td>
<td>58.0±7.1</td>
<td>0.0069</td>
</tr>
<tr>
<td>Volume (cm³)</td>
<td>49.2±22.0</td>
<td>66.2±22.1</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Values are mean±SD.
LA, left atrium; RA, right atrium.

LA size to predict cardiac events for SR but no relation for pts with AF
Tsang et al, JACC 2006;47:1018-1023

Sinus rhythm patients

90 Events (in 62 of 317 SR patients)
new AF =23 strokes =8 TIA =6
MI =12 CHF =14 revasc =26
Death =1

Higher rate of events in AF population compared to SR population but no relation to LA size
TTE in AF: MV function

- MV function (MS, MR) influences LA size
  - Risk of AF
  - Risk of thrombus formation
- Occult MS may present as AF

71 yo F new onset AF and stroke

TTE in AF: LV function

- TTE assessment of LV regional and global function helps guide choice of pharmacologic tx
  - Ventricular rate control
  - Maintenance of SR
- LV dysfunction independent risk for stroke in AF
  - Arch Int Med 1998;158:1316-20
  - BAATAF, SPINAF, SPAF (control/placebo gps)
    - Nonvalvular AF 2.5 RR for stroke when moderate to severe LV dysfunction
      - If low clinical risk but mod/sev LV dysf annual stroke risk increases from 0.8% to 9.3%
        » Converse also true (hi clin risk, nl LV)
AF, embolic stroke, LA thrombus, echo

- LA most common site of cardiac thrombus formation in embolic stroke
  - LA enlargement + AF = biggest risk factor
- TEE – for LA and LA appendage clot assessment

TEE in AF: value in estimating TE risk

- Reserved for when the info will lead to change in tx
  - Early cardioversion strategies
- TEE evidence of LA clot 9 - 15% with nonrheumatic AF of > 3 days duration
  - Increased in high risk pts
    - MS, LVdysf, LAE, SEC, recent TE, higher CHADS2
- LA thrombus by TEE
  - Sens 93-100%; Spec 99-100
  - PPV 86%; NPV 100%
TEE to predict thromboembolism in AF
Stroke Prevention in AF (SPAF)

- 786 pts with non rheumatic AF
  - 382 high risk for thromboembolism (TE)
    - Women > 75
    - Hypertensives
    - prior TE with reduced LV function or recent CHF
- If dense SEC on TEE – > 3X rate of stroke
- If reduced LA appendage peak emptying velocity (< 20 cm/s) – 3X increase
- If LA thrombus – 3X increase
- If complex aortic plaque – 4X increase

LA appendage

- Endocrine role (ANP)
- Source for most of clots
- Most commonly bilobed
  - Spectrum of shapes
    - Different thrombus risks
- Structure: Size, shape
- Function: Cavity velocity, wall velocity, strain
**TEE imaging of the LA appendage**


**LA appendage morphology from CT/cMR association with stroke in AF**

DiBiase et al JACC 2012;60:531-8; Luperico et al, Hrt Rhythm 2016;13:1402-9

Chicken Wing 48%

Cactus 30%

Windsock 19%

Cauliflower 3%

Chicken wing – lowest association with stroke
Cactus – 4X  Windsock – 4.5X  Cauliflower – 8X

Confirmed in meta analysis 8 studies, 2596 pts
LA thrombus

- Can be confused with pectinate muscle, artifact, SEC, sludge, septa between lobes
- Must be seen in multiple views, independent mobility but signal remains present on every frame
Use of contrast in LA appendage

LA appendage function: associated with stroke risk, successful cardioversion

- LAA velocity
  - Normal emptying mean 50-60 cm/s
  - Normal filling mean 40-50 cm/s
- Risk of LAA thrombus increases when emptying velocity < 20 cm/s
- Stroke risk increased when LAA velocity < 15 cm/s (Shively et al, JACC 1996;27:1722)
- If LAA velocity > 40 cm/s higher likelihood will remain in SR after CV
  - Low velocity of limited predictive value
    - Antonielli et al, JACC 2002;39:1443
LAA velocity patterns

SR – biphasic emptying pattern

AF – sawtooth emptying pattern (some AF pts no active emptying velocity)

1 = early diastolic emptying velocity
2 = LAA emptying velocity
3 = LAA filling velocity

Type III

No emptying velocity with AF

sludge
Spontaneous echo contrast (SEC) = stasis commonly when LAA emptying velocity < 20 cm/s

- RBC rouleaux formation
  - Increased RBC aggregation in setting of reduced flow, promoted by fibrinogen and other plasma proteins
- Strong risk factor for thrombus formation (?precursor)
  - Sensitive not specific sign for thrombus formation
  - Present in > 50% with AF, > 80% with LA clot or recent TE
- Prevalence of neuro events higher in pts with SEC (20.5%) than those without (5.7%)
  - Leung et al, JACC 1994;24:755-77
  - ? Still hold with higher frequency imaging

Spontaneous echo contrast (SEC, smoke) gain dependent

- Various qualitative grading schemes (LAA vel, stroke risk proportional)
  - Faint - intermittent
  - Marked/dense – present throughout cardiac cycle
- Sludge - gelatinous, precipitous echodensity without a discrete mass, present throughout the cardiac cycle
Spontaneous echo contrast spectrum of SEC

Safety of CV with non-sludge SEC
all patients had pre-CV AC

<table>
<thead>
<tr>
<th>Study</th>
<th>Total TEE patients</th>
<th>Patients with SEC alone</th>
<th>Patients with SEC cardioverted n (%)**</th>
<th>Pre-CV anticoagulation</th>
<th>Type of anticoagulation (anticoagulation goal)</th>
<th>Complications/ events (%)</th>
<th>Follow-up duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manning**</td>
<td>94</td>
<td>42</td>
<td>42 (44)</td>
<td>Yes</td>
<td>Heparin (PTT 1.4–1.7)</td>
<td>0</td>
<td>30 days</td>
</tr>
<tr>
<td>Manning**</td>
<td>230</td>
<td>85</td>
<td>85 (36)</td>
<td>Yes</td>
<td>Heparin (PTT 1.4–1.7)</td>
<td>0</td>
<td>30 days</td>
</tr>
<tr>
<td>Stoddard**</td>
<td>266</td>
<td>71</td>
<td>54a (20)</td>
<td>Yes: 46 No: 107</td>
<td>Unknown</td>
<td>0</td>
<td>28 days</td>
</tr>
<tr>
<td>Orsinelli**</td>
<td>39</td>
<td>NA</td>
<td>NA</td>
<td>Yes: 19 No: 9</td>
<td>Unknown</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Corrado**</td>
<td>183</td>
<td>68</td>
<td>68 (37)</td>
<td>Yes</td>
<td>Warfarin (INR ≥ 2.0) LMWH (PTT 1.5–2.5)</td>
<td>0</td>
<td>30 days</td>
</tr>
<tr>
<td>ACUTE pilot**</td>
<td>56</td>
<td>37</td>
<td>37 (66)</td>
<td>Yes</td>
<td>Warfarin (INR 2.0–3.0) LMWH (PTT 1.5–2.5)</td>
<td>0</td>
<td>28–56 days</td>
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<tr>
<td>ACUTE trial**</td>
<td>549</td>
<td>NA</td>
<td>NA</td>
<td>Yes</td>
<td>Warfarin (INR 2.0–3.0) LMWH (PTT 1.5–2.5)</td>
<td>5 (0.8)</td>
<td>56 days</td>
</tr>
<tr>
<td>Malataglisi**</td>
<td>757</td>
<td>525</td>
<td>472a (62)</td>
<td>Yes: 78 No:51a</td>
<td>Warfarin (INR 2.0–3.0) LMWH (PTT 1.5–2.5)</td>
<td>1 (0.15)</td>
<td>N/A</td>
</tr>
<tr>
<td>Strandberg**</td>
<td>346</td>
<td>70</td>
<td>70 (20)</td>
<td>Yes</td>
<td>Warfarin, LMWH Unknown</td>
<td>1 (0.36)</td>
<td>365 days</td>
</tr>
</tbody>
</table>

LA appendage function: strain

- Direct measure of LAA function/contractility
- Correlated with LAA emptying velocities
- Reduced post-CV with subsequent improvement


Role of Repeat TEE

- Initial TEE +, course of warfarin, recheck prior to CV
- Initial TEE -, failed DCCV/RFA, do you need to recheck TEE?
    - < 1% incidence of LA thrombus on repeat if initial TEE –
    - No LA thrombus if in SR at repeat
    - The rare thrombi associated with SEC, low EF, ? low INR
    - Retrospective, not randomized
LA Appendage occlusion
Watchman device

- Prospective, controlled, randomized trials
  - PROTECT AF trial
    - First randomized trial → Device vs warfarin
    - CVA, systemic embolus → 3 vs 4.9%
  - PREVAIL trial

- After placement patients are given ASA and warfarin for 45 days
  - Warfarin → clopidogrel for 6 months

LA Appendage occlusion devices:
multiple devices, one FDA approved

www.cito.com/images/articles/2015-08/ss8.jpg
Measuring LAA for device sizing: multiple views to measure depth and find largest orifice diameter

Sizing landing zone for device: from inferior part of LAA ostium at level of Cx to a point 1-2 cm distal to tip of rim of LUPV
At least 0, 45, 90, 135 degrees

TEE procedural guidance: LAA occluder
positioning, tug test for stability, color Doppler assess for leaks, compression diameter (8-20%), deploy, check LUPV to insure no compression/obstruction, check for Peric eff
Post-deployment assessment

- Residual leaks common in first year after deployment
  - 16% Plug (not FDA approved indication); 32% Watchman
  - no standardized definition for grading leaks

- Protect AF Trial
  - Leak < 5 mm did not resume AC and noninferior stroke rate c/w AC group (no device)
  - Leak > 5 mm restart AC
Summary: many roles for echo in AF

- TTE
  - in all with first episode of AF
  - LA size, LV function, valve function, pericardial effusion
  - Repeat TTE for recurrent AF only if clinical presentation/condition has changed

Summary (continued)

*Echo in AF*

- TEE
  - Main role to guide early CV (LA thrombus)
    - Assessing complex-shaped LA appendage
      - Morphology, function
  - Delay CV if LA clot present and repeat TEE after appropriate course of anticoagulation and prior to CV
  - Guiding deployment of LA appendage occlusion devices