Echocardiographic Cardiovascular Risk Stratification: Beyond Ejection Fraction

October 4, 2014

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Disclosures

- Financial – none
- Images – “borrowed”
Objectives

- Understand the concept of clinical risk stratification
- Learn about the application of echocardiography to cardiovascular risk stratification
- Review specific echocardiographic parameters and their clinical significance
Diagnosis: To Be, or Not To Be…

To evaluate…
- Abnormal EKG
- Murmur
- Chest pain
- Shortness of breath/dyspnea
- Lightheadedness/dizziness/presyncope/syncope
- Sepsis
- Stroke

...and diagnose or rule out…
- Cardiomyopathy
- Valvular disease
- Ischemia
- Heart failure
- Pericardial effusion
- Endocarditis
- Thrombus
Clinical Risk Stratification (Prognosis)

“What are the risk/chances/odds that my patient will have XYZ-outcome?”

- Death
- Myocardial infarction
- Stroke / systemic embolism
- Congestive heart failure
- New onset atrial fibrillation
- Syncope
- Hospitalization
- Coronary revascularization (PCI or CABG)
- Valvular surgery or procedure
- Pacemaker / defibrillator
Risk Stratification

- **Clinical variables (the “H&P”)**
  - Age, Sex, Ethnicity
  - History of present illness / Symptoms
  - Past medical history / Comorbidities
  - Social history, Family history
  - Vital signs, Physical exam findings

- **EKG variables**
  - Rhythm, Rate
  - Intervals, QRS

- **Imaging**

- **Laboratory variables**
  - CBC, Chem, TFTs
  - FLP, A1C, BNP, hs CRP, Troponin

- **Other testing**

- **Pretest probability**

- **Clinical decision making**
“There’s just so much information in an echocardiogram.”

- Left ventricular size, structure and function
- Valvular stenosis and regurgitation
- Left atrium
- Right ventricular size, structure and function
- Hemodynamics
  - Inferior vena cava size
  - Left ventricular outflow tract VTI
- Aortic root
Technical Difficulties...

“Echocardiography is operator dependent”

Accuracy depends on...
- Sonographer
- Interpreting physician
- Instrument

Some findings can change significantly over short periods of time
Left Ventricle

- Size
- Structure
  - Wall thickness
  - Shape (aneurysm, spherical remodeling, pattern of hypertrophy, etc.)
- Systolic function
  - **EJECTION FRACTION**
  - Regional wall motion abnormalities
  - Paradoxical septal motion
- Diastolic function
- Tissue Doppler, strain, strain rate, etc.
Valvular Disease

- Regurgitation
- Stenosis
- Other (rheumatic, congenital, etc.)

Mild, mild-moderate, moderate, moderate-severe, severe – a gradient of risk

Findings, particularly for regurgitation, are dynamic
Recommendations for Chamber Quantification: A Report from the American Society of Echocardiography’s Guidelines and Standards Committee and the Chamber Quantification Writing Group, Developed in Conjunction with the European Association of Echocardiography, a Branch of the European Society of Cardiology

Members of the Chamber Quantification Writing Group are: Roberto M. Lang, MD, FASE, Michelle Bierig, MPH, RDCS, FASE, Richard B. Devereux, MD, Frank A. Flachskampf, MD, Elyse Foster, MD, Patricia A. Pellikka, MD, Michael H. Picard, MD, Mary J. Roman, MD, James Seward, MD, Jack S. Shanewise, MD, FASE, Scott D. Solomon, MD, Kirk T. Spencer, MD, FASE, Martin St John Sutton, MD, FASE, and William J. Stewart, MD

Quantification of cardiac chamber size, ventricular mass, and function ranks among the most clinically important and most frequently requested tasks of echocardiography. Standardization of chamber quantification has been an early concern in echocardiography and recommendations on how to measure such fundamental parameters are among the most often cited articles in the field.¹,² During the last decades, echocardiographic methods and techniques have improved monic imaging, fully digital machines, left-sided contrast agents, and other technologic advancements.

Furthermore, echocardiography has become the dominant cardiac imaging technique, which, because of its portability and versatility, is now used in emergency, operating, and intensive care departments. Standardization of measurements in echocardiography has been inconsistent and less often compared with other imaging modalities.
What is Normal? (i.e., the Importance of Indexing)
Left Atrium: Diameter

- 1 dimensional
- 2D preferred over M-mode
- Simple, easy, fast
- Overly simplistic
Left Atrium: Area

- Somewhat more accurate
- Simple, easy, fast
- Overly simplistic
Left Atrium: Volume

- Ellipsoid (area-length) or Simpson’s
- Biplane preferred over single plane
- More time consuming
- Still overly simplistic, but getting closer…
<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reference range</td>
<td>Mildly abnormal</td>
</tr>
<tr>
<td><strong>Atrial dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA diameter, cm</td>
<td>2.7–3.8</td>
<td>3.9–4.2</td>
</tr>
<tr>
<td>LA diameter/BSA, cm/m²</td>
<td>1.5–2.3</td>
<td>2.4–2.6</td>
</tr>
<tr>
<td>RA minor-axis dimension, cm</td>
<td>2.9–4.5</td>
<td>4.6–4.9</td>
</tr>
<tr>
<td>RA minor-axis dimension/BSA, cm/m²</td>
<td>1.7–2.5</td>
<td>2.6–2.8</td>
</tr>
<tr>
<td><strong>Atrial area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA area, cm²</td>
<td>≤20</td>
<td>20–30</td>
</tr>
<tr>
<td><strong>Atrial volumes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA volume, mL</td>
<td>22–52</td>
<td>53–62</td>
</tr>
<tr>
<td><em>LA volume/BSA, mL/m²</em></td>
<td>22 ± 6</td>
<td>29–33</td>
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</table>
So What?

- Increased LA size is a marker of severity and chronicity of LV diastolic dysfunction, increased LA (and LV) filling pressures, and risk for...
  - Atrial fibrillation – incidence and recurrence
  - Heart failure – hospitalization and death
  - Stroke
  - Death after myocardial infarction
  - Death

- Advancing age alone does not independently contribute to LA enlargement; the indexed volume from childhood onward in normal healthy patients does not change significantly

- Sex differences in LA volume can largely be accounted for by the differences in body surface area between men and women
Case – 66 yo W with palpitations

- 66 yo African American woman with mild palpitations described as “fluttering” most often at night when trying to sleep, sometimes during the day when sitting quietly at her desk, two or three times a week for the last six weeks – no other symptoms – sent by PMD
- Admits to increased stress at work, considering retirement
- PMH: HTN, overweight
- Married, two grown children
- Administrative assistant
- Never smoked, exercises by walking around the neighborhood 30-45 minutes three times a week with husband
- PE – normal VS, BMI 30, II/VI HSM @ LLSB
- EKG – NSR, possible LAE, NSTTs
- PMD performed routine labs (CBC, Chem, TFTs) – all normal
Case

Possible diagnoses

- Stress-related (benign)
- Primary arrhythmias – atrial fibrillation
- Secondary arrhythmias (due to other underlying disease, i.e. cardiomyopathy)
- Other medical problem (hyperthyroidism, anemia, etc.)

Echo? Holter? Event monitor? Xanax?
Right Ventricle: Neglected

- Size
- Wall thickness
- Systolic function
- Diastolic function
- Tissue Doppler, strain, strain rate
RV Size and Function:
Qualitative “method” (i.e. eyeball it)

- **Size**
  - Mild – smaller than LV, not reaching the apex
  - Moderate – similar to LV, sharing the apex
  - Severe – larger than LV, apex-forming

- **Function**
  - Wall motion
  - “TAPSE”
So What?

- The RV is not just a conduit, it provides the entire cardiac output... to the lungs
- Size and function have prognostic implications on:
  - Congenital heart disease
  - Pulmonary embolism
  - Pulmonary arterial hypertension
  - Myocardial infarction
  - Left sided systolic heart failure
Hemodynamics: IVC

- Size ~ right atrial pressure
- ASE recommends:
  - 0.5 to 3 cm proximal to hepatic vein
  - Sniff and quiet respiration
  - Can also use short axis view (cross section) to rule out translation of the IVC into another imaging plane
  - Dilated IVC may be normal in young athletes
  - Not reliable in mechanically ventilated patients (<1.2 cm accurately identifies hypovolemic patients)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal (0-5 [3] mm Hg)</th>
<th>Intermediate (5-10 [8] mm Hg)</th>
<th>High (15 mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVC diameter</td>
<td>≤2.1 cm</td>
<td>≤2.1 cm</td>
<td>&gt;2.1 cm</td>
</tr>
<tr>
<td>Collapse with sniff</td>
<td>&gt;50%</td>
<td>&lt;50%</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>Secondary indices of elevated RA pressure</td>
<td></td>
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</tr>
</tbody>
</table>

- Restrictive filling
- Tricuspid E/E' > 6
- Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)
So What?

- Rapid assessment of volume status
- \[ \text{PASP} = \text{RVSP} + \text{RAP} \]
- \[ \text{Systemic Vascular Resistance (SVR)} = \frac{\text{MAP} - \text{CVP}}{\text{RAP}} \]
- \[ \frac{\text{CO}}{} \]

- Non-invasive pulmonary artery (Swan-Ganz) catheterization
Hemodynamics: LVOT VTI

- Not only for AS...
- Can use LVOT VTI to estimate CO
- Poor CO is half the diagnosis of cardiogenic shock
- Also useful to identify high CO

**INTERMACS Official Shorthand**

<table>
<thead>
<tr>
<th>Category</th>
<th>Shorthand</th>
<th>Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Critical Cardiogenic Shock</td>
<td>&quot;Crash &amp; Burn&quot;</td>
<td>Hours</td>
</tr>
<tr>
<td>2. Progressive Decline</td>
<td>&quot;Sliding Fast&quot;</td>
<td>Days to Weeks</td>
</tr>
<tr>
<td>3. Stable but Inotrope Dependent</td>
<td>&quot;Stable but Dependent&quot;</td>
<td>Weeks</td>
</tr>
<tr>
<td>4. Recurrent Advanced Heart Failure</td>
<td>&quot;Frequent Flyer&quot;</td>
<td>Weeks to Months if baseline is restored</td>
</tr>
<tr>
<td>5. Exertion Intolerant</td>
<td>&quot;Housebound&quot;</td>
<td>Weeks to Months</td>
</tr>
<tr>
<td>6. Exertion Limited</td>
<td>&quot;Walking Wounded&quot;</td>
<td>Months if nutrition and activity maintained</td>
</tr>
</tbody>
</table>

Source: INTERMACS quarterly statistical report released June 2, 2009
Aortic Root

- TTE - parasternal long axis
- TEE provides much more complete exam
- Aortic root diameter at the sinuses of Valsalva is related most strongly to BSA and age
- 2D more accurate than M-mode (which underestimates)
So What?

- Aortic root dilatation associated with...
  - Bicuspid aortic valve
  - Marfan’s
  - Aortic regurgitation
  - Risk for aortic dissection
  - Risk for aortic rupture

- TTE allows for identification and surveillance of at-risk patients
Technical Difficulties…

Recommendations (requests / pleas!):

– Make linear measurements using 2D, not M-mode
– Use Simpson’s method to estimate LVEF
– Use left atrial volume > left atrial area > left atrial diameter
– Index to body surface area
Clinical Echocardiography in 2014

Despite rapidly advancing knowledge and technology, medicine (and the universe) still obeys the Law of Diminishing Marginal Utility or Return.
A
B
M
2D
Doppler
Tissue Doppler
3D
The future and beyond!
Strain, speckle…

3D
Tissue Doppler
Doppler
2D
M
B
A
Conclusions

There really is “so much” information in an echocardiogram
- there is more to the left ventricle than just EF
- there is more to the heart than just the left ventricle
- there is more to the echocardiogram than just the heart
- (there is more to the patient than just the echocardiogram)

Echocardiography will remain a workhorse of clinical cardiology