Echo in CAD: Wall Motion Assessment

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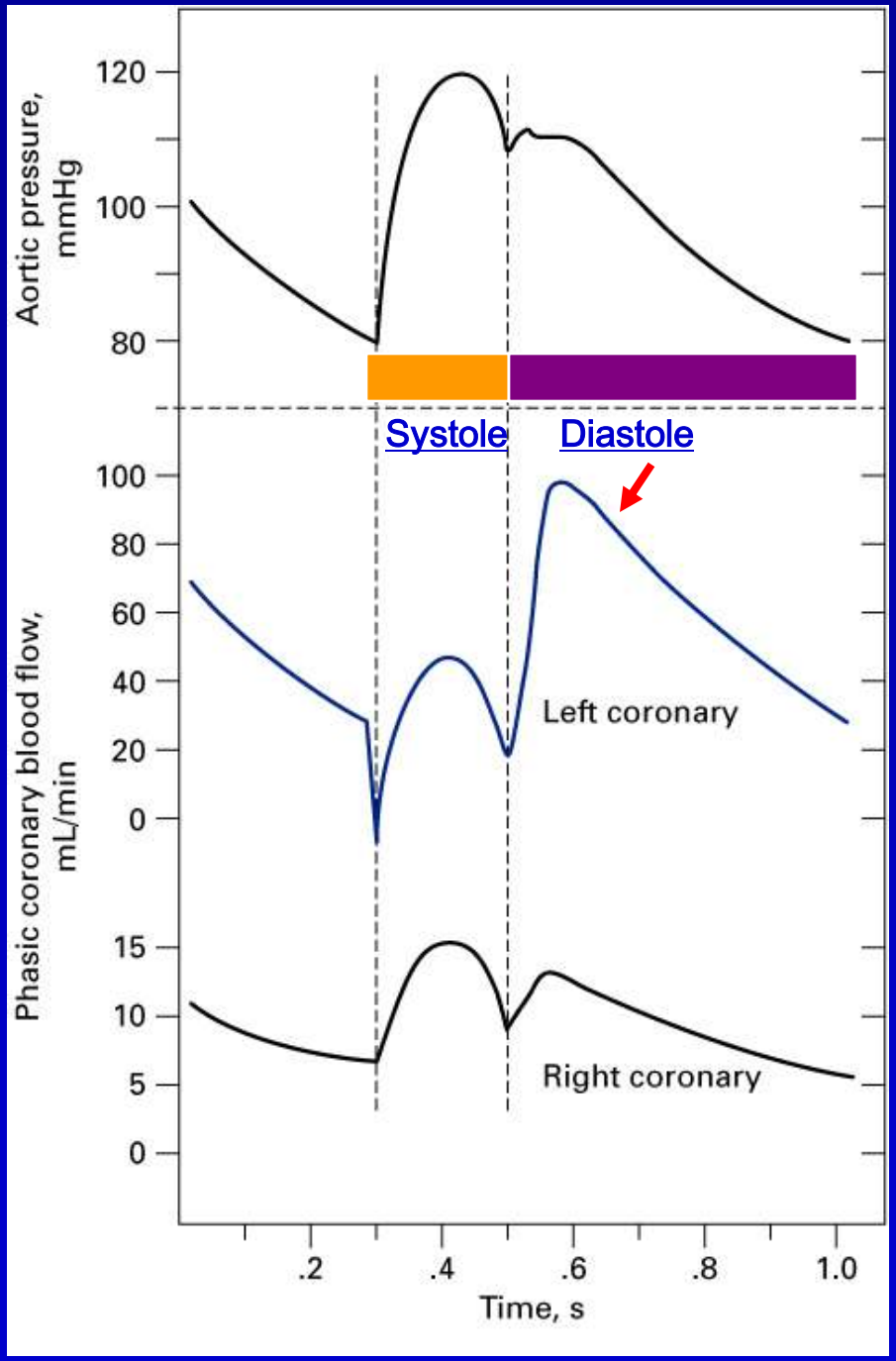
Relevant References

- 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.
- Douglas P et al. “2007 Appropriateness Criteria for TTE and TEE” J Am Coll Cardiol. 2007.
- Feigenbaum, 6th ed. 2005. Ch 15: “Coronary Artery Disease.”
- 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”

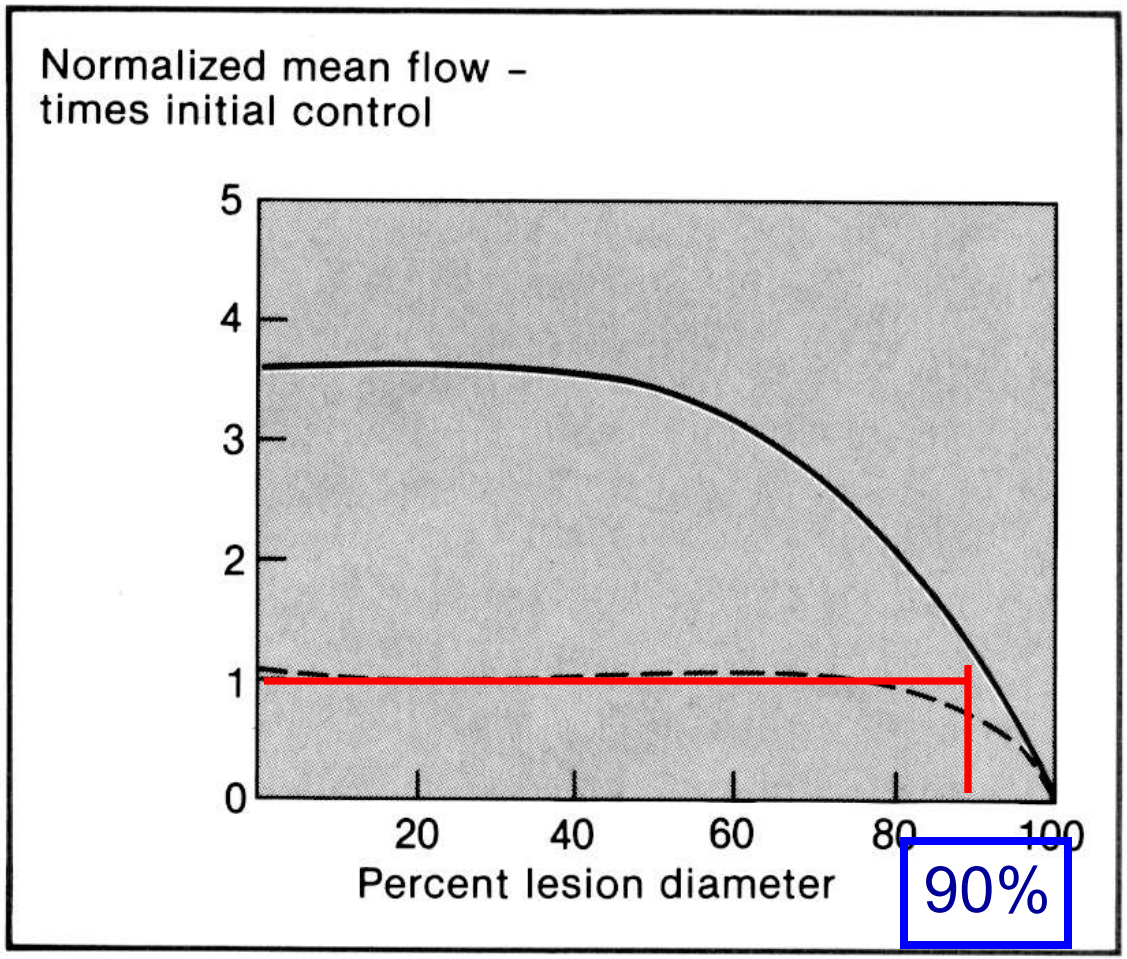
Coronary Flow Physiology

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



Hurst, 9th ed, 1998, p.108.

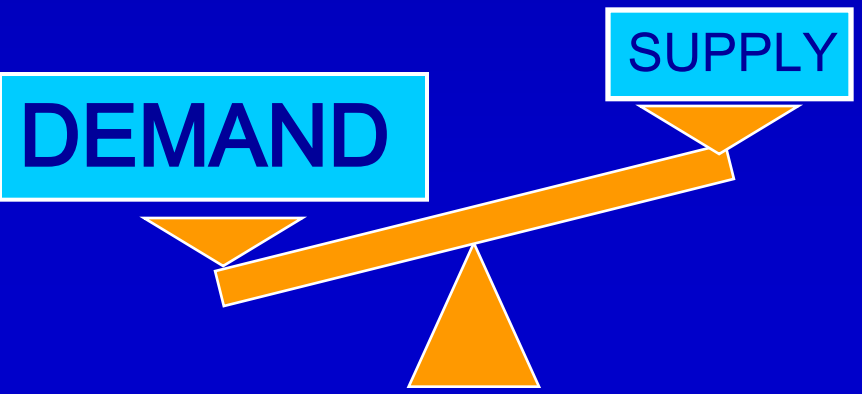
Coronary Reserve

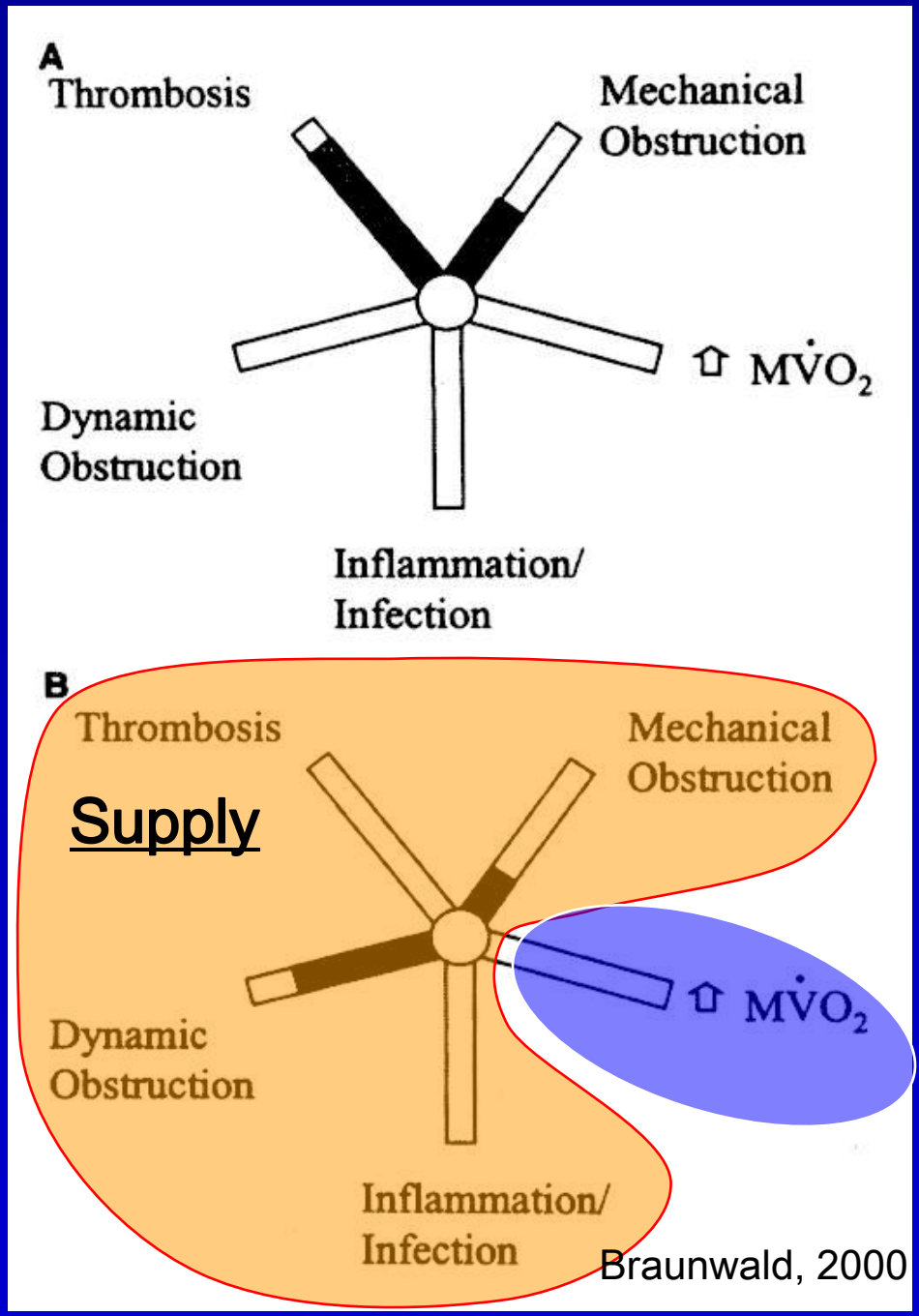


Braunwald, 1997
P. 1172

Myocardial Ischemia

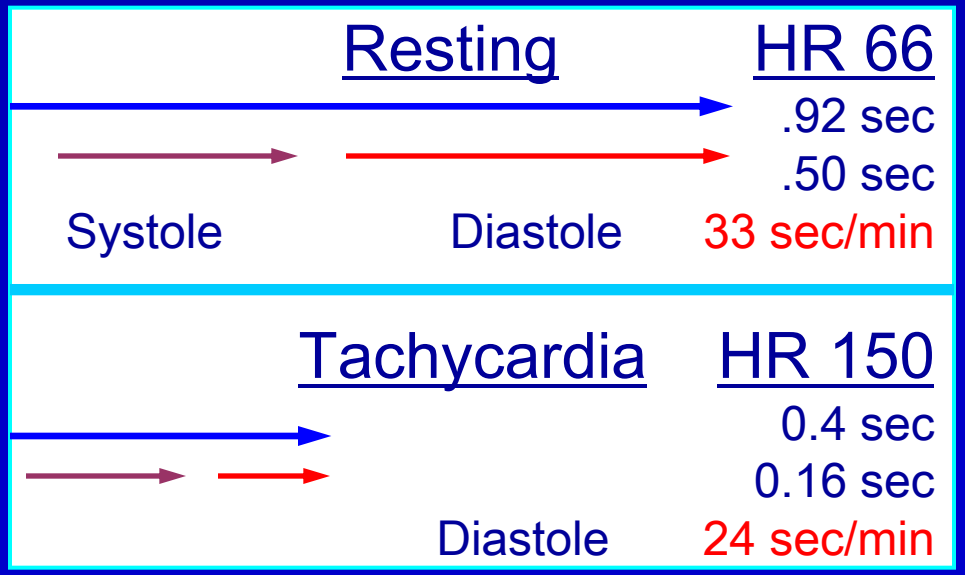
- Imbalance between myocardial oxygen demand and supply





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

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.

Feigenbaum, 6th ed. 2005. Ch 15: “Coronary Artery Disease.”

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

Douglas P et al. “2007 Appropriateness Criteria for TTE and TEE” J Am Coll Cardiol. 2007.

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

Otto CM. 2nd Ed. 2002. p. 254.

Wall Motion

- 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

Otto CM. 2nd Ed. 2002. p. 275, 307

Physiologic Points in Wall Motion

- Akinesis or dyskinesis and thinned and dense wall – most likely infarction
- If not thin, quite likely to be viable

Otto CM. 2nd Ed. 2002. p. 307.

Categories of Wall Motion Response

Wall Motion at Rest	Wall Motion During Exercise	Category
Normal	Normal	Normal
Normal	Abnormal: Worsening	Ischemic
Abnormal excursion (thinned)	Fixed: No significant change	Scar: Transmural Infarction
Abnormal excursion (preserved thickness)	New or worsening abnormality	Hibernating

Otto CM. 2nd Ed 2002, p. 283.

Scoring System for Wall Motion

Score	Wall Motion	Endocardial Motion	Wall thickening
1	Normal	Normal	Normal (>30%)*
2	Hypokinesis	Reduced	Reduced (<30%)
3	Akinesis	Absent	Absent
4	Dyskinesis	Outward	Thinning
5	Aneurysmal	Diastolic deformity	Absent or thinning

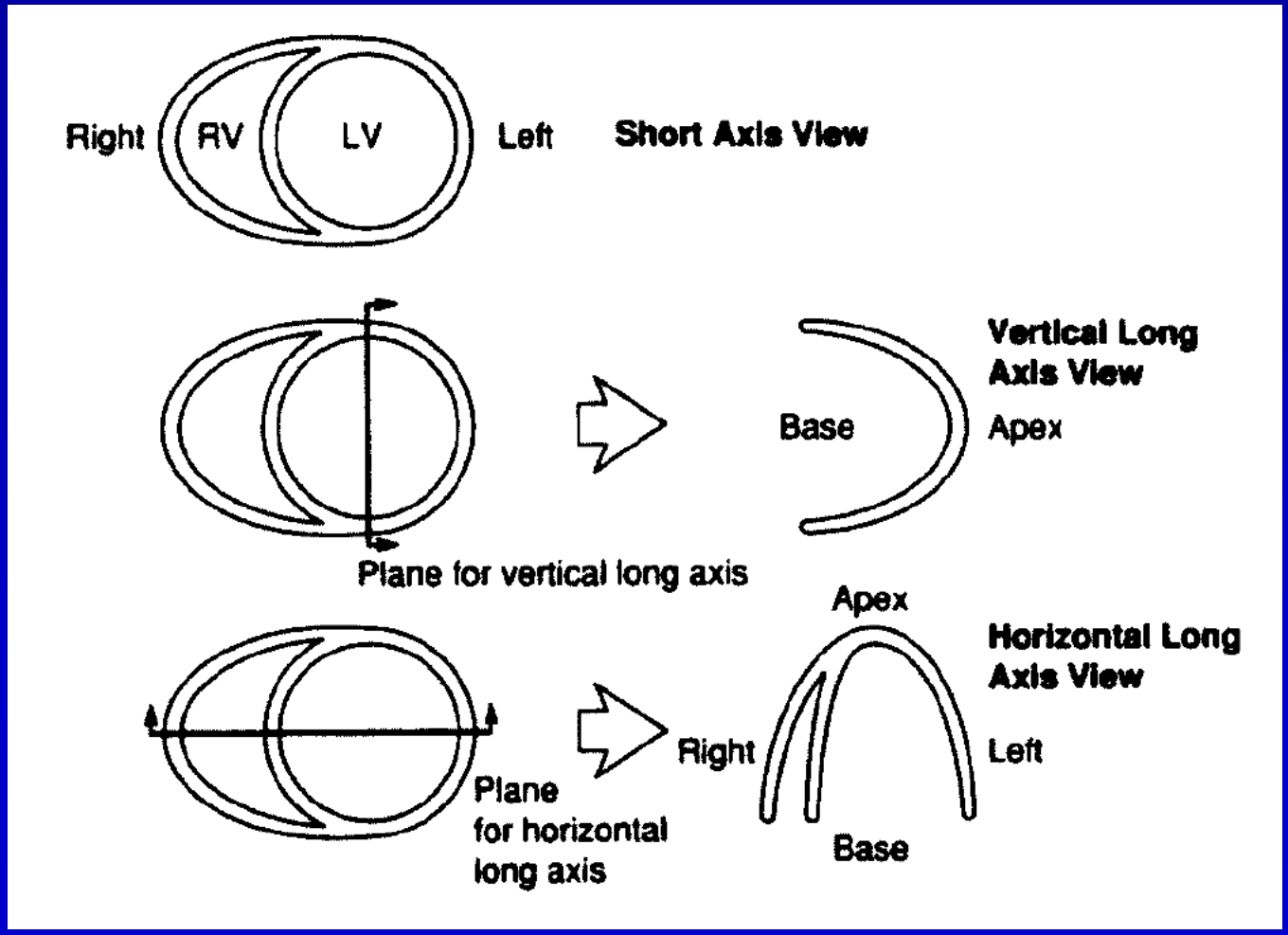
Otto CM. 2nd Ed 2002, p. 256. *35-40%; from 9-11 to 14-16 mm (Feigenbaum)

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

Naming the Views

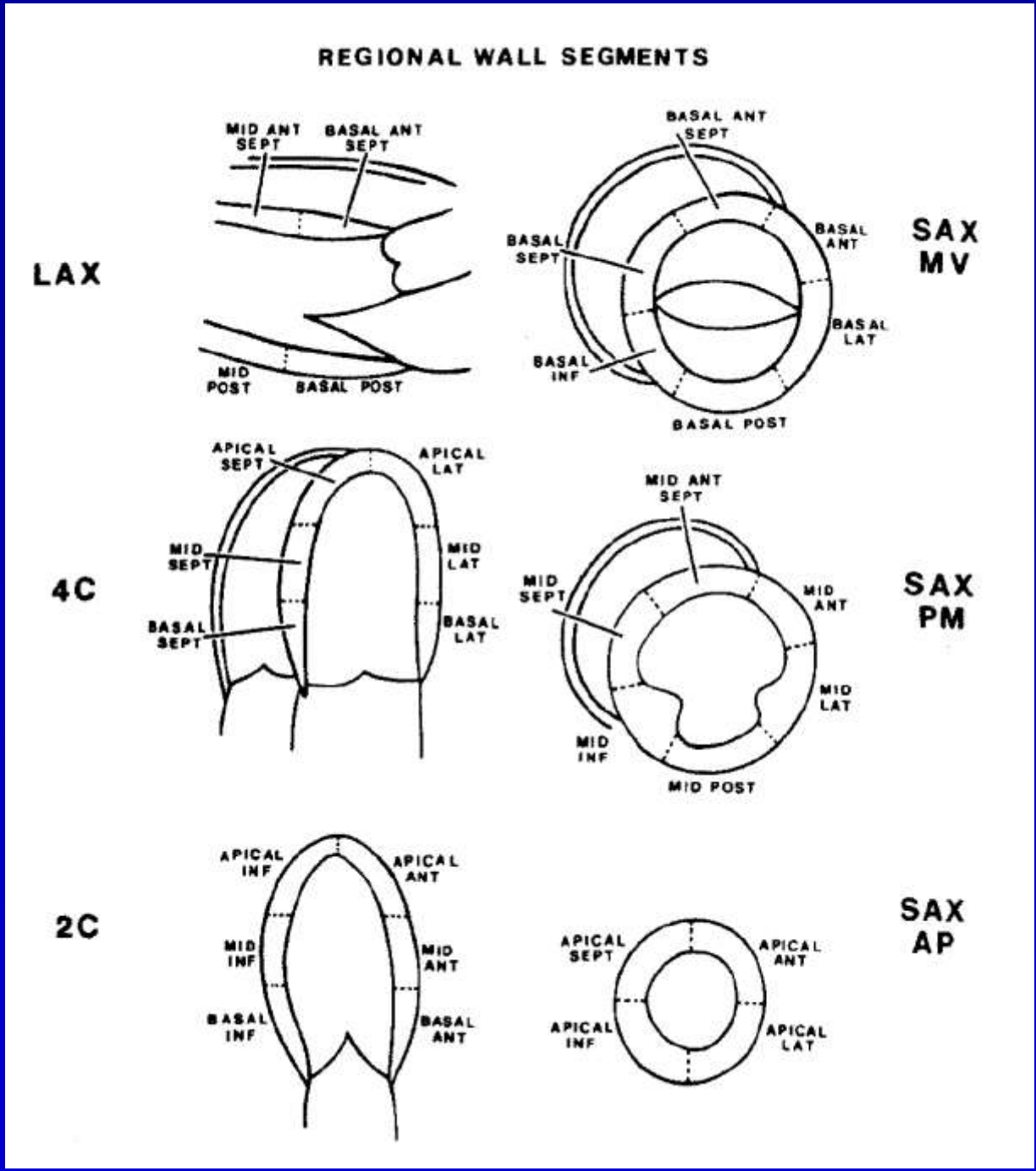


AHA Scientific Statement: Standardized Myocardial Segmentation and Nomenclature for Tomographic Imaging of the Heart. Circulation 2002;105:539

Echo Wall Segments

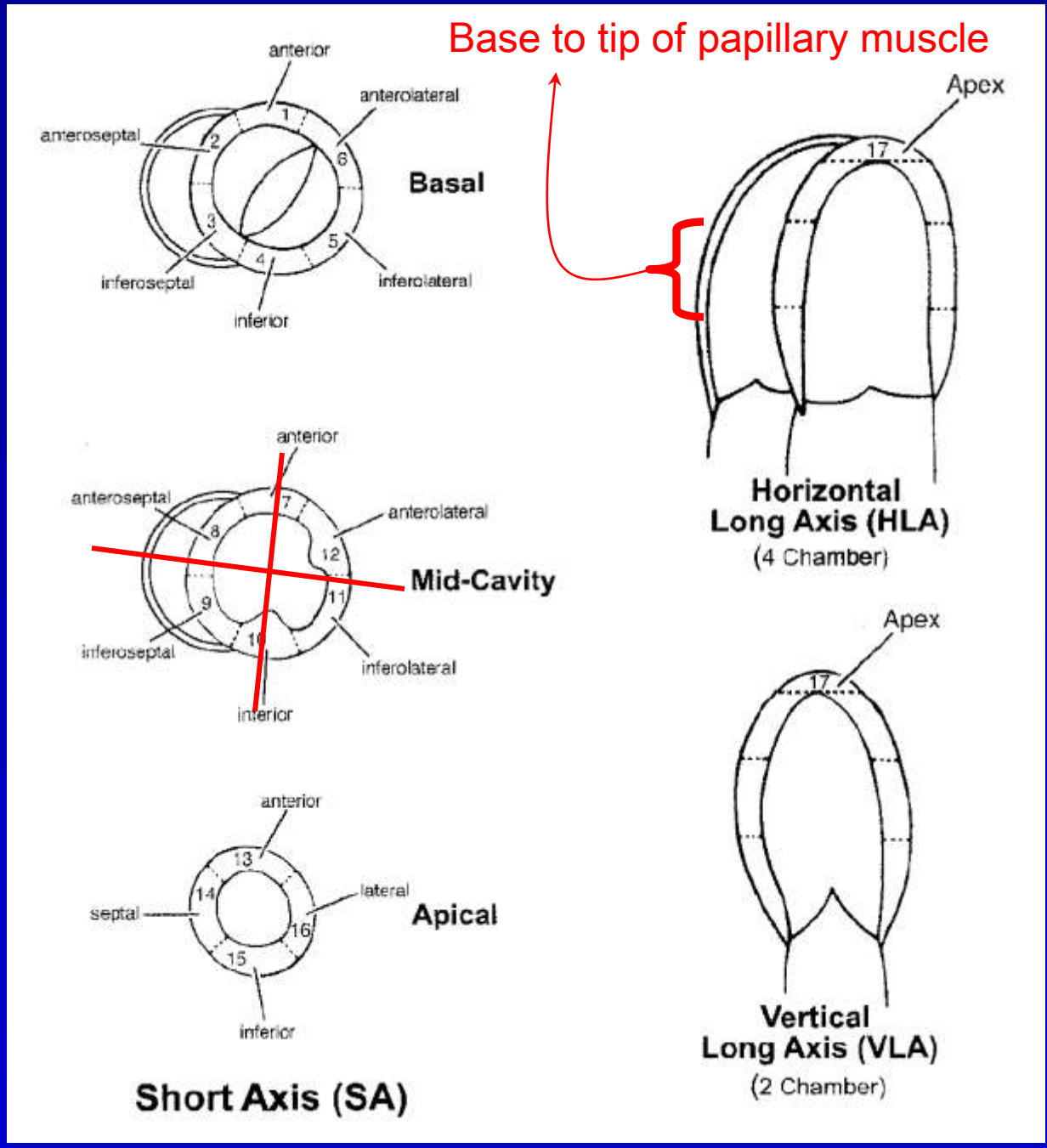
Of interest as prior method, 16 segments

AHA Scientific Statement: Standardized Myocardial Segmentation and Nomenclature for Tomographic Imaging of the Heart. Circulation 2002;105:539



Wall Segments

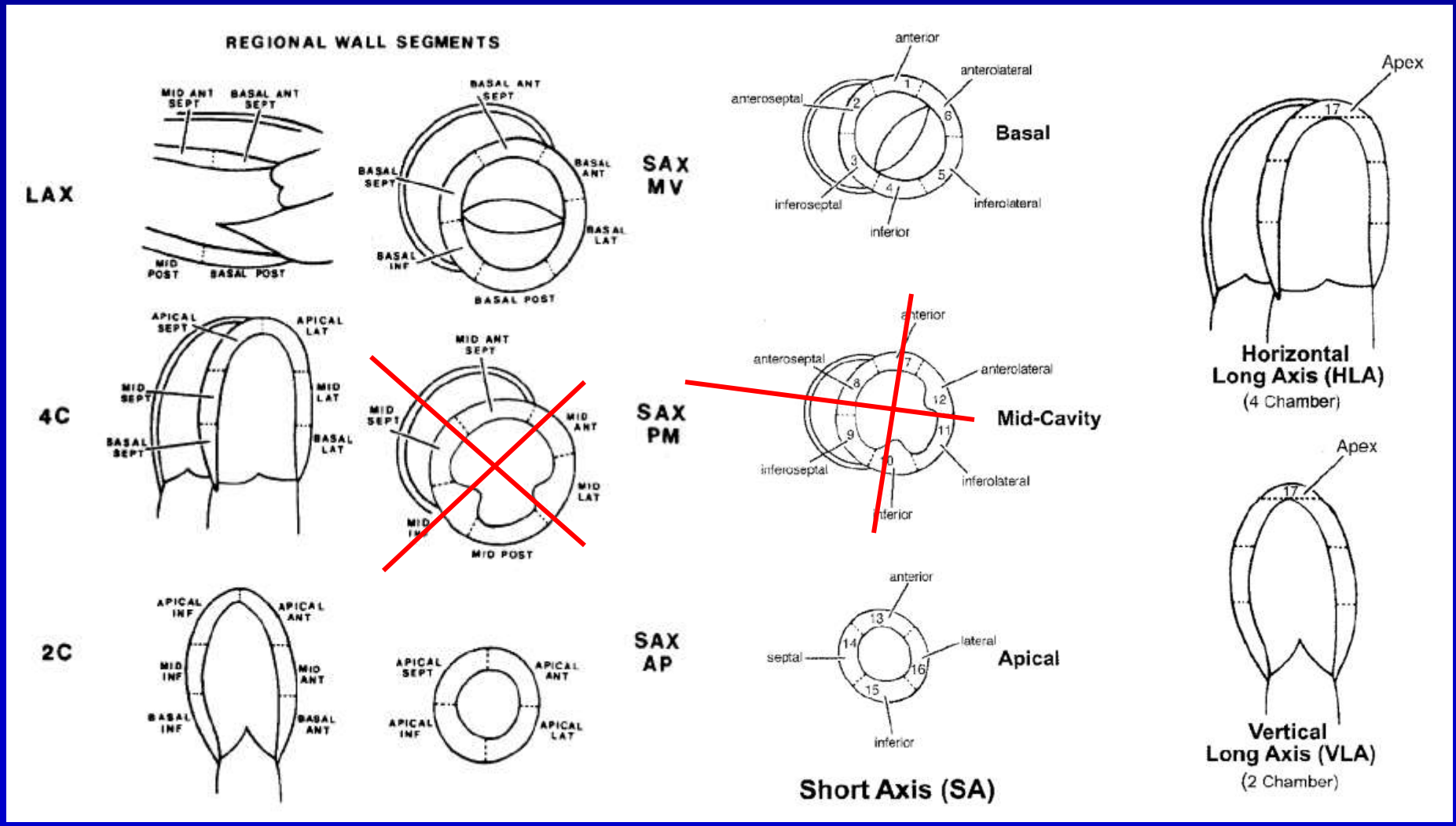
Not 16 but 17



AHA Scientific Statement: Standardized Myocardial Segmentation and Nomenclature for Tomographic Imaging of the Heart. Circulation 2002;105:539

Wall Segments

(Otto's second ed, 2002 still uses the classic echo terminology)



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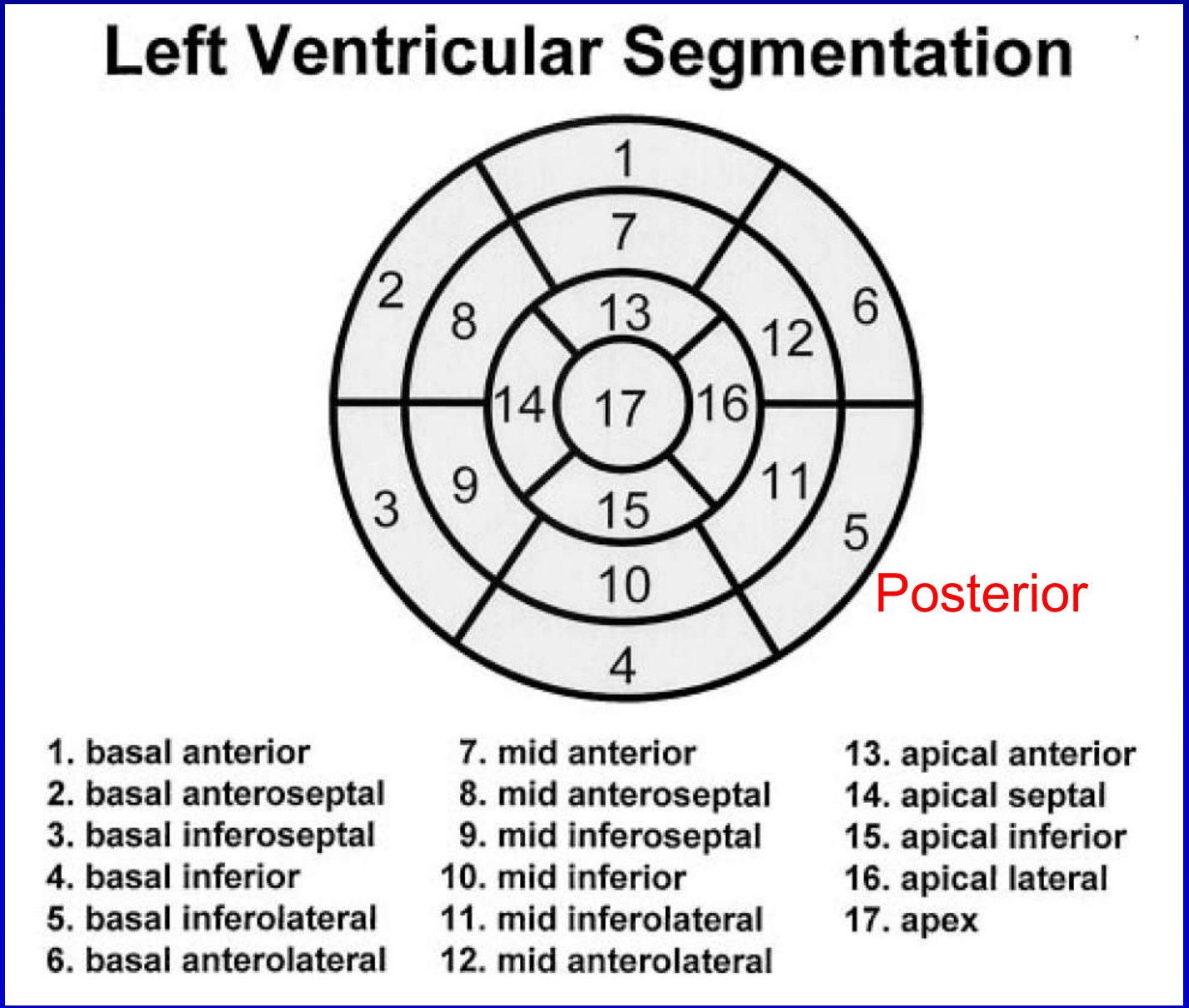
Wall Segments



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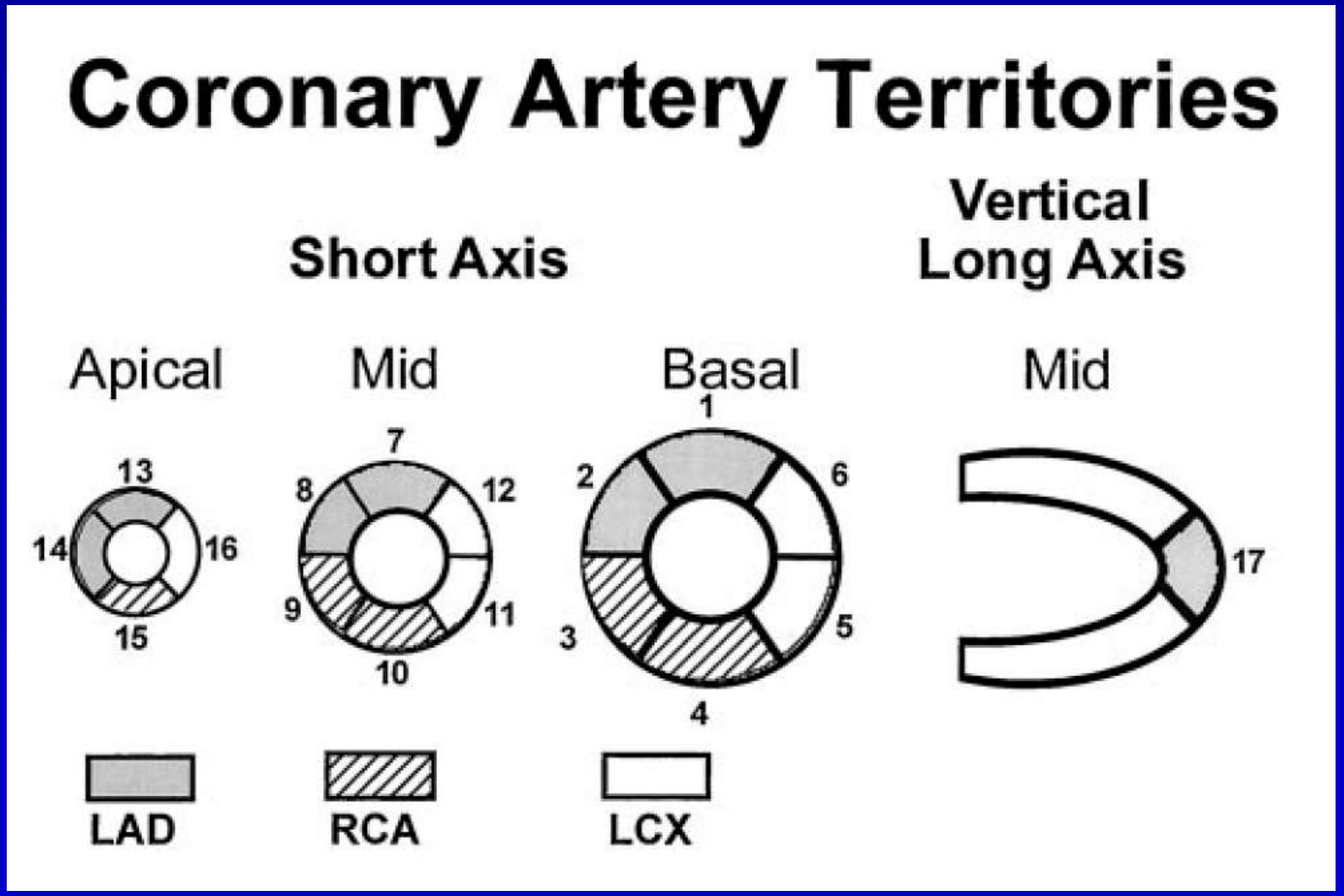
Wall Segments

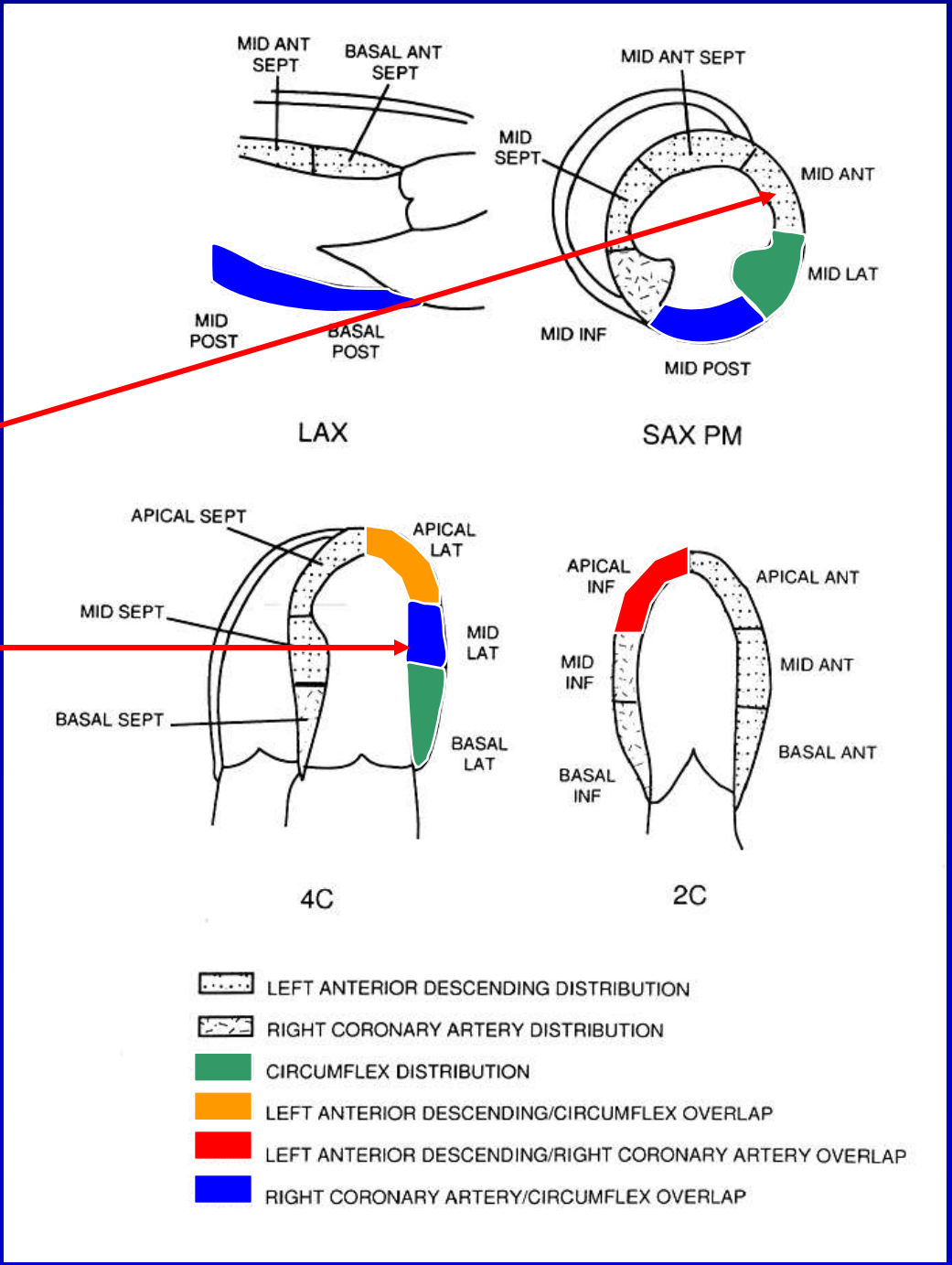


AHA Scientific Statement: Standardized Myocardial Segmentation and Nomenclature for Tomographic Imaging of the Heart. Circulation 2002;105:539

Coronary Segments

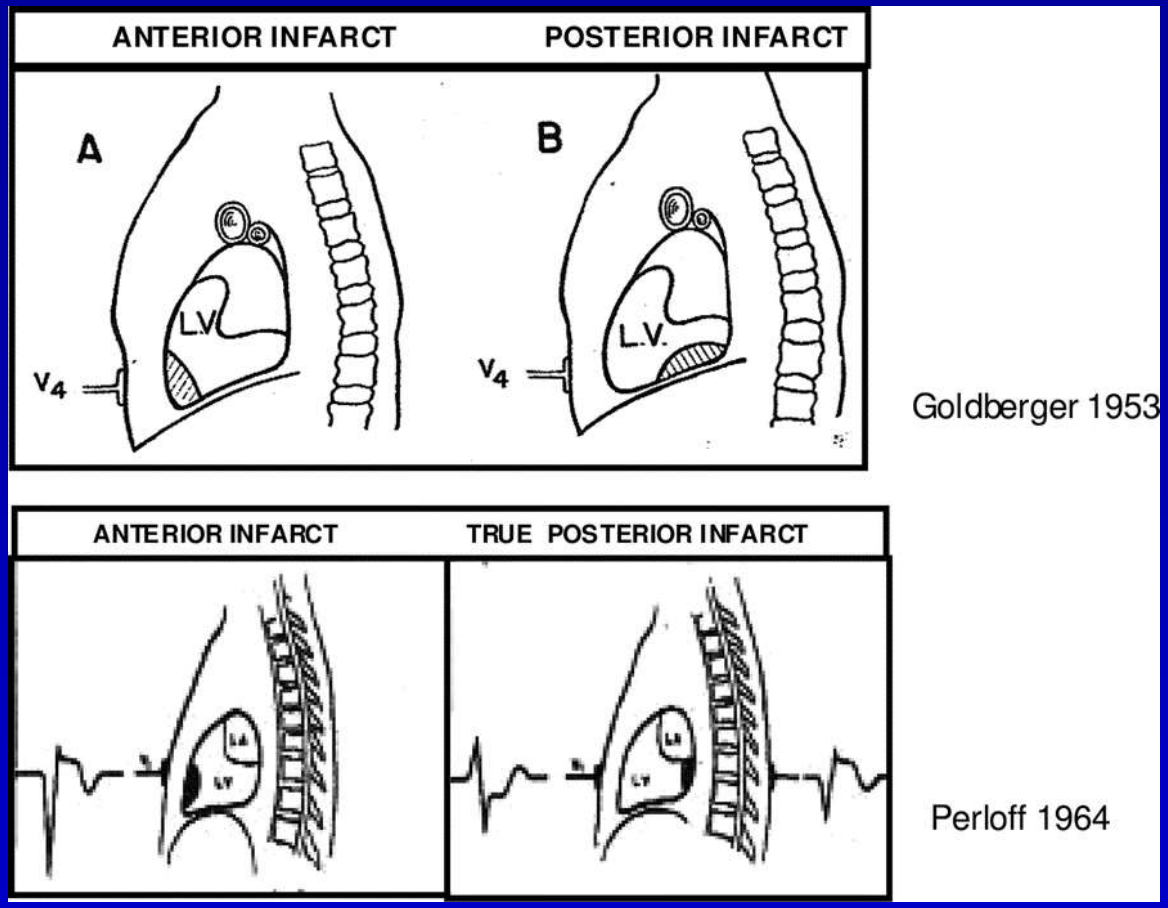
Feigenbaum LAD or LCX

Feigenbaum LCX



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

Historic Wall Motion



Goldberger 1953

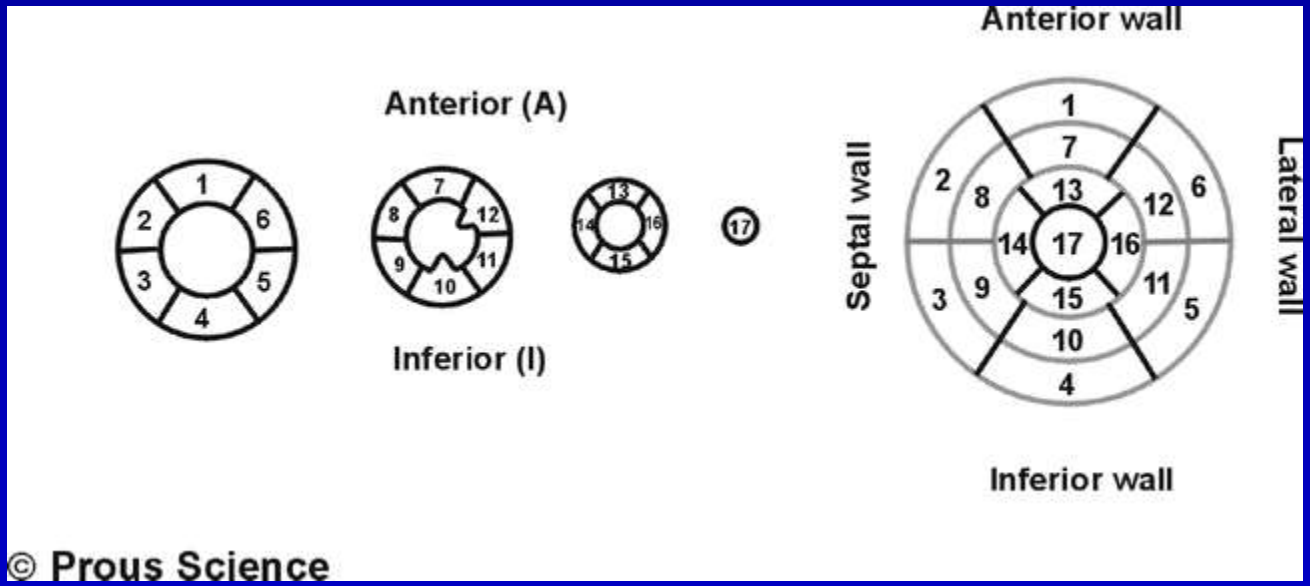
Perloff 1964

Figure 1. Top, Original drawings in Goldberger's[2] book in 1953 showing the location of an anterior and a posterior infarct. Bottom, Drawings of anterior and true posterior infarcts with the QRS morphology according to Perloff.[7]

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.

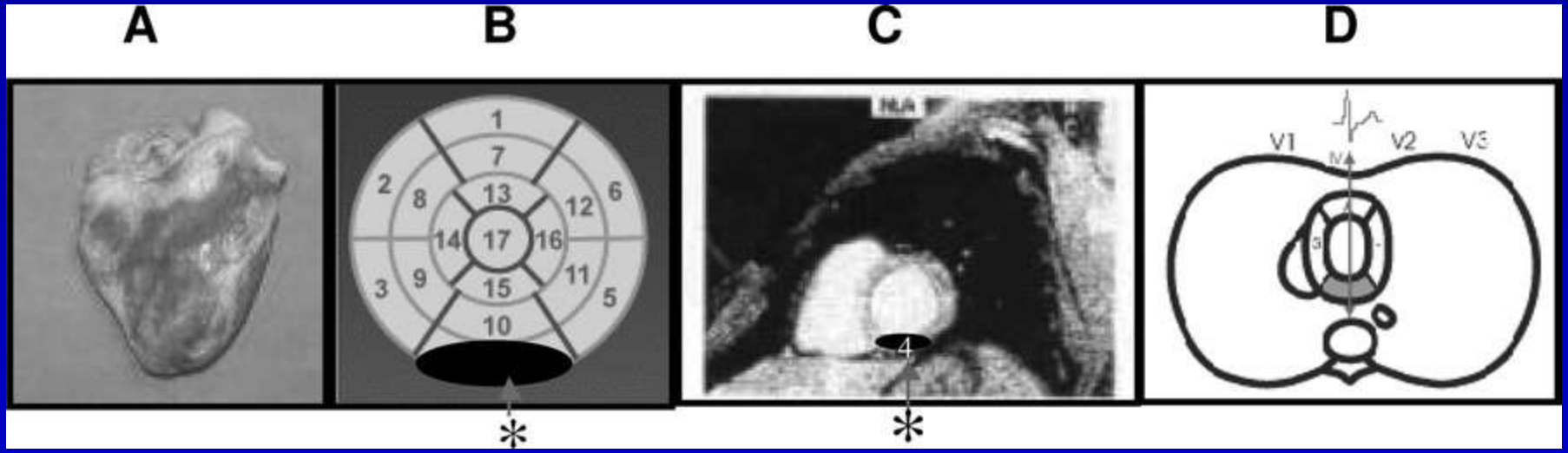
Bayes de Luna A et al. Circulation. 2006;114:1755

Recent Guidelines



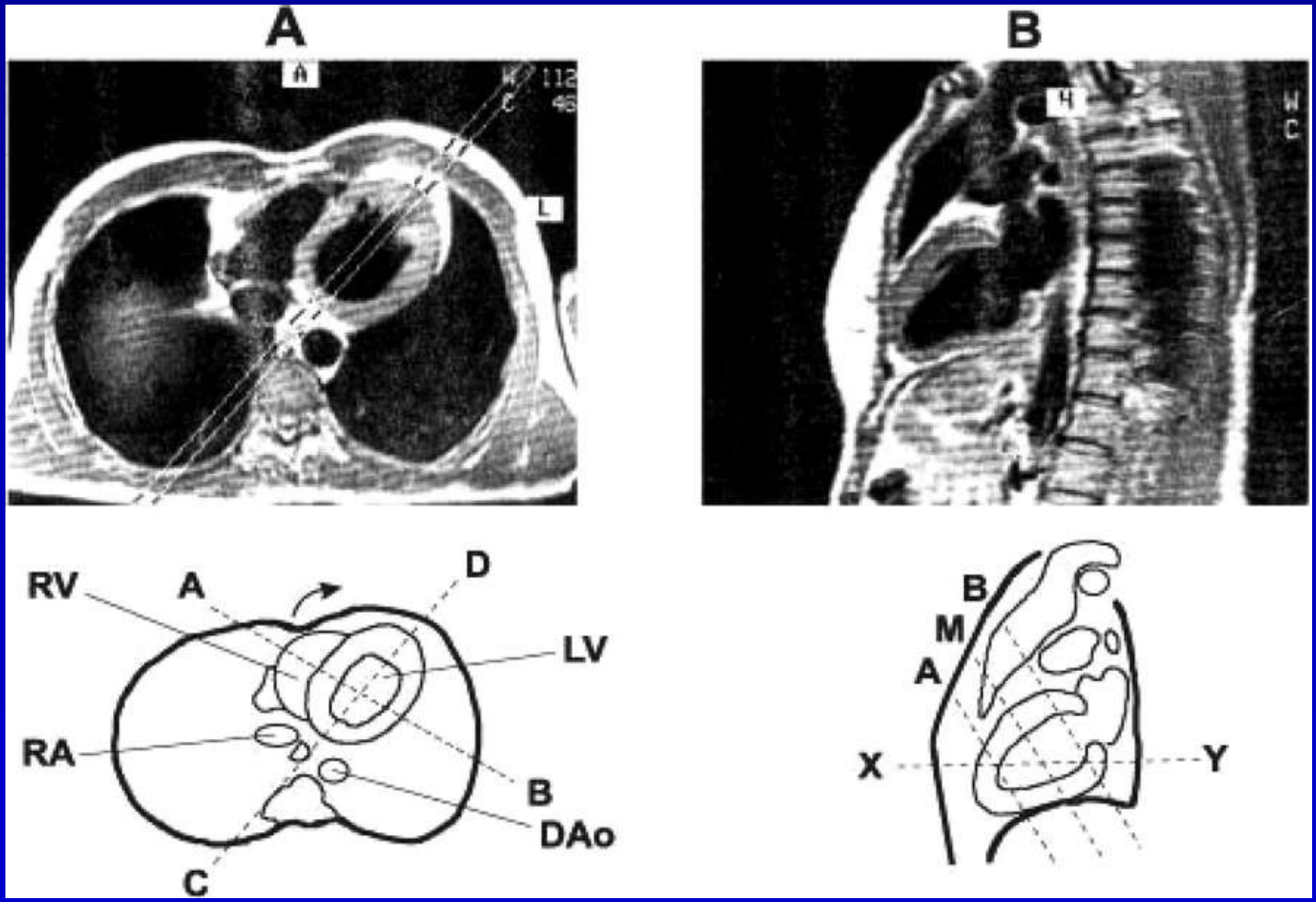
Bayes de Luna A et al. Circulation. 2006;114:1755

Correlation with MRI in inferior base



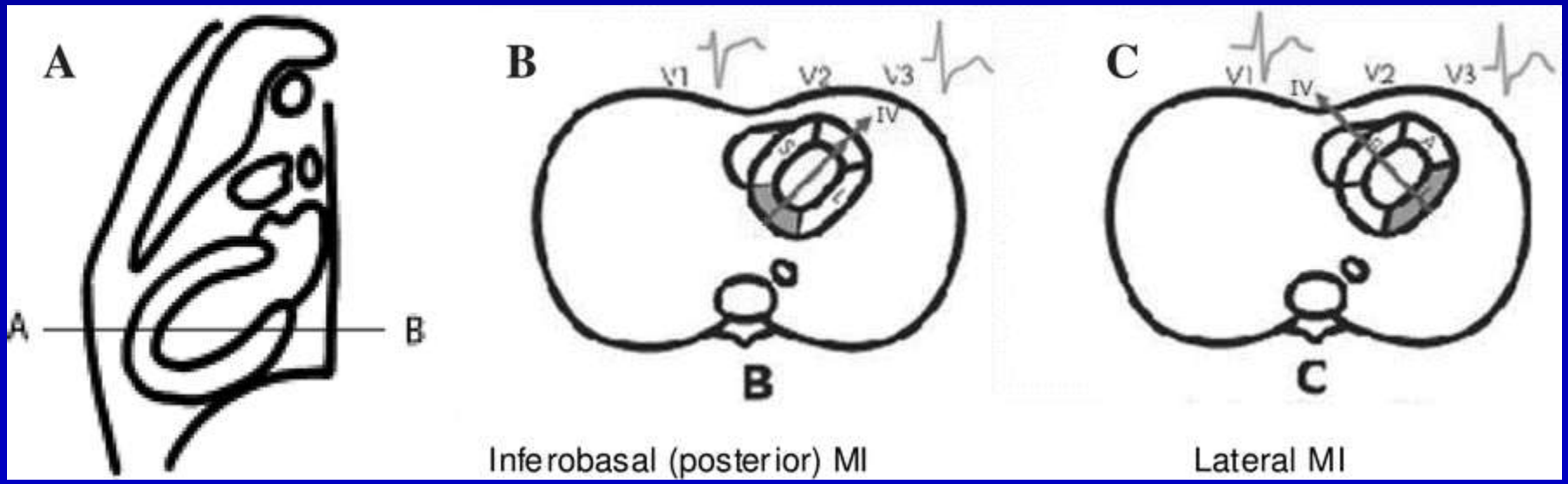
Bayes de Luna A et al. Circulation. 2006;114:1755

Wall Analysis in MRI



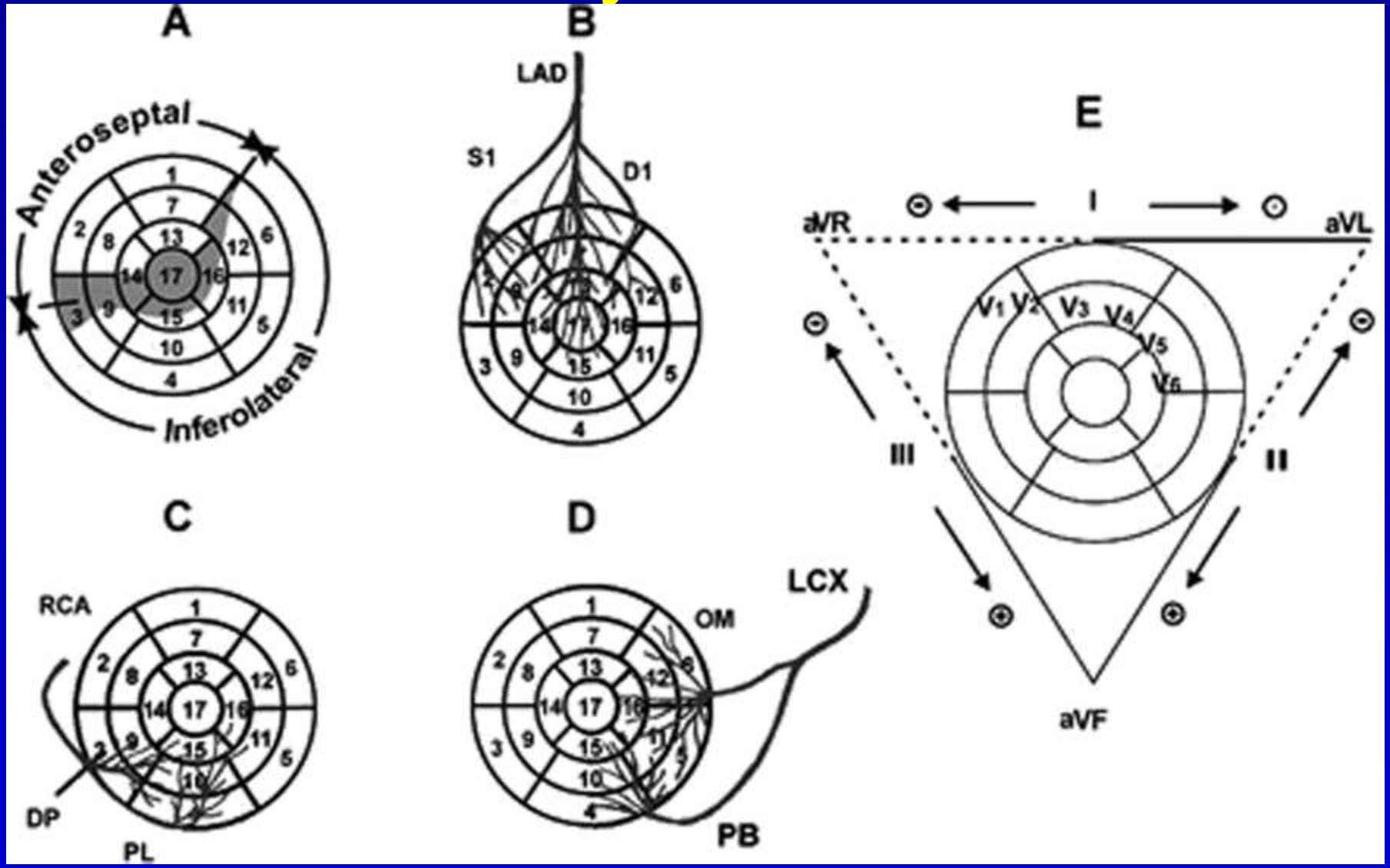
Bayes de Luna A et al. Circulation. 2006;114:1755

Lateral MI and Inferobasal MI



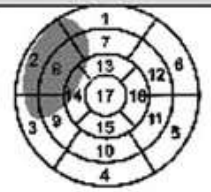
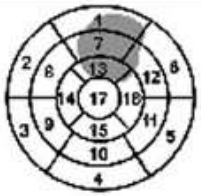
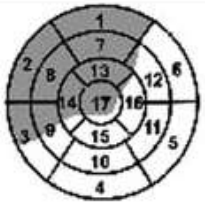
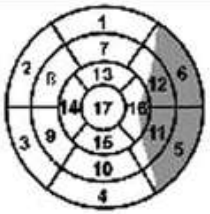
Bayes de Luna A et al. Circulation. 2006;114:1755

Coronary Distribution



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

ECG Terminology Consensus

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

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

Interpretation of Complex Responses

Interpretation	At Rest	After Exercise
Normal		
Excursion	Normal	Normal
Wall thickness	Normal	
CAD/No MI		
Excursion	Normal	Hypokinetic, akinetic, or dyskinetic
Wall thickness	Normal	
CAD/Nontransmural MI		
Excursion	Hypokinetic/akinetic	Augmented, hypokinetic, akinetic, or dyskinetic (depending on IRA patency)
Wall thickness	Partial or full	
CAD/Transmural MI		
Excursion	Akinetic	Akinetic or dyskinetic
Wall thickness	Thinned	
CAD/Hibernating/Stunned		
Excursion	Hypokinetic or akinetic	Incompletely investigated, may augment with mild exercise
Wall thickness	Partial or full	

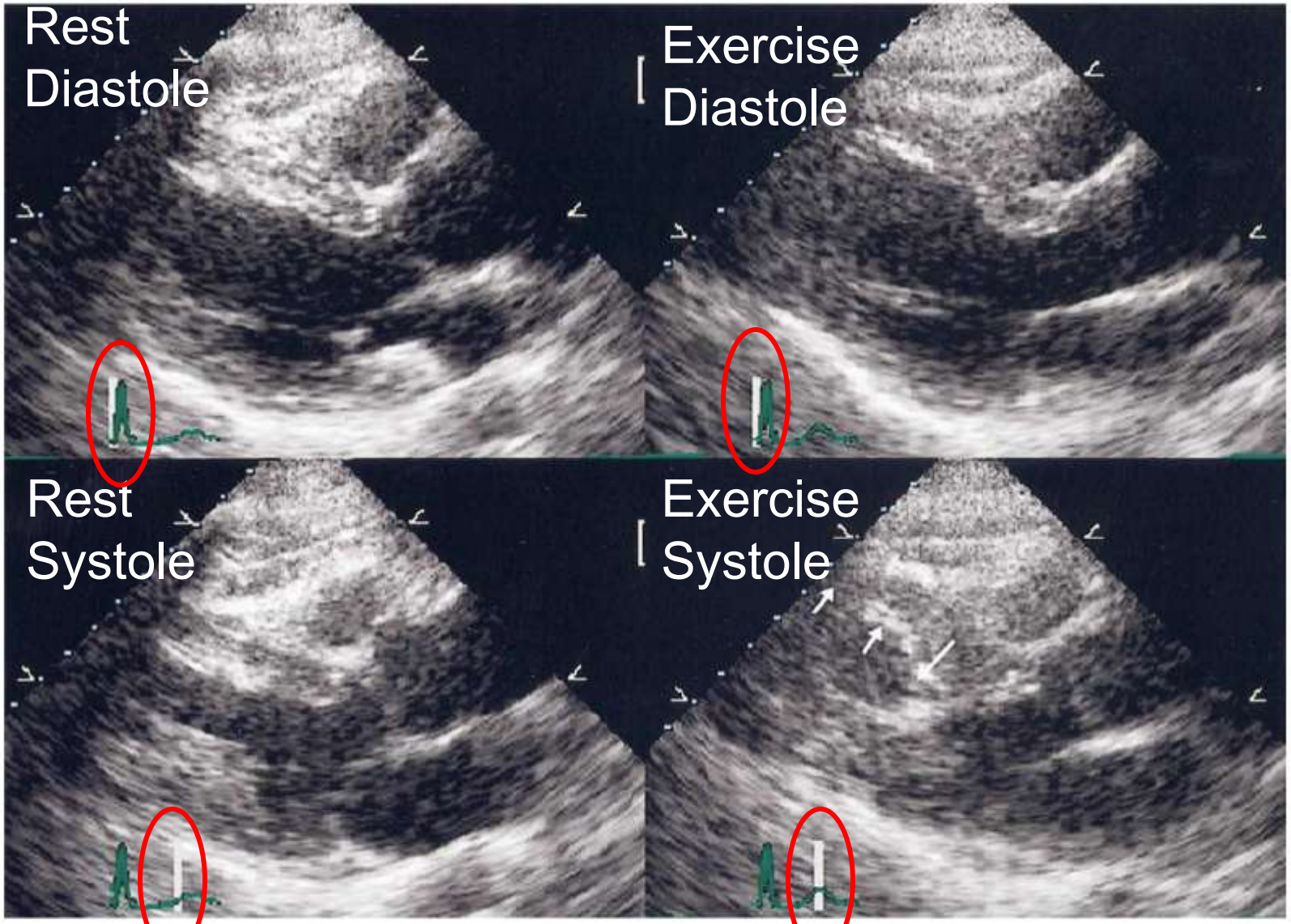


Figure 1. Parasternal long-axis echocardiogram recorded at rest **(left)** and immediately after exercise **(right)** in a patient with stenosis of the left anterior descending coronary artery. Diastolic frames are on the **top**, and systolic frames are on the **bottom**. At rest, notice the normal 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)**.

Armstrong WF et al. J Am Coll Cardiol. 2005;45:1739 Review.

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

Marwick T. Acta Clin Belg 1992;47:1.

Interpretation of Viability and Ischemia with Dobutamine Echocardiography

Diagnosis	Resting Function	Low-Dose	Peak/Poststress Function
Normal	Normal	Normal	Hyperkinetic
Ischemic	Normal	Normal (unless severe CAD)	Reduction vs. rest Reduction vs. other segments Delayed contrac tion
Viable, patient IRA	Hypo/akinetic	Improvement	Sustained improvement
Viable, stenosed IRA	Hypo/akinetic	Improvement	Reduction (c/w low-dose)
Infarction	A/dyskinetic	No change	No change

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 akinesis or dyskinesis
- 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

Hoffmann R et al. Am J Cardiol. 1998;82:1520-4.

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=akinetic, 4=dyskinetic
- 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%)

Armstrong WF et al. J Am Coll Cardiol. 2005;45:1739 Review.

Echo in Mechanical Complications of MI

- VSD
- MR
- Rupture
- True Aneurysm
- Pseudoaneurysm

Thank you.

Questions?