Echocardiographic Evaluation of the Heart Failure Patient

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Echo in Heart Failure

• “The single most useful diagnostic test in the evaluation of patients with heart failure is the comprehensive 2-dimensional echocardiogram coupled with Doppler flow studies…”

Hunt et al., ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult., JACC 2005;46:e1-82.
When to Get an Echo in the Patient with Heart Failure

• New Diagnosis
2-D Echo Measurements in HF
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When to Get an Echo in the Patient with Heart Failure

- New Diagnosis
- Change in clinical status
- After uptitration of medical therapy
- Routine exams
  - ? frequency
### Evaluation of Standard Doppler Echocardiographic Techniques in HF

<table>
<thead>
<tr>
<th>Technique</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doppler (hemodynamics)</td>
<td>1. Facile</td>
<td>1. Requires parallel alignment of Doppler beam</td>
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<tr>
<td></td>
<td>2. Rapid</td>
<td>2. Pulmonary and tricuspid valve regurgitation not always present</td>
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<tr>
<td></td>
<td>3. On-line</td>
<td>3. Stroke volume measurement from LVOT overestimated in significant AI</td>
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<tr>
<td>Doppler (diastolic function)</td>
<td>1. Facile</td>
<td>1. Requires parallel alignment of Doppler beam</td>
</tr>
<tr>
<td></td>
<td>2. Rapid</td>
<td>2. Heart rate dependent</td>
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<tr>
<td></td>
<td>3. On-line</td>
<td>3. Load dependent</td>
</tr>
<tr>
<td></td>
<td>4. Prognostic</td>
<td></td>
</tr>
<tr>
<td>2D EF, dimensions and mass</td>
<td>1. Facile</td>
<td>1. Dependent on image quality</td>
</tr>
<tr>
<td></td>
<td>2. Rapid</td>
<td>2. Foreshortening common</td>
</tr>
<tr>
<td></td>
<td>3. Prognostic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. On-line</td>
<td>3. High inter- and intra-observer variability</td>
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<td></td>
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<td>4. Requires geometric assumptions</td>
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<td></td>
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<td>5. Does not correlate well with clinical status</td>
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</tbody>
</table>

2D = 2-dimensional; AI = aortic insufficiency; EF = ejection fraction; HF = heart failure; LVOT = left ventricular outflow tract.
2-D Echo Measurements in HF

- Left ventricle:
  - Dimensions
  - Ejection fraction
  - Volumes
2-D Measurements of the LV
• EF and LV dimensions do NOT correlate with:
  – HF symptoms
  – Exercise capacity
  – Myocardial oxygen consumption
2-D Echo Measurements in HF
Ejection Fraction

- There is a difference between normal EF and normal stroke volume.
  - Severe concentric hypertrophy
  - Severe mitral regurgitation.
Right Ventricle

• Very hard to quantify.
• Difficult to assess size with certainty.
• Multiple images imperative.
• Subcostal and Parasternal long are probably most important.
Mass and Volumes

• Important markers of disease progression and prognosis.
• Require careful comparison of serial echos.
• Rarely done in quantitative fashion in clinical practice.
• Unlikely to appear in a boards question.
Hemodynamic Assessment in the Echo Lab

- Left sided filling pressures
  - Mitral inflow
  - Pulmonary vein flow
  - Tissue Doppler of mitral annulus
- Cardiac Output
  - 2-D dimension and pulse wave Doppler of LVOT
- PA pressures
  - Continuous wave Doppler of TR
- CVP
  - IVC Imaging
Hemodynamic Assessment in the Echo Lab

- Left sided filling pressures
  - Mitral inflow
  - Pulmonary vein flow
  - Tissue Doppler of mitral annulus
Diastolic Dysfunction

Diastole is divided into 4 phases:
- **IVRT**
- **Rapid Filling**
- **Diastasis**
- **Atrial Filling**

- **RELAXATION**
- **ELASTIC RECOIL**
- **PASSIVE ELASTICITY**

Left ventricle

Left atrium

IVRT Rapid Filling Diastasis Atrial Filling

Diastole is divided into 4 phases
Echo Assessment of Diastole: Mitral Inflow Pattern

- Peak E velocity
- E decel slope
- E decel time
- Peak A velocity
- A wave duration
Diastolic Filling Measured Non-Invasively

Left ventricle

Left atrium
Diastolic Filling Measured Non-Invasively

Left ventricle

Left atrium

Impaired relaxation
Diastolic Filling Measured Non-Invasively

Left ventricle

Left atrium

Normal or Pseudonormal?
Tissue Doppler Imaging
Annular Velocities

![Graph showing annular velocities with categories: REALLY GOOD, GOOD, BAD, REALLY BAD, REALLY, REALLY BAD. The graph indicates a line that peaks at REALLY BAD and REALLY, REALLY BAD, and troughs at BAD.]
Tissue Doppler Imaging
Annular Velocities

S, peak systolic velocity; E, peak early diastolic velocity; A, peak atrial velocity.
Echo Assessment of Diastole

Graph showing different metrics for diastolic function:
- **E/A Ratio**
- **Relaxation Velocity**
- **Atrial Pressure**

Axes:
- **Low** to **High**

Categories:
- **Really Good**
- **Good**
- **Bad**
- **Really Bad**
- **Really, really bad**
Diastolic Filling Measured Non-Invasively

92 cm/s

18.3 cm/s

127 cm/s

6.5 cm/s
Assessment of LA Pressure by Echo

\[ Y = 1.55 + 1.47X \]

\[ R = 0.86 \]

\[ N = 100 \]
Restrictive Filling

Octave
Freq.: 1.7 MHz/3.3 MHz
Proc.: 14.0/5.0/5.9/0.4
Power: 0.0 dB
FPS: 38.3
Depth: 15.0 cm
Scale: 173.1 cm/s
LVRel: 4.8 cm/s
Proc.: -6.0/5.0/0.0

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>MV E Vel</td>
<td>1.09 m/s</td>
</tr>
<tr>
<td>MV DecT</td>
<td>79 ms</td>
</tr>
<tr>
<td>MV Dec Slope</td>
<td>13.8 m/s²</td>
</tr>
<tr>
<td>MV A Vel</td>
<td>0.23 m/s</td>
</tr>
<tr>
<td>MV E/A Ratio</td>
<td>4.72</td>
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Hemodynamic Assessment in the Echo Lab

• Left sided filling pressures
  – Mitral inflow
  – Pulmonary vein flow
  – Tissue Doppler of mitral annulus

• Cardiac Output
  – 2-D dimension and pulse wave Doppler of LVOT
Figure 5 Left ventricular outflow tract diameter is measured in the parasternal long-axis view in mid-systole from the white-black interface of the septal endocardium to the anterior mitral leaflet, parallel to the aortic valve plane and within 0.5–1.0 cm of the valve orifice.

\[ SV = \left( \frac{\text{LVOT diameter}}{2} \right)^2 \times 3.1415 \times \text{LVOT VTI}. \]

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Newer Echo Techniques that may have utility in Heart Failure

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Evaluation of Novel Doppler Echocardiographic Techniques in HF</th>
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| Real time 3D for EF and volumes | 1. Eliminates foreshortening  
2. Geometric assumptions not required  
3. Simultaneous assessment of all wall segments | 1. Highly dependent on image quality  
2. Extra expense of software and probe  
3. Incremental value over 2D not well established  
4. Sonographer expertise required  
5. Not widely available |
| Tissue Doppler, strain, and strain rate | 1. Prognostic  
2. Most parameters load independent  
3. Widely available (tissue velocity)  
4. Less dependent on image quality | 1. Angle dependent  
2. Strain and strain rate require off-line analysis  
3. Low signal/noise ratio |
| Tissue tracking | 1. Not angle dependent  
2. Able to assess torsional mechanics | 1. Extra expense of software  
2. Incremental value over TDI not well established  
3. Speckles move in and out of plane (requires mathematical assumptions to compensate)  
4. Requires off-line analysis  
5. Not widely available |

Kirkpatrick et al., JACC 2007; 50:381-96.