Echo in CAD: Wall Motion Assessment

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Relevant References

• ACC/AHA/ASE 2003 Guideline Update for the Clinical Application of Echocardiography
• Bayes de Luna A et al. “A new terminology for LV walls and localization of MI that present Q wave based on MRI” Circulation. 2006;114:1755.
• Otto CM. The Practice of Clinical Echocardiography. 2nd Ed. 2002.
  – Ch 11: “The role of echocardiographic evaluation in patients with acute chest pain”
  – Ch 12: “Echocardiography in the coronary care unit”
  – Ch 13: “Exercise echocardiography”
  – Ch 14: “Stress echocardiography with nonexercise techniques”
Coronary Flow Physiology

- Different physiology between right and left coronary arteries
- Based on differences between right and left ventricular systolic pressures

Coronary Reserve

Normalized mean flow - times initial control

Braunwald, 1997
P. 1172
Myocardial Ischemia

- Imbalance between myocardial oxygen demand and supply

Braunwald, 2000
Causes of Myocardial Ischemia

- **Inadequate Supply**
  - Coronary

- **Obstruction**
  - Spasm
  - Thrombosis
  - Steal
  - Severe diastolic ↓BP
  - Tachycardia
  - Cardiomegaly
  - Low capillary density
  - Anemia

- **Excessive Demand**
  - Tachycardia
  - Hypertension
  - Cardiomegaly
  - High contractility

Heart Rate Effects on the Cardiac Cycle

<table>
<thead>
<tr>
<th>Resting HR 66</th>
<th>Tachycardia HR 150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systole</td>
<td>Diastole</td>
</tr>
<tr>
<td>0.92 sec</td>
<td>0.4 sec</td>
</tr>
<tr>
<td>0.50 sec</td>
<td>0.16 sec</td>
</tr>
<tr>
<td>33 sec/min</td>
<td>24 sec/min</td>
</tr>
</tbody>
</table>
Ischemic time and outcome

- <5 min – recovery in 1-2 min
- 30-120 min – recovery in 48-72 hours
- 4-6 hours – no recovery; scar in 6 weeks
- In clinical practice, may take weeks to months to recover
- Repetitive ischemia may mimic hibernation
- Infarct expansion occurs in about 48 hours, acute thinning (often pain and ECG changes but no biomarker elevation) – risk (substrate) for mechanical complication
- Wall motion abnormality overestimates MI size due to tethering (overestimation is about 15%)
- Vertical (endo-to-epi) tethering gives akinesis if 20% of endocardial thickness is affected.

Indications for TTE and TEE

- Concerning test results (CXR, BNP, ECG)
- LV function post MI, first evaluation
- LV function in MI recovery when results will guide therapy
- Hypotension or hemodynamic instability of uncertain or suspected cardiac origin
- TTE during chest pain with suspected but not confirmed ischemia (indeterminate biomarkers or ECG)
- Suspected complication of AMI
- Respiratory failure with suspected cardiac cause
- Known or suspected heart failure, first evaluation

Technical Points in Wall Motion

• Good endocardial border definition is key (add contrast if 2-4 segments are completely or partially obscured)
• Regional wall motion interpretation requires an experienced echocardiographer

Otto CM. 2nd Ed. 2002. p. 239.
Physiologic Points in Wall Motion

• Transmural extent of infarction is related to regional wall motion
  – Both acute (6 hr) and subacute (72 hr)
  – 75% thickness infarction moves better than 100% thickness

• Distribution of wall motion is correspondent to coronary artery supplying the area
  – May be atypical in presence of collaterals or prior CABG

• Infarct expansion – infarcted segment thins and stretches and circumferential extent of necrotic zone increases
  – Begins immediately with infarction, progresses over 7 days
  – Requires involvement of 20% of myocardial mass to occur
  – Leads to aneurysm
  – Noninfarcted myocardium also increases – LV dilation

• Definitions
  – Normal: at least 5 mm endocardial excursion
  – Hypokinesia: less than 5 mm
  – Akinesia: no inward excursion (less than 2 mm)
  – Dyskinesia: outward excursion

• Experimental Ischemia
  – Threshold of 10-20% reduction in blood flow impairs wall thickening and 80% reduction results in akinesis
  – Decreased wall thickening extends beyond reduced flow (“tethering”)

• Clinical Ischemia (complete balloon occlusion)
  – Regional endocardial dysfunction in 19 sec
  – ECG change in 30 sec
  – Chest pain 39 sec

• Clinical Ischemia (stress in region of coronary stenosis)
  – Wall motion abnormality in 30 sec
  – ECG change in 90 sec

Physiologic Points in Wall Motion

• Akinesia or dyskinesia and thinned and dense wall – most likely infarction
• If not thin, quite likely to be viable

<table>
<thead>
<tr>
<th>Wall Motion at Rest</th>
<th>Wall Motion During Exercise</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Normal</td>
<td>Abnormal: Worsening</td>
<td>Ischemic</td>
</tr>
<tr>
<td>Abnormal excursion</td>
<td>Fixed: No significant</td>
<td>Scar: Transmural Infarction</td>
</tr>
<tr>
<td>(thinned)</td>
<td>change</td>
<td></td>
</tr>
<tr>
<td>Abnormal excursion</td>
<td>New or worsening abnormality</td>
<td>Hibernating</td>
</tr>
<tr>
<td>(preserved thickness)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Scoring System for Wall Motion

<table>
<thead>
<tr>
<th>Score</th>
<th>Wall Motion</th>
<th>Endocardial Motion</th>
<th>Wall thickening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal (&gt;30%)*</td>
</tr>
<tr>
<td>2</td>
<td>Hypokinesis</td>
<td>Reduced</td>
<td>Reduced (&lt;30%)</td>
</tr>
<tr>
<td>3</td>
<td>Akineses</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>4</td>
<td>Dyskinesis</td>
<td>Outward</td>
<td>Thinning</td>
</tr>
<tr>
<td>5</td>
<td>Aneurysmal</td>
<td>Diastolic deformity</td>
<td>Absent or thinning</td>
</tr>
</tbody>
</table>

*35-40%; from 9-11 to 14-16 mm (Feigenbaum)

Wall Motion Scoring

• Interpretation: most widely accepted is that recommended by ASE
  – 1 is normal
  – 2 is hypokinetic
  – 3 is akinetic
  – 4 is dyskinetic
  – 5 is aneurysm
  – Some use 0 as hyperkinetic (expected with stress)

From Otto, CM. 2nd ed, 2002; p. 239, 275
Echo Wall Segments

Of interest as prior method, 16 segments

Wall Segments

Not 16 but 17

Wall Segments


( Otto’s second ed, 2002 still uses the classic echo terminology )
Wall Segments

Coronary Artery Territories

Coronary Segments

Feigenbaum LAD or LCX

Feigenbaum LCX

From Otto, CM. The Practice of Clinical Echocardiography, 2nd ed, 2002; p. 284
Historic Wall Motion

It is the consensus of this report to recommend that the term *posterior* be abandoned and that the term *inferior* be applied to the entire LV wall that lies on the diaphragm.

Bayes de Luna A et al. *Circulation*. 2006;114:1755
Recent Guidelines

Bayes de Luna A et al. Circulation. 2006;114:1755
Correlation with MRI in inferior base

Bayes de Luna A et al. Circulation. 2006;114:1755
Wall Analysis in MRI

Bayes de Luna A et al. Circulation. 2006;114:1755
Lateral MI and Inferobasal MI

Bayes de Luna A et al. Circulation. 2006;114:1755
Coronary Distribution

Bayes de Luna A et al. Circulation. 2006;114:1755
ECG Terminology Consensus

<table>
<thead>
<tr>
<th>NAME</th>
<th>ECG PATTERN</th>
<th>INFARCTION AREA (CMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPTAL</td>
<td>Q in V1-V2</td>
<td></td>
</tr>
<tr>
<td>MID-ANTERIOR</td>
<td>Q (qs or qr) in aVL and sometimes in I and/or V2-V3</td>
<td></td>
</tr>
<tr>
<td>APICAL - ANTERIOR</td>
<td>Q in V1-V2 to V3-V6</td>
<td></td>
</tr>
<tr>
<td>EXTENSIVE ANTERIOR</td>
<td>Q in V1-V2 to V4-V6, aVL and sometimes I</td>
<td></td>
</tr>
<tr>
<td>LATERAL</td>
<td>RS in V1-V2 and/or Q wave in leads I, aVL, V6 and/or diminished R wave in V6</td>
<td></td>
</tr>
<tr>
<td>INFERIOR</td>
<td>Q in II, III, aVF</td>
<td></td>
</tr>
</tbody>
</table>

Bayes de Luna A et al. Circulation. 2006;114:1755
<table>
<thead>
<tr>
<th>Interpretation</th>
<th>At Rest</th>
<th>After Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td><strong>CAD/No MI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>Normal</td>
<td>Hypokinetic, akinetic, or dyskinetic</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td><strong>CAD/Nontransmural MI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>Hypokinetic/akinetic</td>
<td>Augmented, hypokinetic, akinetic, or dyskinetic (depending on IRA patency)</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Partial or full</td>
<td></td>
</tr>
<tr>
<td><strong>CAD/Transmural MI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>Akinetic</td>
<td>Akinetic or dyskinetic</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Thinned</td>
<td></td>
</tr>
<tr>
<td><strong>CAD/Hibernating/Stunned</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>Hypokinetic or akinetic</td>
<td>Incompletely investigated, may augment with mild exercise</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Partial or full</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Parasternal long-axis echocardiogram recorded at rest (left) and immediately after exercise (right) in a patient with stenosis of the left anterior descending coronary artery. Diastolic frames are on the top, and systolic frames are on the bottom. At rest, notice the normal contraction of the septum and posterior wall. Immediately after exercise, the proximal septum has normal contractility (downward pointing arrow), and there is dyskinesia of the distal ventricular septum (upward pointing arrows).
Proportion of Patients Referred for Exercise Testing

- 35% Able to exercise, ECG interpretable
- 24% Able to exercise, but ECG not interpretable
- 20% Submaximal exercise
- 21% Unable to exercise

## Interpretation of Viability and Ischemia with Dobutamine Echocardiography

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Resting Function</th>
<th>Low-Dose Function</th>
<th>Peak/Poststress Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Hyperkinetic</td>
</tr>
<tr>
<td>Ischemic</td>
<td>Normal</td>
<td>Normal (unless severe CAD)</td>
<td>Reduction vs. rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduction vs. other segments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Delayed contraction</td>
</tr>
<tr>
<td>Viable, patient IRA</td>
<td>Hypo/akinetic</td>
<td>Improvement</td>
<td>Sustained improvement</td>
</tr>
<tr>
<td>Viable, stenosed IRA</td>
<td>Hypo/akinetic</td>
<td>Improvement</td>
<td>Reduction (c/w low-dose)</td>
</tr>
<tr>
<td>Infarction</td>
<td>A/dyskinetic</td>
<td>No change</td>
<td>No change</td>
</tr>
</tbody>
</table>

From Otto, CM. *The Practice of Clinical Echocardiography*, 2nd ed, 2002; p. 306
Interpretive Tips

• Regions that fail to thicken or that move only in late systole (after movement of adjacent myocardium) may be moving passively and should be considered akinetic, irrespective of endocardial excursion.

• Segments with resting akinesis or dyskinesis are most likely composed of infarcted myocardium if the wall is thinned and dense, but in the absence of thinning are quite likely to consist of viable tissue.

• Improvement of abnormal function in response to low dose (5-10) suggests viable myocardium, although this finding is more reliable if the segment subsequently deteriorates, which indicates ischemia.

• The LV cavity should decrease; if it increases it indicates multivessel or LMCA disease.

From Otto, CM. The Practice of Clinical Echocardiography, 2nd ed, 2002; p. 309
Interpretive Tips - 2

- Deterioration from rest or after an initial enhancement indicates ischemia
- Variants include tardokinesis or reduction of myocardial thickening
- Caution assessing adjacent zone to MI that even though normal can appear hypokinetic or dyskinetic due to tethering
- Diagnosis of ischemia in hypokinetic resting segments is most challenging because differentiation between degrees of hypokinesis may be difficult, even with quad screen display
- Hypokinetic region that fails to improve can call ischemic if adjacent segments become hyperkinetic
- Greatest limitations are subjectivity and reproducibility

From Otto, CM. The Practice of Clinical Echocardiography, 2nd ed, 2002; p. 309
Interpretive Guideline

• Basal inferior or basal septal hypokinesis ignored unless
  – Adjacent area affected by new dyssynergy
  – Clear deterioration to akinesias or dyskinesia
• Induced delayed contraction is ischemic if no BBB
• Identification of ischemia based on expected coronary distribution
  – A mid septal abnormality was disregarded if the apex was spared
• Significant resting abnormality
  – Hypokinesis in at least 3 segments or akinesis in at least 1 segment
  – Suggests abnormal test and presence of CAD

Guidelines to Reduce Variability in Interpretation

• Minor degrees of hypokinesia are not identified as ischemia (esp. if only at peak and not poststress)
• Focal abnormalities that do not follow angiographic territories are ignored
• Abnormalities are corroborated whenever possible with another view
• Basal inferior and septal segments are not identified as abnormal in the absence of a neighboring abnormal segment
• Studies are read by multiple observers whenever possible
• Reading is blinded to all other data

From Otto, CM. The Practice of Clinical Echocardiography, 2nd ed, 2002; p. 309
Wall motion Score Index WMSI

- Segment number: 1=normal, 2=hypo, 3=akineti, 4=dyskinetica
- Sum the segment numbers and divide by number of segments
- WMSI>1.4 or stress EF<50% is worse prognosis (similar to perfusion defect size >15%)

Echo in Mechanical Complications of MI

- VSD
- MR
- Rupture
- True Aneurysm
- Pseudoaneurysm
Thank you.

Questions?