Echocardiography in Heart Failure

Anthony DeMaria

2009 Focused Update Incorporated Into the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in Adults

A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With the International Society for Heart and Lung Transplantation

CLASS I

7. Two-dimensional echocardiography with Doppler should be performed during initial evaluation of patients presenting with HF to assess LVEF, left ventricular size, wall thickness, and valve function. Radionuclide ventriculography can be performed to assess LVEF and volumes. (*Level of Evidence: C*)

Dyspnea: Clinical Questions

- Is heart failure present?
- What is the etiology?
  - Structural, systolic or diastolic dysfunction
- What is the state of systolic function
- What is the optimal treatment?
- How is the pt responding to therapy?
- What is the prognosis?
- Is the pt compensated or decompensating

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BNP vs Echocardiography

- Echocardiography provides data regarding cardiac structure and performance
- BNP provides information regarding LV/LA wall stress and pressure

BNP vs Echocardiography

- BNP provides information regarding LV/LA wall stress and pressure
  - Distinguishes heart failure from other SOBs
  - Tracks efficacy of therapy
  - Assessment of prognosis, compensation and decompensation currently underway

BNP vs Echocardiography

- *Echocardiography provides data regarding cardiac structure and performance*

- Identify etiology
  - Mechanical (structural) vs Functional
  - Systolic vs Diastolic
  - Ischemic vs Nonischemic
- Quantify abnormality
- Select therapy
- Define prognosis
- Follow course

Etiology of Heart Failure by Echo

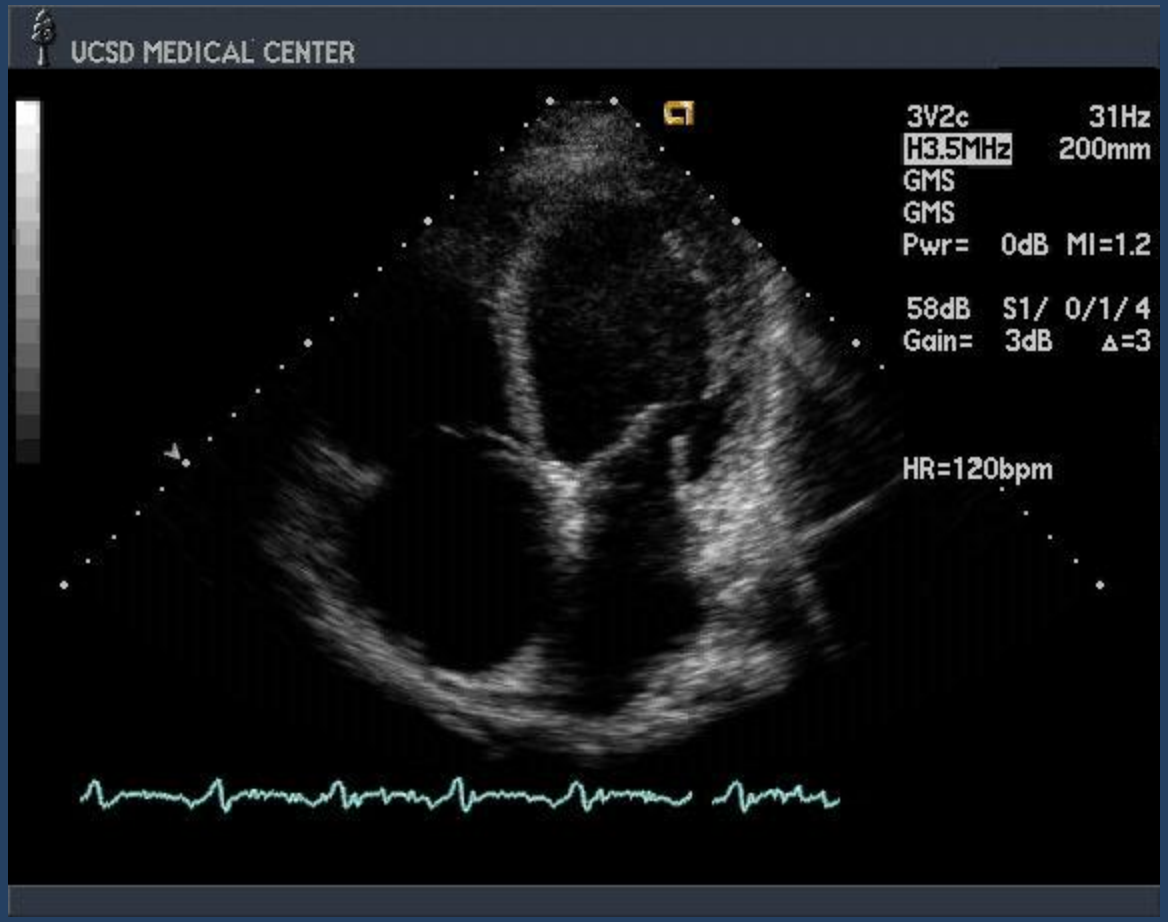
- Valve Disease ——— Stenosis/Regurgitation
- Coronary Disease — Segmental dysfunction
- Congenital Disease – Abnormal anatomy
- Pericardial Disease – Effusion/constriction
- Hypertension ——— LVH
- Cardiomyopathy — Composite (cavity size, wall thickness, contraction)

Echo Distinction of Cardiomyopathy

	DCM	HCM	RCM
LV volume	↑↑↑↑	↓↓	↔
Wall thickness	↕	↑↑↑ (IVS)	↑↑↑
Contractility	↓↓↓↓	↑(↓)	↔

Diagnostic Features of Nonischemic Cardiomyopathy

- Generalized myocardial dysfunction
  - Absence of regional contractile abnormality
    - Dobutamine or rest
  - Absence of localized scar
  - Absence of aneurysm
- Right ventricular dysfunction
- Diastolic dysfunction
- Increased LV sphericity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GMS
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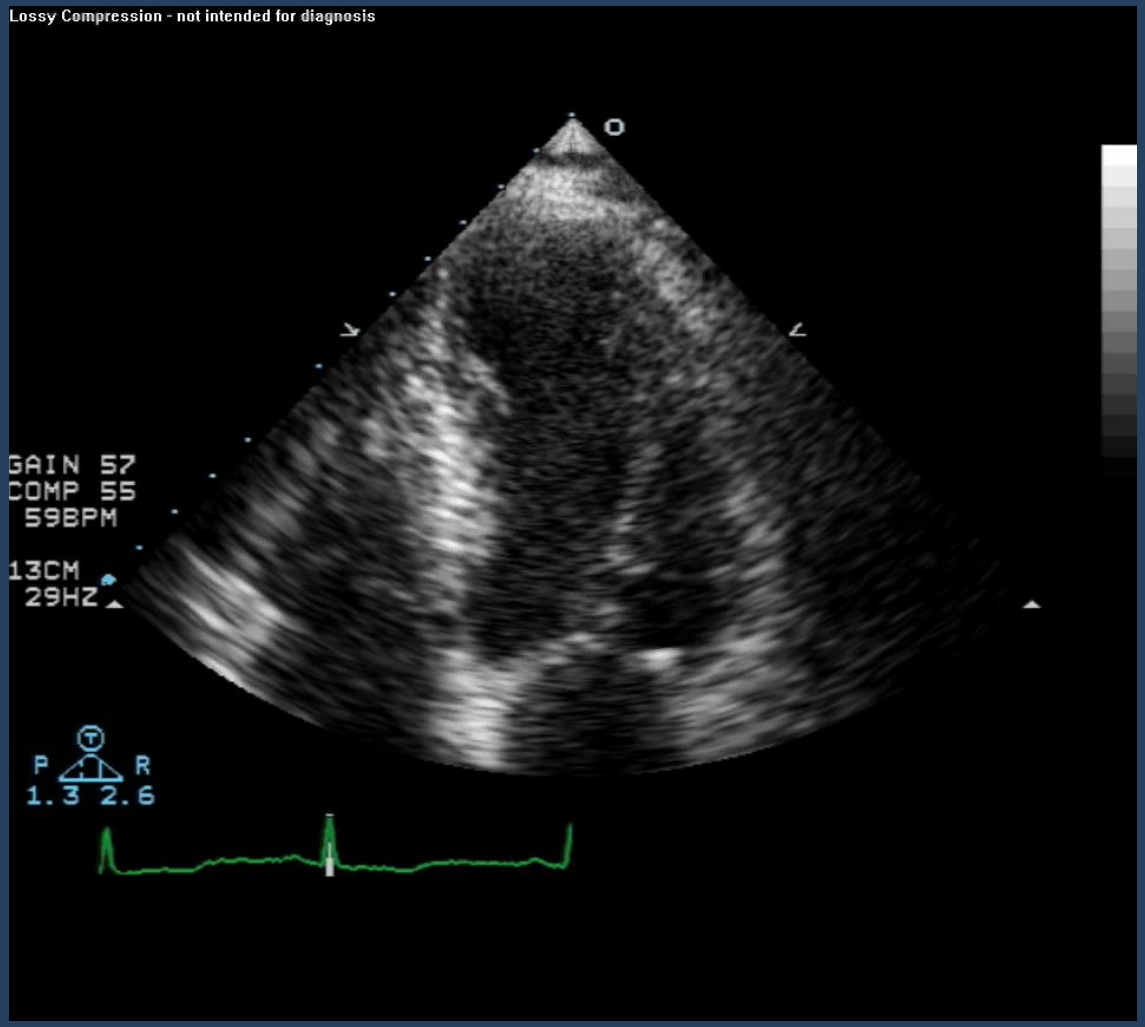
HR=120bpm

Ischemic Heart Disease



Assess LV Structure/Function

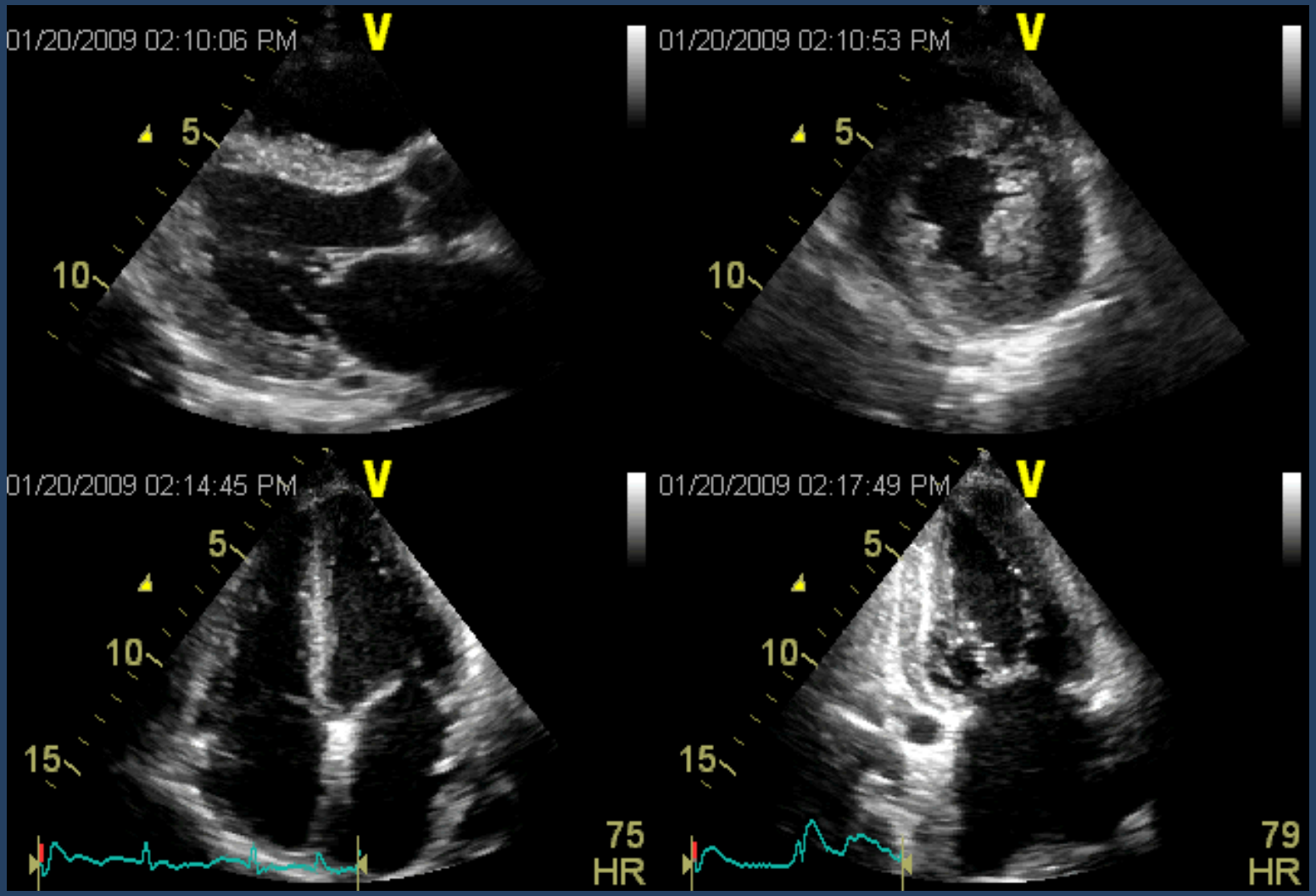
- Volumes and mass
- Ejection fraction
- Endocardial motion } Velocity
- Wall thickening } Extent

- *Susceptible to in-plane motion and tethering*
- *Transition from motion to deformation (strain)*

Published Trials in Which EF was Part of the Entry Criteria (Partial List)

- SOLVD Treatment Trial
- SOLVD Prevention Trial
- SAVE
- US Cravedilol Trials
- MERIT-HF
- CIBIS 1 & 2
- COPERNICUS
- CAPRICORN
- RALES
- ELITE 1 & 2
- Val-HEFT
- PRAISE 1 & 2
- OVERTURE

- ***ICD***
- ***Bi-ventricular pacing***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V
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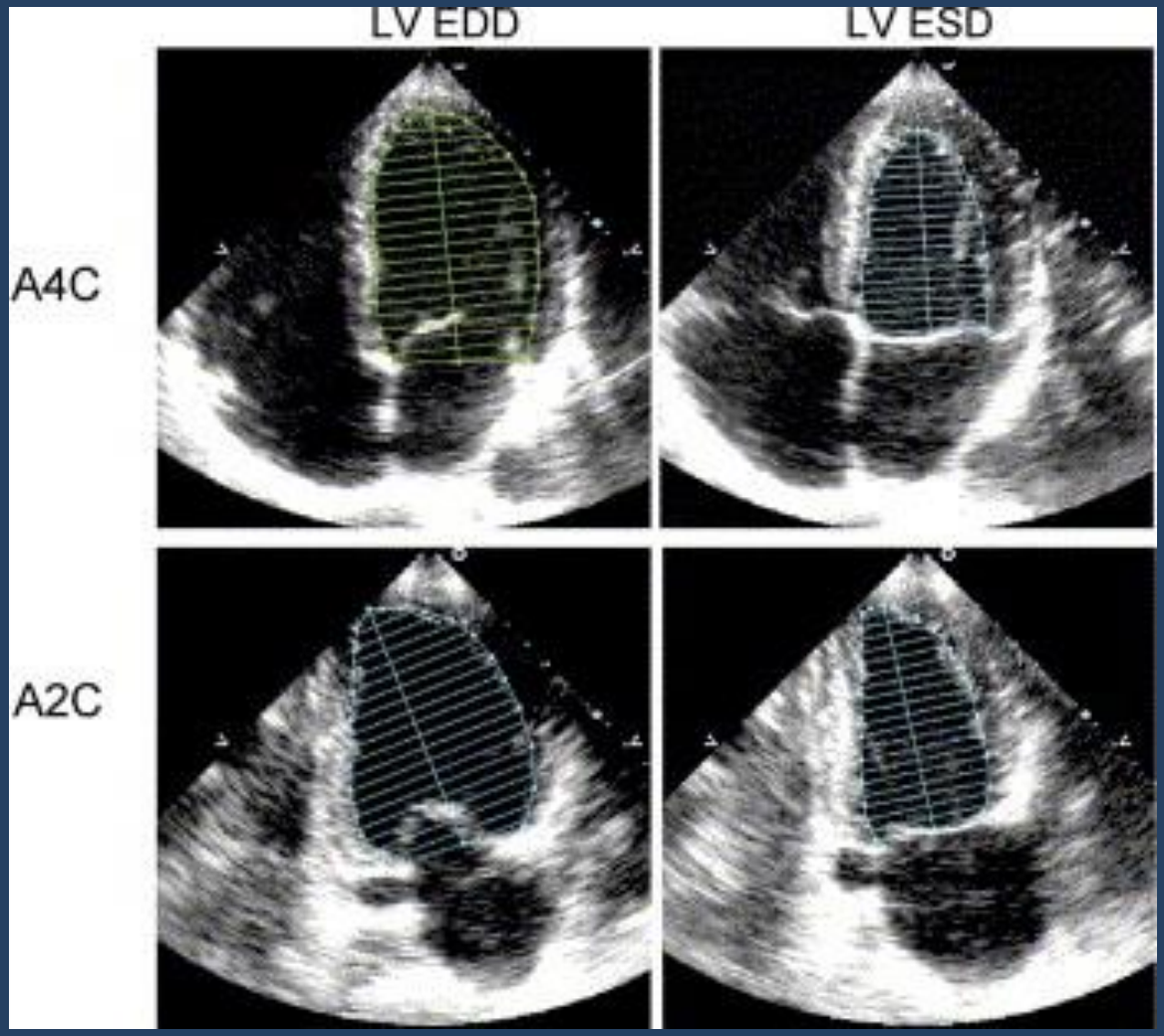
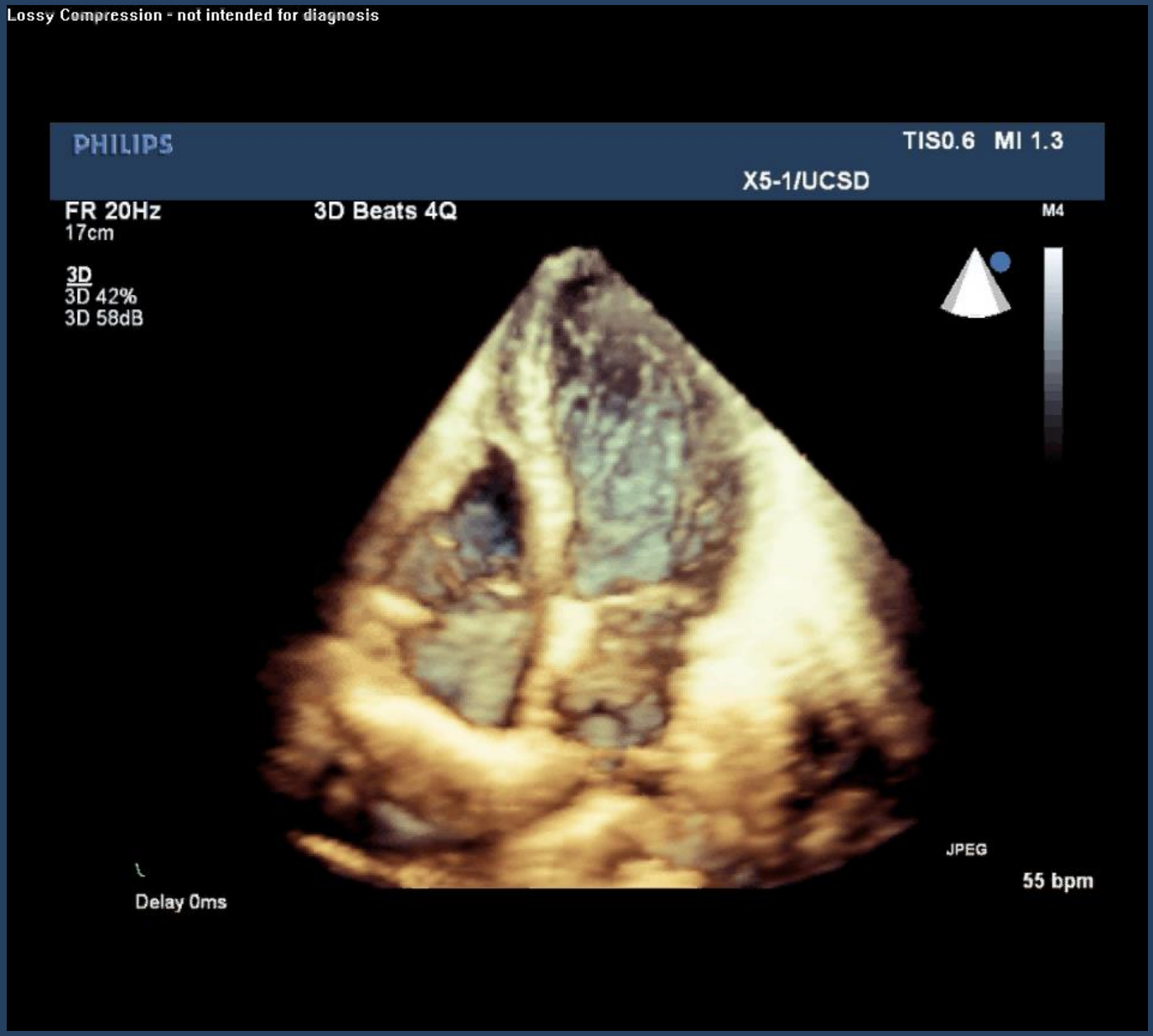
HR

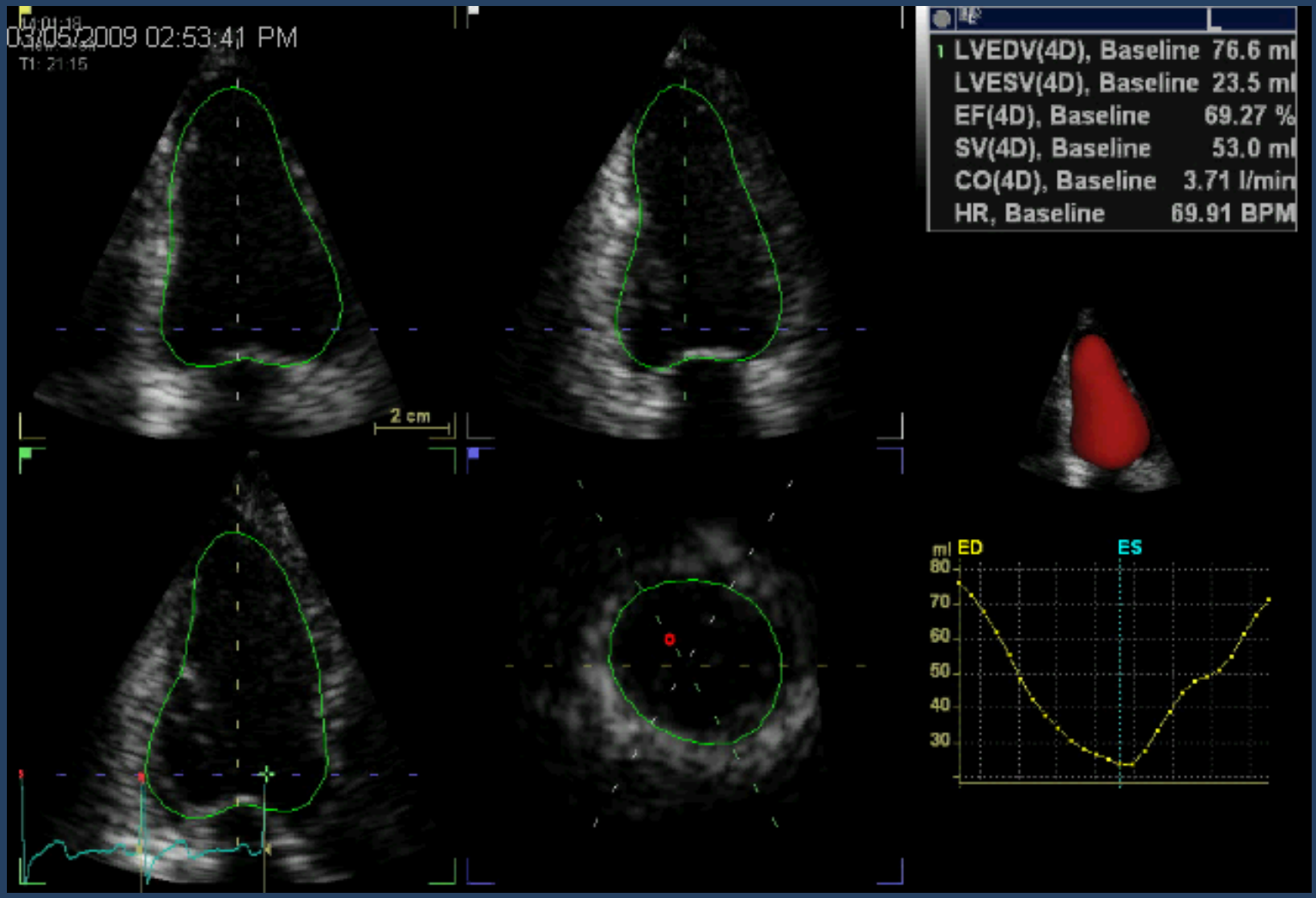
Quantitation of LV Function by Echocardiography

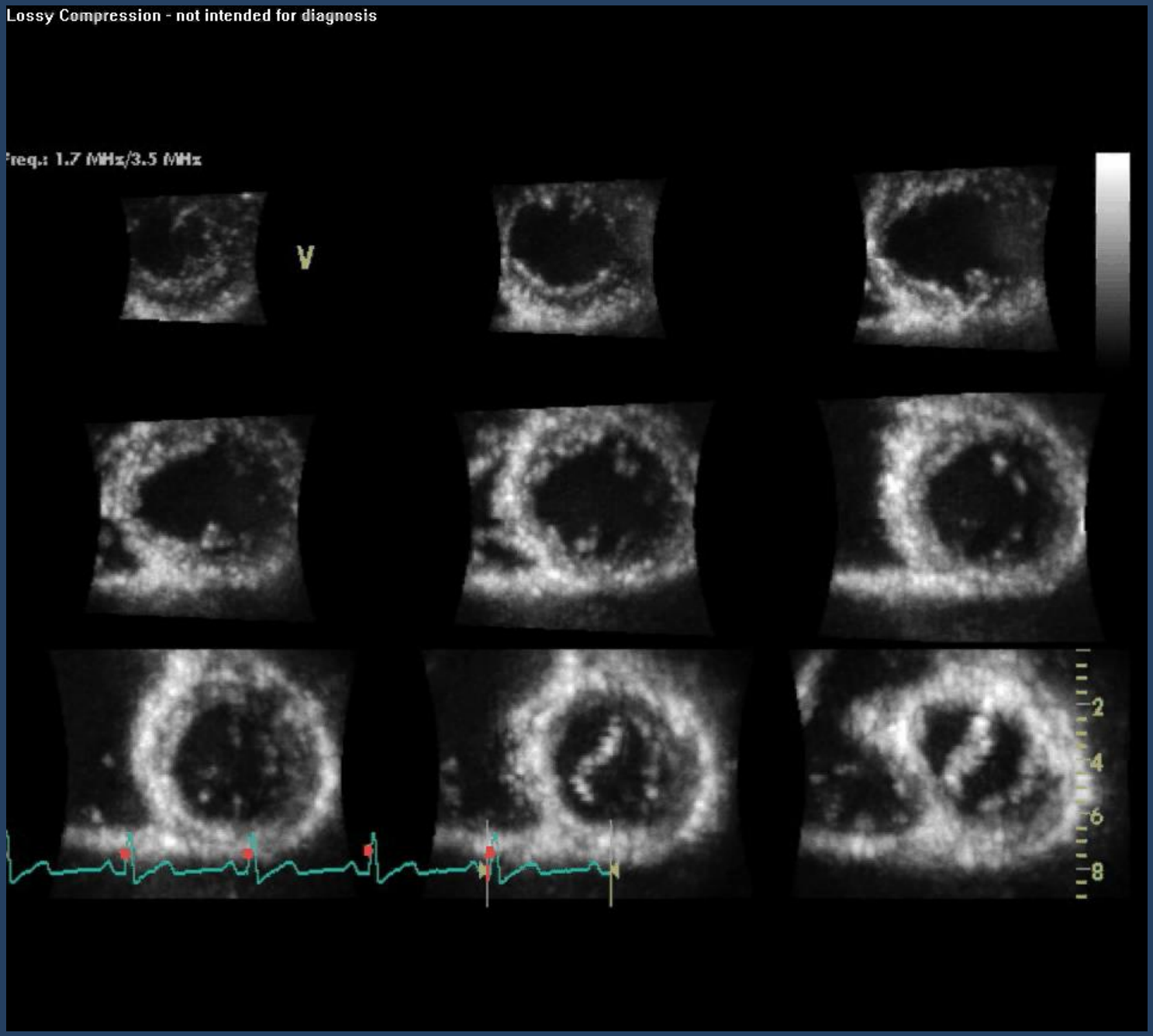


Lang et al; JASE, 18: 2005

Lossy Compression - not intended for diagnosis




03/05/2009 02:53:41 PM
TI: 21:15
2 cm
1 LVEDV(4D), Baseline 76.6 ml
LVESV(4D), Baseline 23.5 ml
EF(4D), Baseline 69.27 %
SV(4D), Baseline 53.0 ml
CO(4D), Baseline 3.71 l/min
HR, Baseline 69.91 BPM
ml
ED
ES
80
70
60
50
40
30


Lossy Compression - not intended for diagnosis
Freq.: 1.7 MHz/3.5 MHz
V
2
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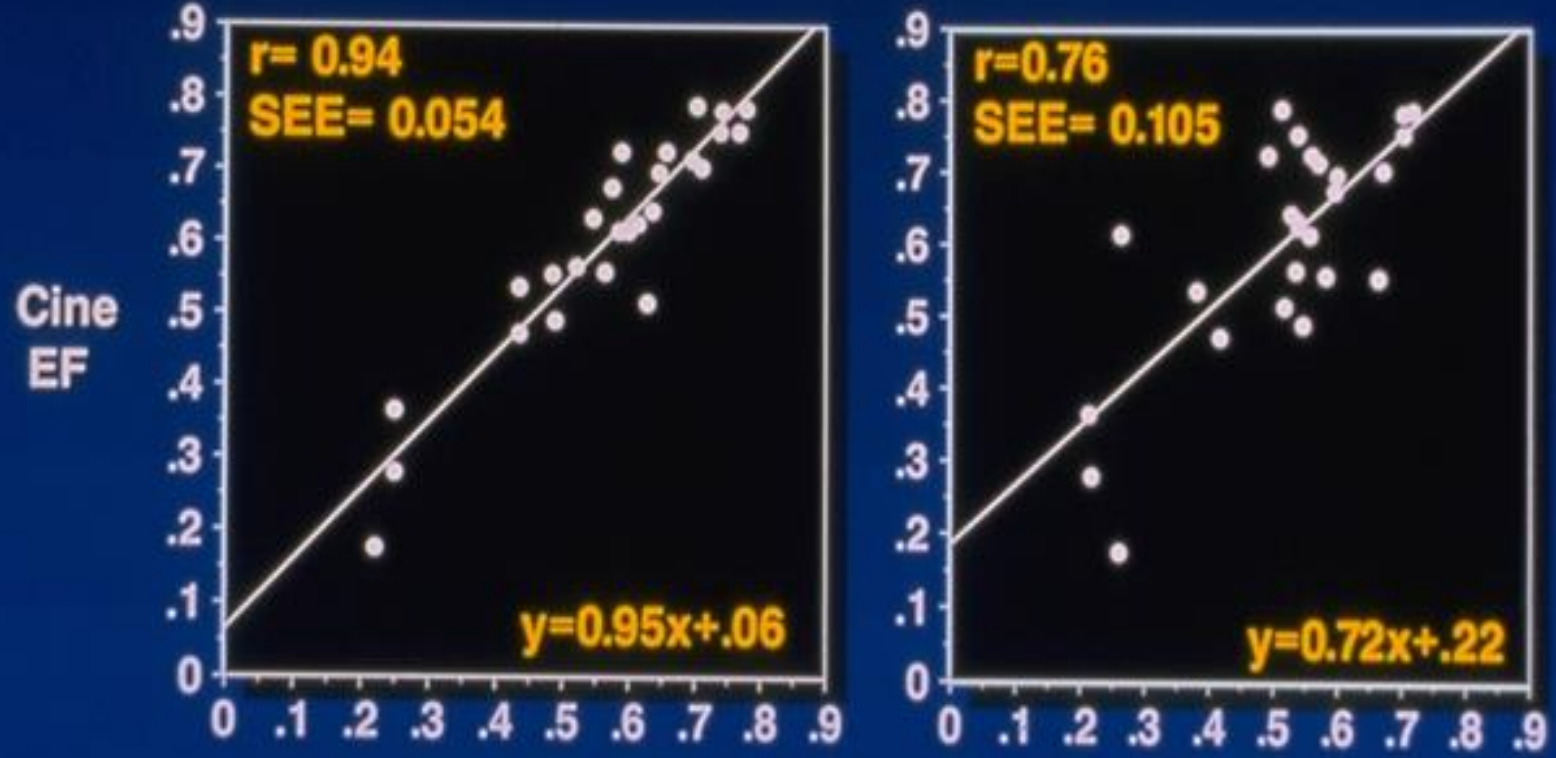
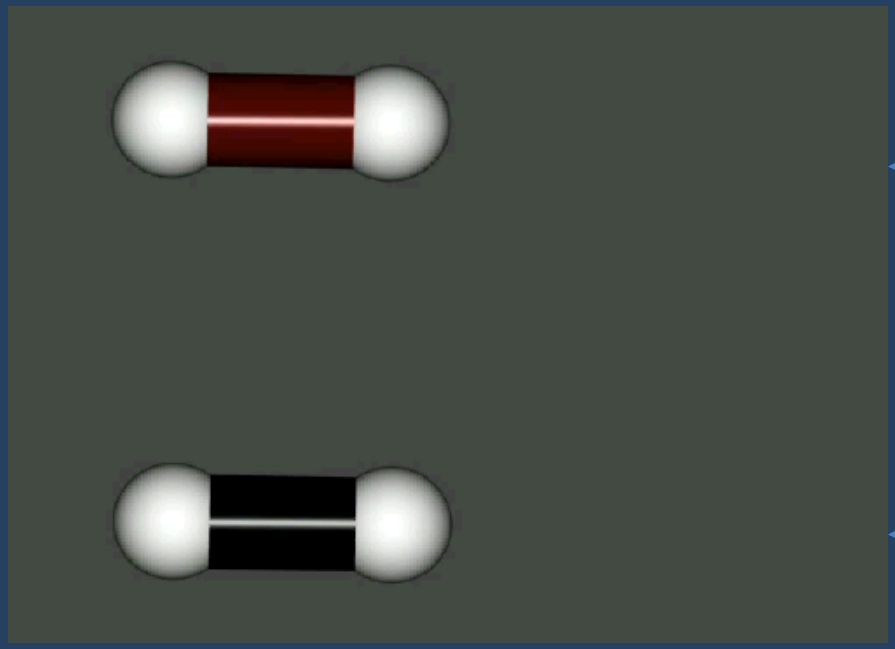
Echo vs Cine: Ejection Fraction



Deformation (Strain) vs Movement

Strain = Change in Length / Original Length



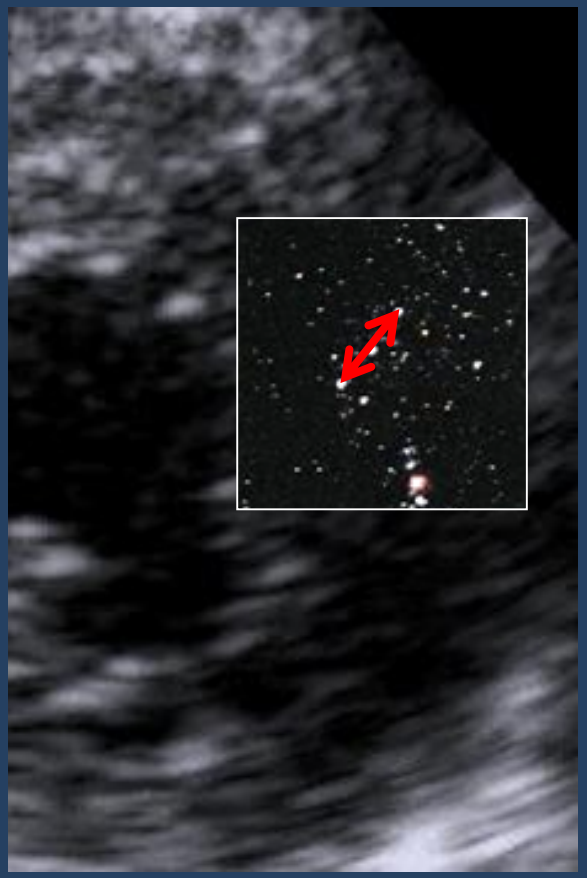
Thickening

Passive Movement

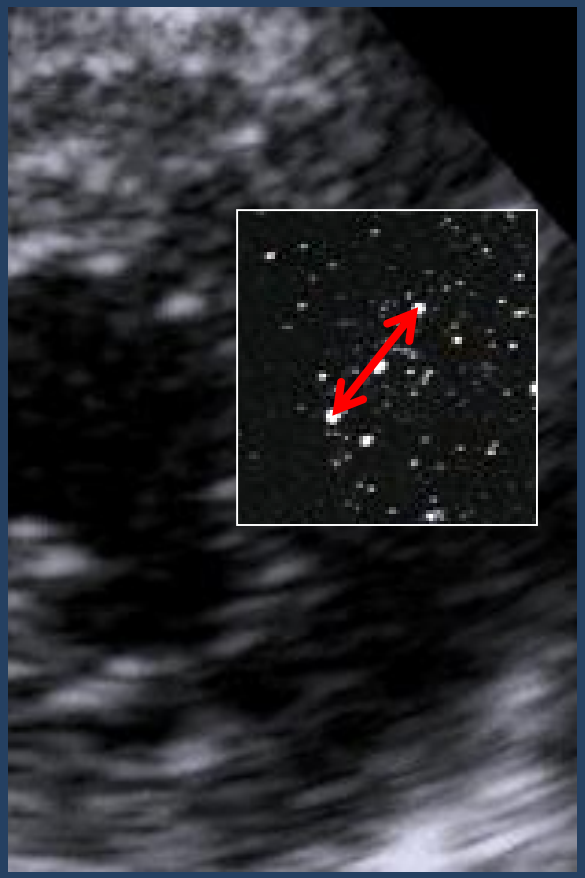
L_0 L

Courtesy Toshiba Corp.

Calculation of Strain From Speckle Tracking



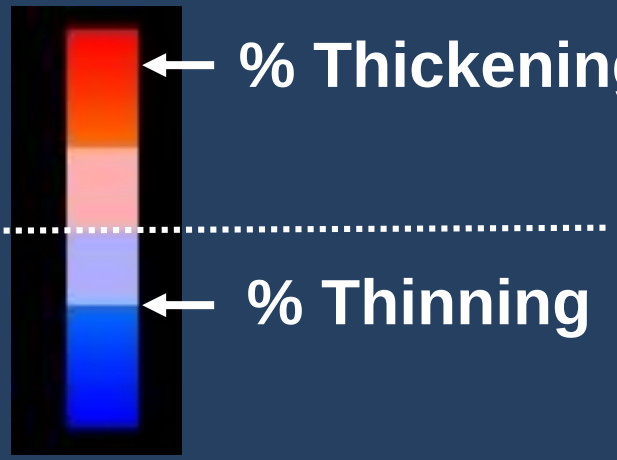
Frame 1



Frame 1 + n

Strain =

$$\frac{\text{Change in Length}}{\text{Original Length}}$$



Modified from Freedman Z. and Lysysanksyv P

CHF with Normal LVEF

- Wrong Diagnosis
- Volume Overload
- High Output Failure
- LV Underloading
  - Mechanical lesions
  - Pericardial disease
- ***Diastolic dysfunction***

Diastolic Dysfunction

- Multiple determinants
- Difficult to measure
- Diagnosis by exclusion
- Nonspecific treatment

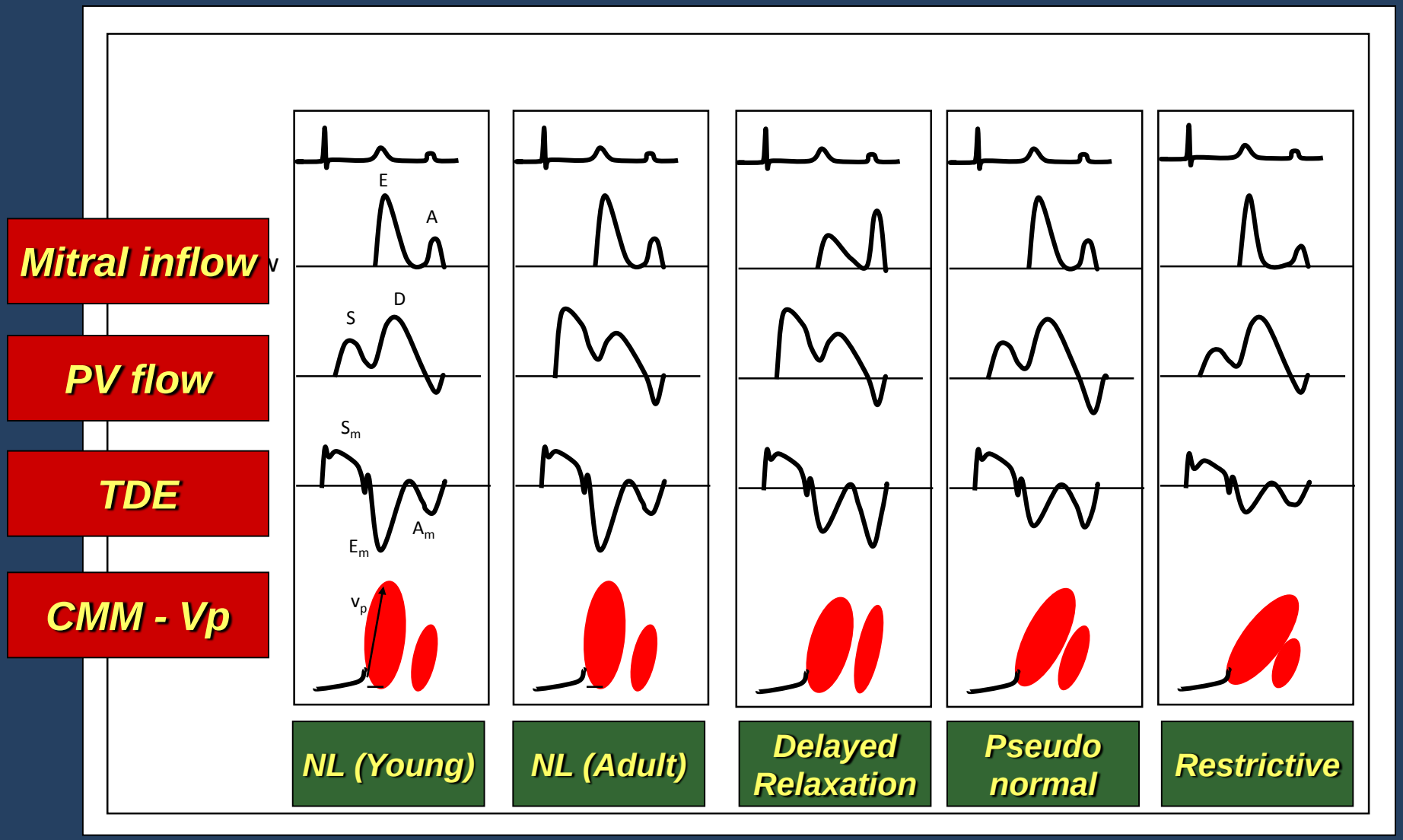
Determinants of Diastolic Function

- Myocardial Relaxation
- Chamber stiffness
- Compliance
- Atrial function
- Pericardial restraint
- Ventricular interaction
- Coronary blood volume

Echo Assessment of Diastole

- Transmitral filling velocities (E, A, integrated)
- Decleration time
- Isovolumic Relaxation Time (IVRT)
- Pulmonary Vein Flow
- Tissue Doppler Velocities
- Color Doppler flow propagation

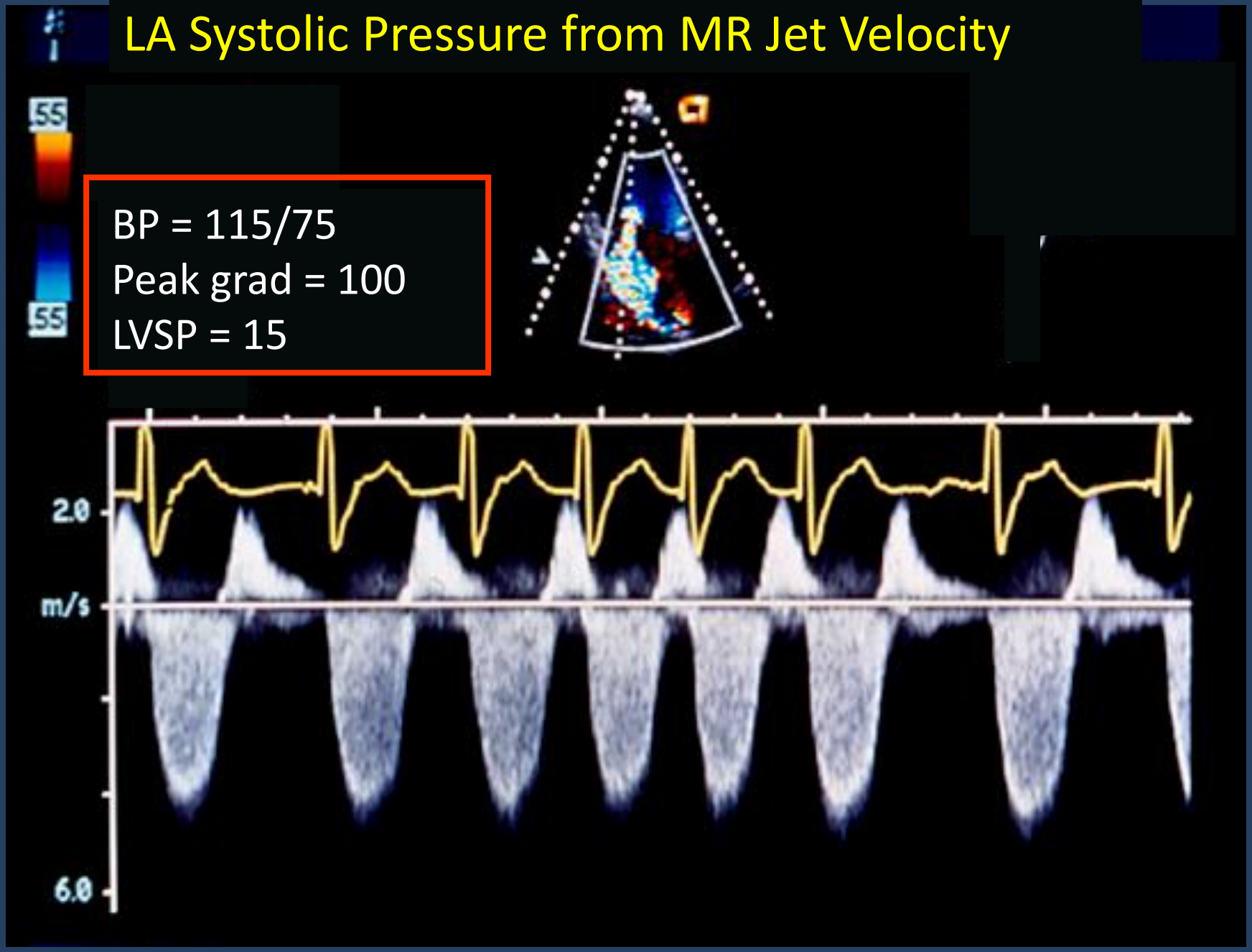
Patterns of Diastolic Function



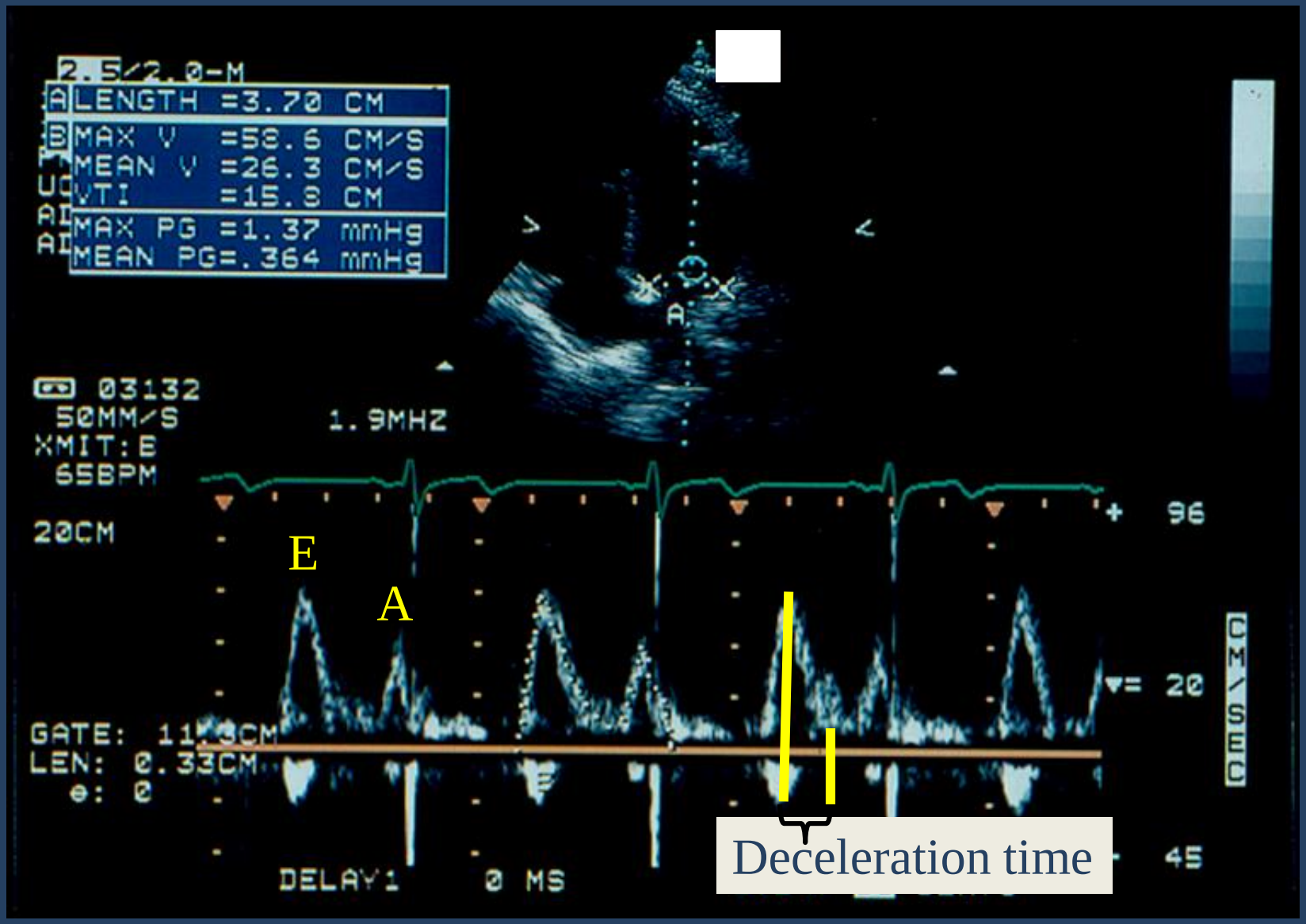
Aproaches to Estimate LV/LA Diastolic Pressure

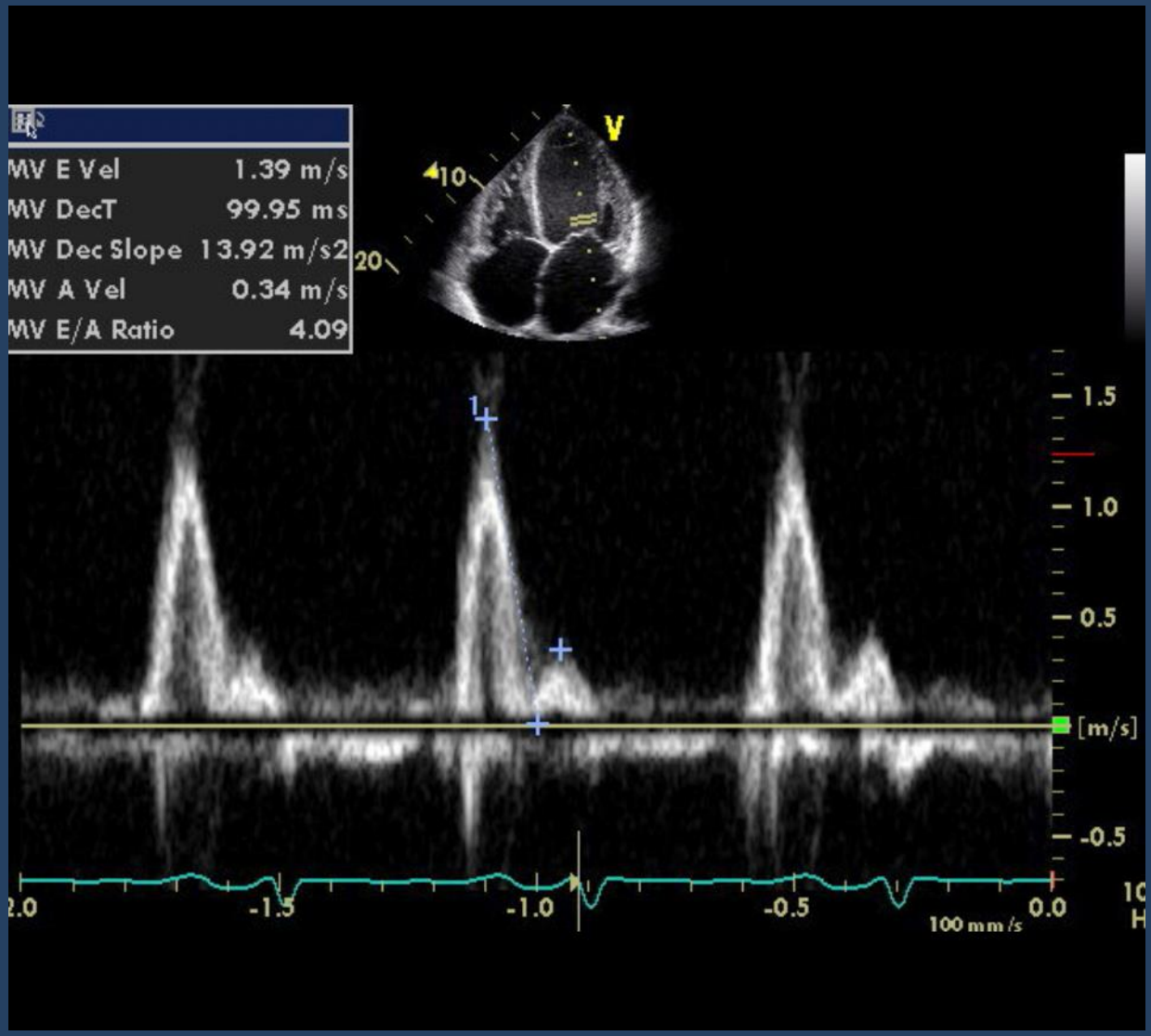
- MV systolic gradient with MR
- Transmitral filling dynamics
  - E/A, DcT, IVRT,etc (*with Valsalva*)
- ***Pulmonary vein systolic filling fraction***
- ***Ratio of pulmonary vein Ar/mitral A***
- ***E/Ea (E/E’) ratio***
- E/Vpm (color Doppler flow propagation)

LA Systolic Pressure from MR Jet Velocity

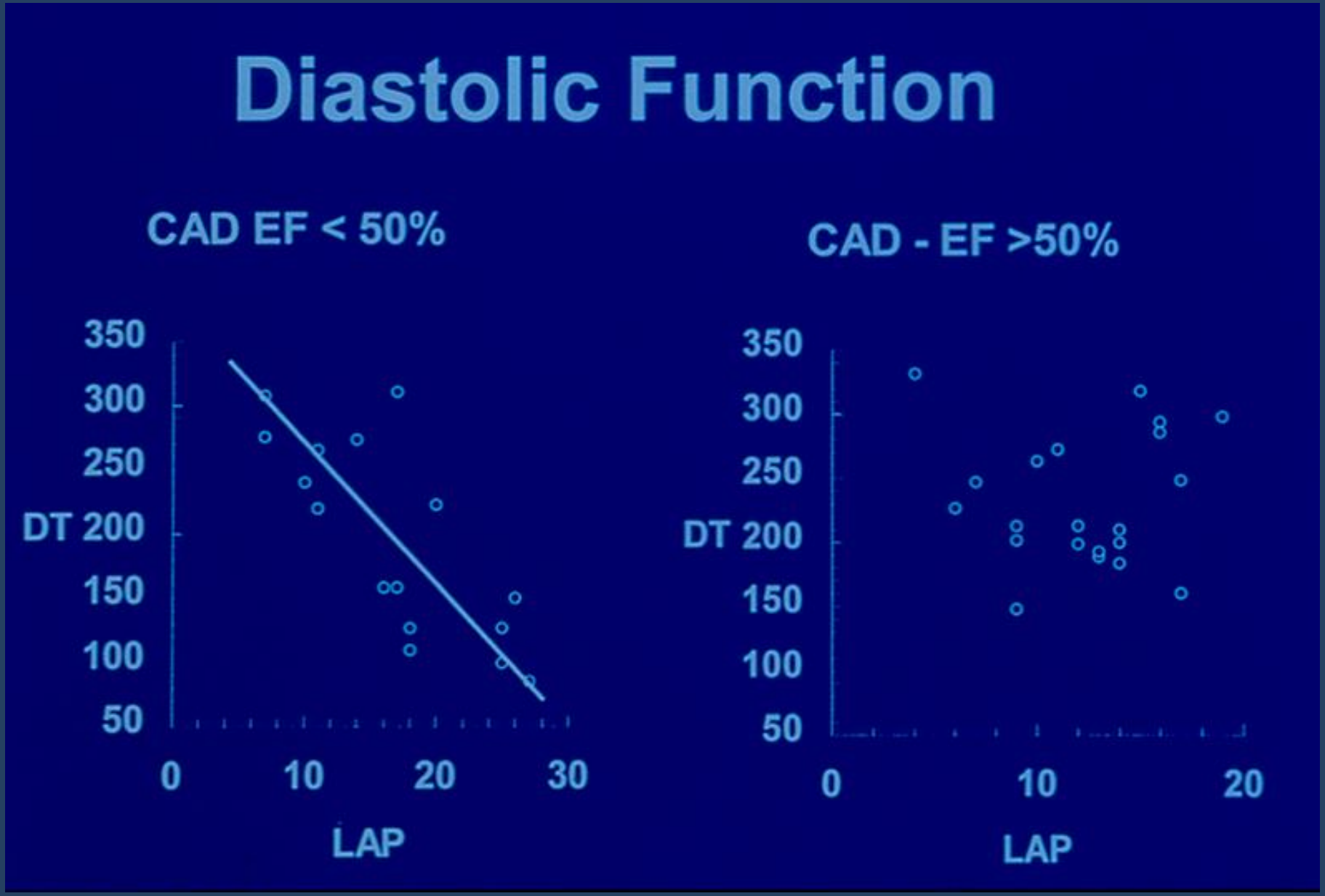


Deceleration Time




MV E Vel 1.39 m/s
MV DecT 99.95 ms
MV Dec Slope 13.92 m/s2
MV A Vel 0.34 m/s
MV E/A Ratio 4.09
V
10
20
1
1.5
1.0
0.5
[m/s]
-0.5
-1.5
-1.0
-0.5
0.0
100 mm/s

Diastolic Function



Deceleration Time Predicts Mortality and Events

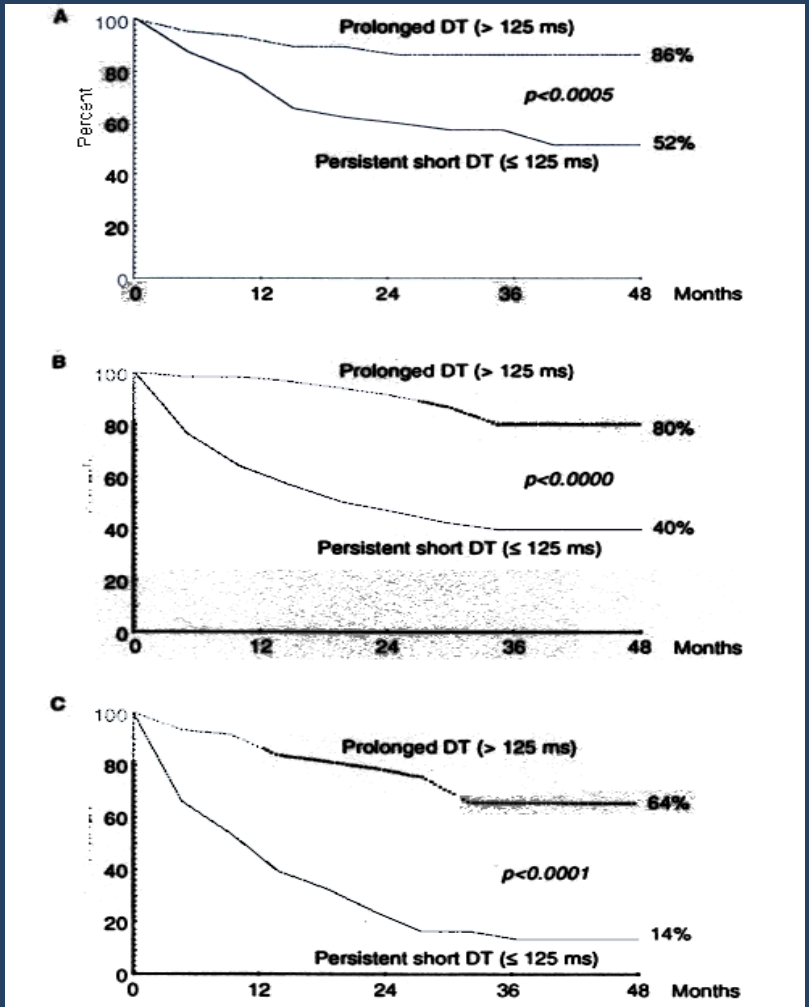
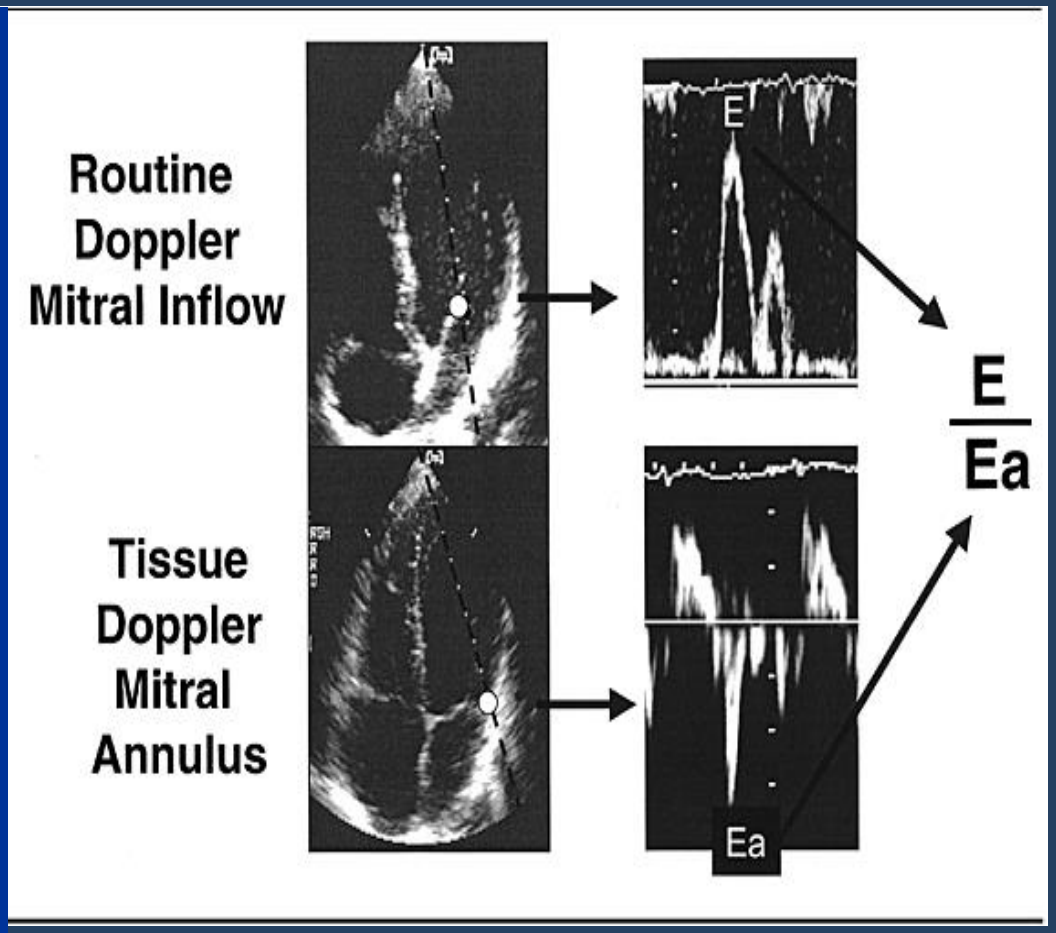
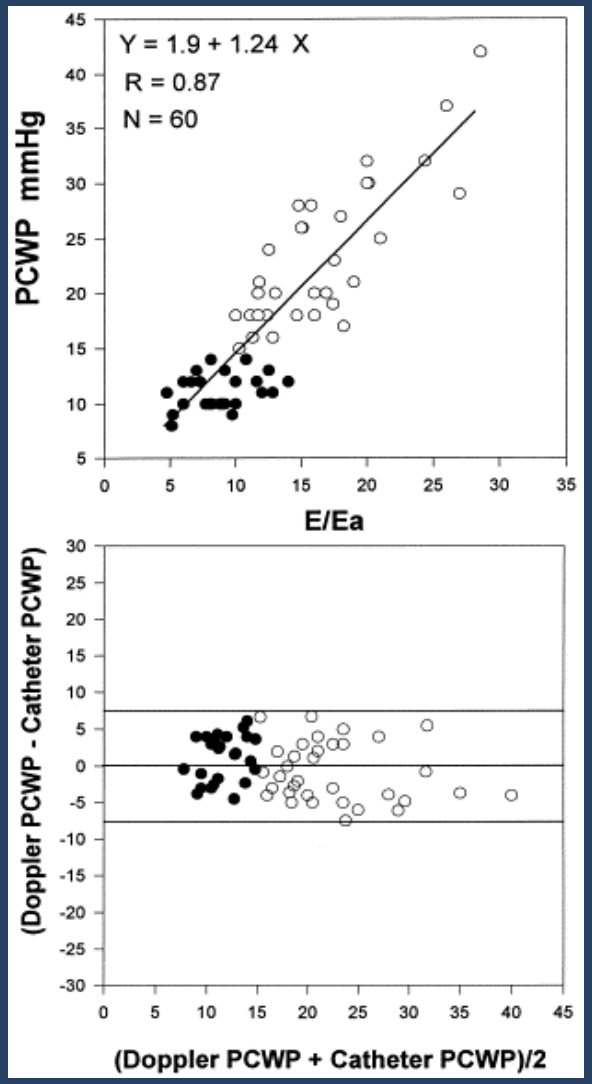


Figure 1. Cumulative survival rates for cardiac mortality as an event (A); cumulative survival rates free of hospital admission for CHF (B); and cumulative survival rates free of all cardiac events (death, transplantation and hospital admission for worsening heart failure) in the two study groups according to the value of DT of early filling: prolonged DT (>125 ms) versus persistent short DT (≤125 ms).

Gianuzzi,JACC

E/Ea Estimates LV Filling Pressure





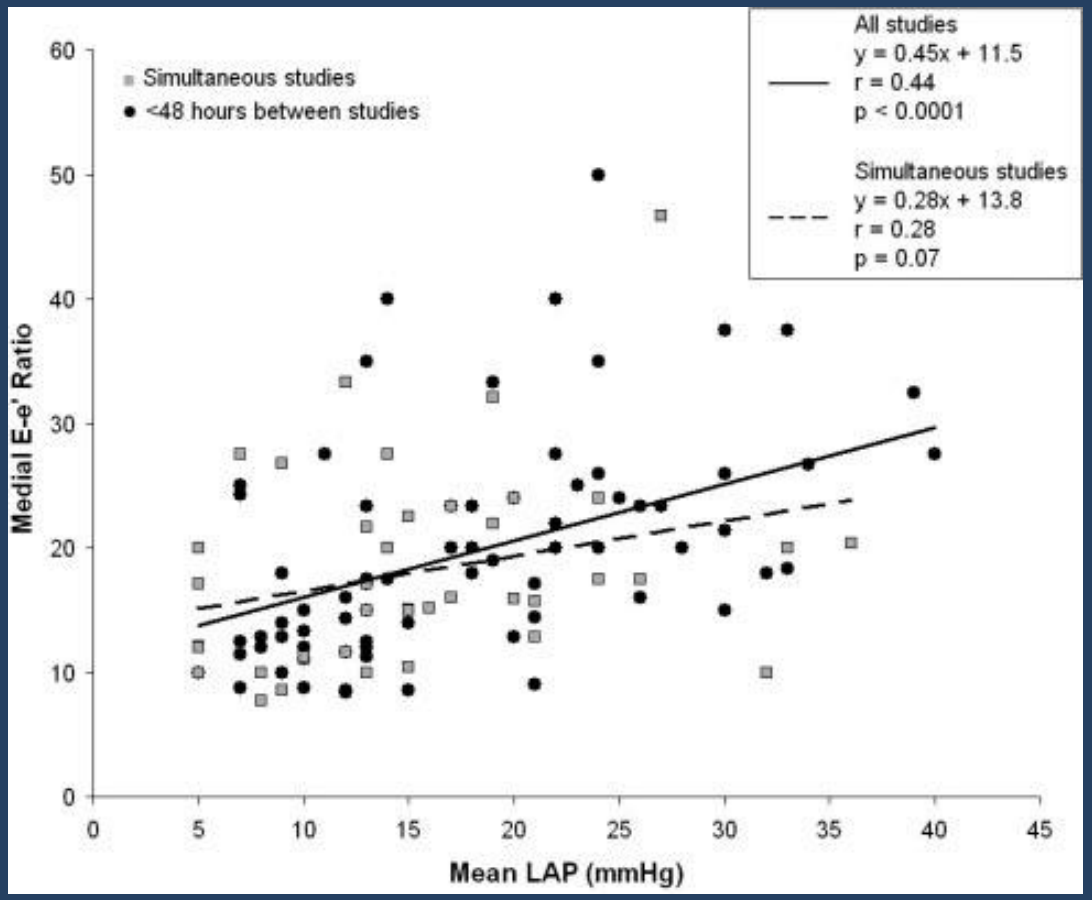
Nagueh et al; JACC, 1997

Evaluation of Left Ventricular Filling Pressures by Doppler Echocardiography in Patients With Hypertrophic Cardiomyopathy

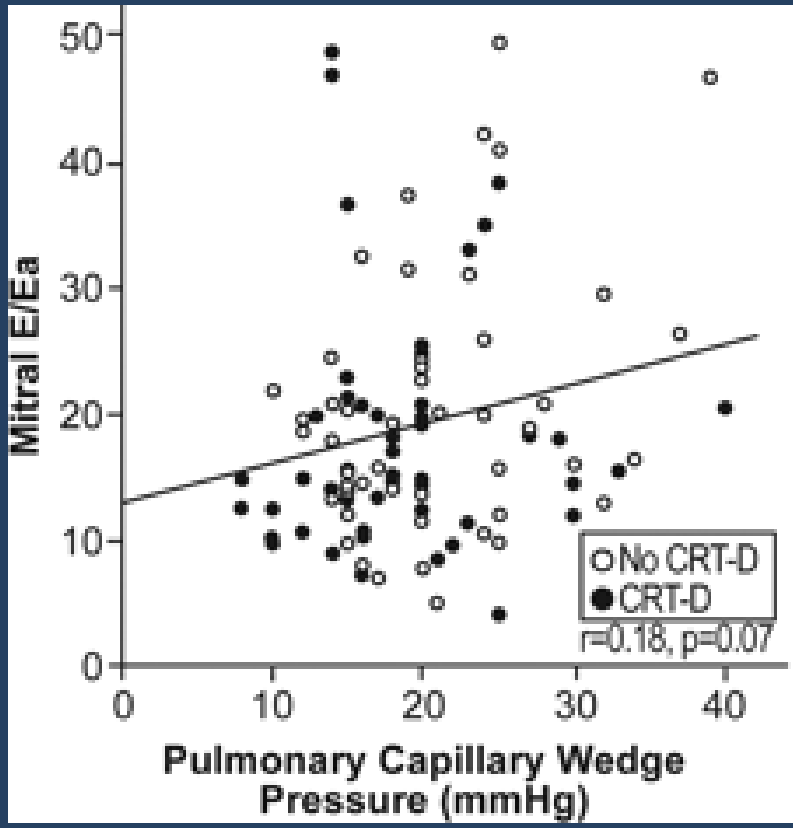
Correlation With Direct Left Atrial Pressure Measurement at Cardiac Catheterization

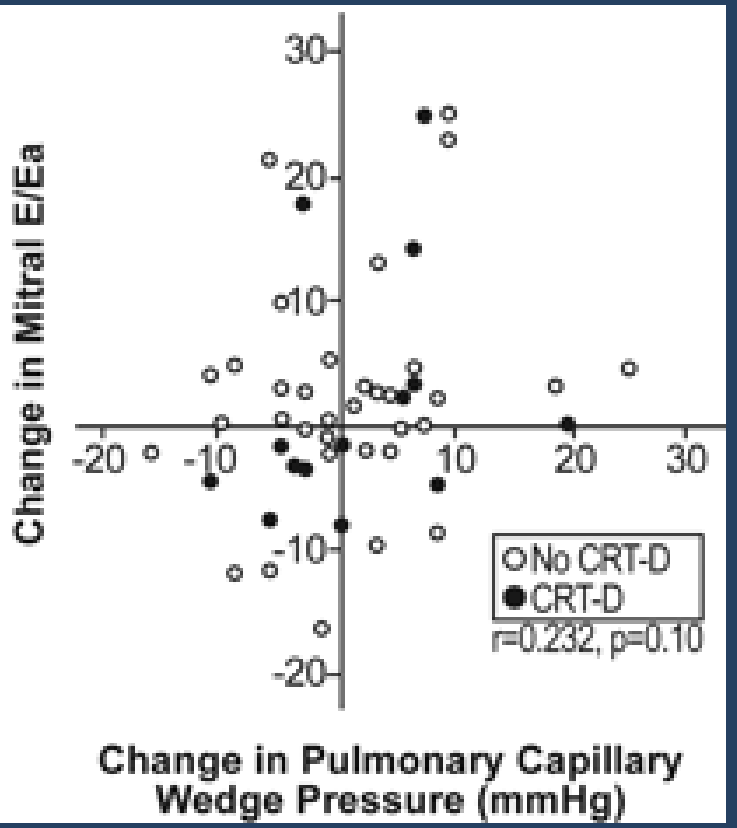
(*Circulation*. 2007;116:2702-2708.)

Jeffrey B. Geske, MD; Paul Sorajja, MD; Rick A. Nishimura, MD; Steve R. Ommen, MD



Limitations of E/E’ for Diastolic Function

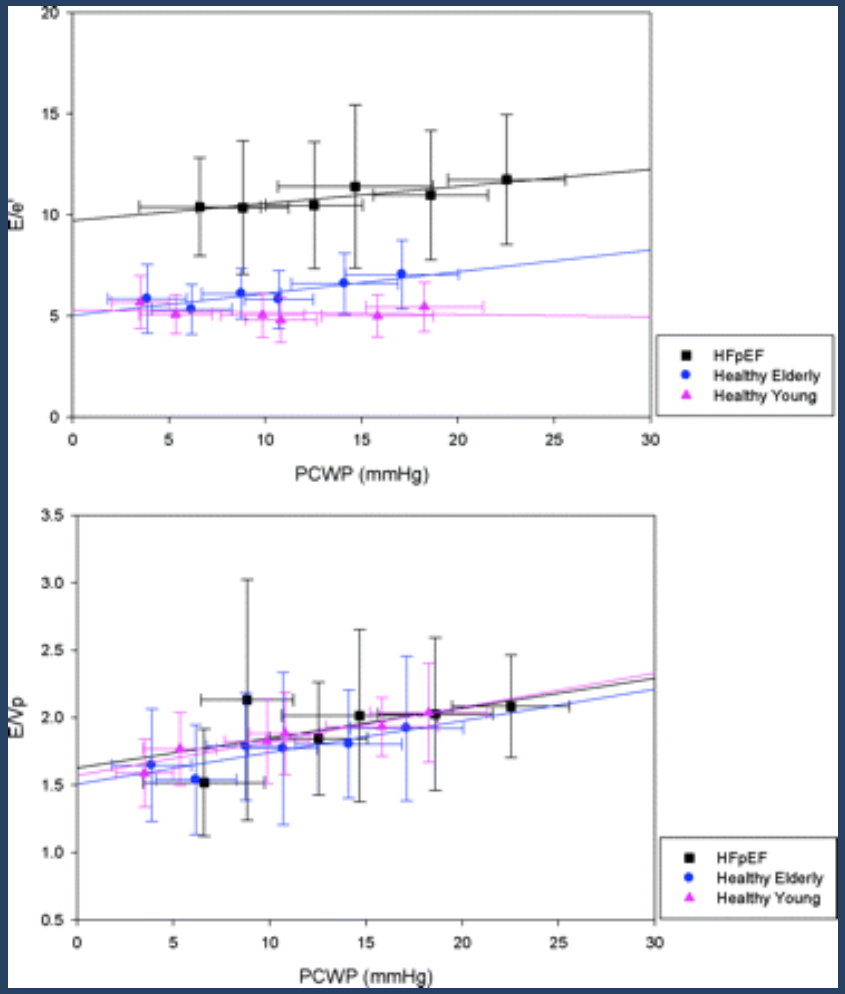




Tissue Doppler Imaging in the Estimation of Intracardiac Filling Pressure in Decompensated Patients With Advanced Systolic Heart Failure

Wilfried Mullens, MD; Allen G. Borowski, RDCS; Ronan J. Curtin, MD; James D. Thomas, MD; W.H. Tang, MD

Limitations of E/E’ for Diastolic Function



Bhella et al; Circ CV Image, 2011

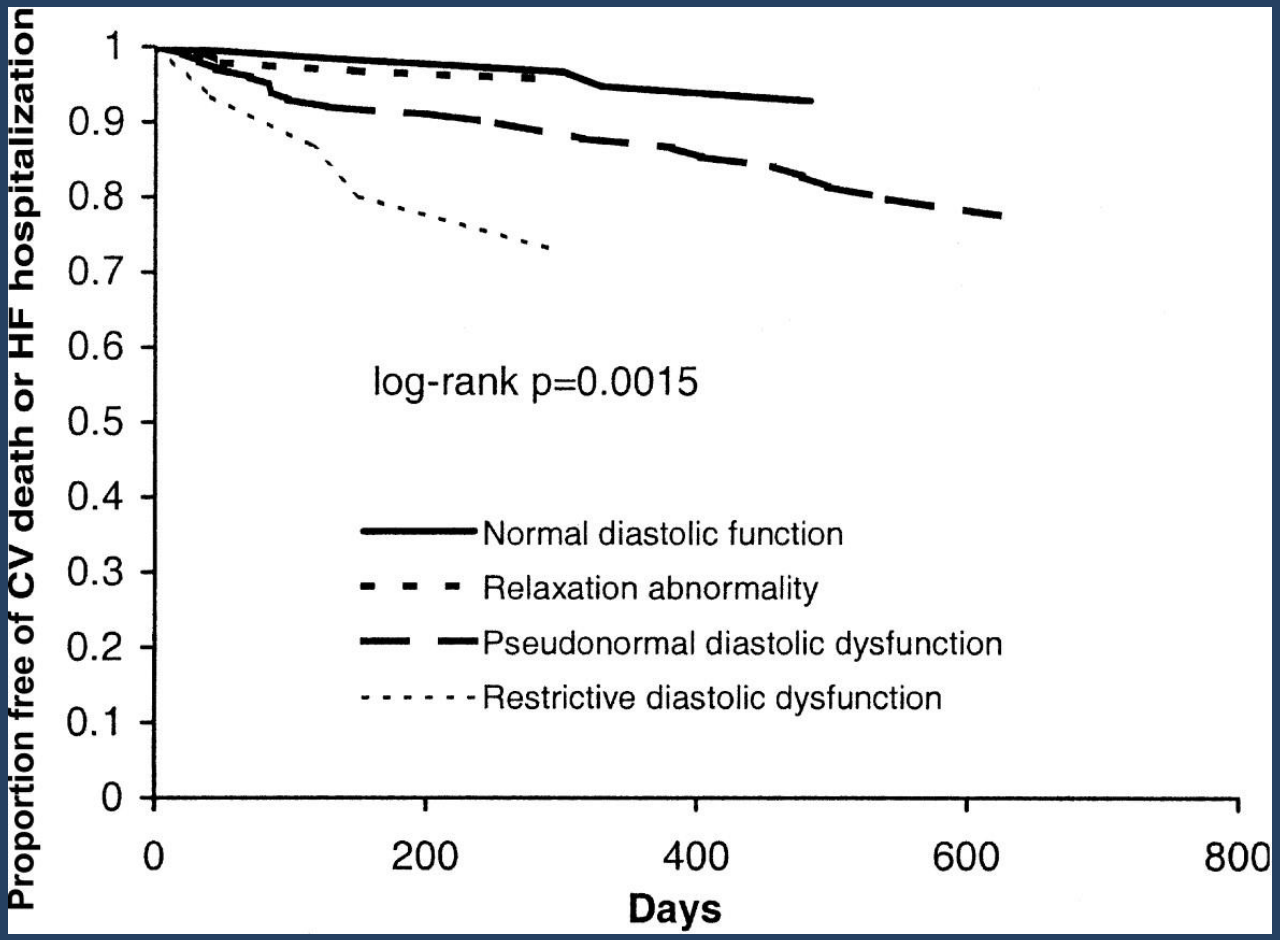
E/E’ Ratio May Not Apply

- Normal heart
- Constrictive pericarditis
- Mitral stenosis or insufficiency
- Mitral or aortic valve replacement
- Mitral annular calcification
- Hypertrophic cardiomyopathy
- Acute decompensated heart failure (CRT)

Diastolic Dysfunction and Mortality in CHARM

- Subgroup of CHARM Preserved
- 66% had evidence of diastolic dysfunction
  - 44% moderate to severe
- Adverse prognosis in those with dysfunction

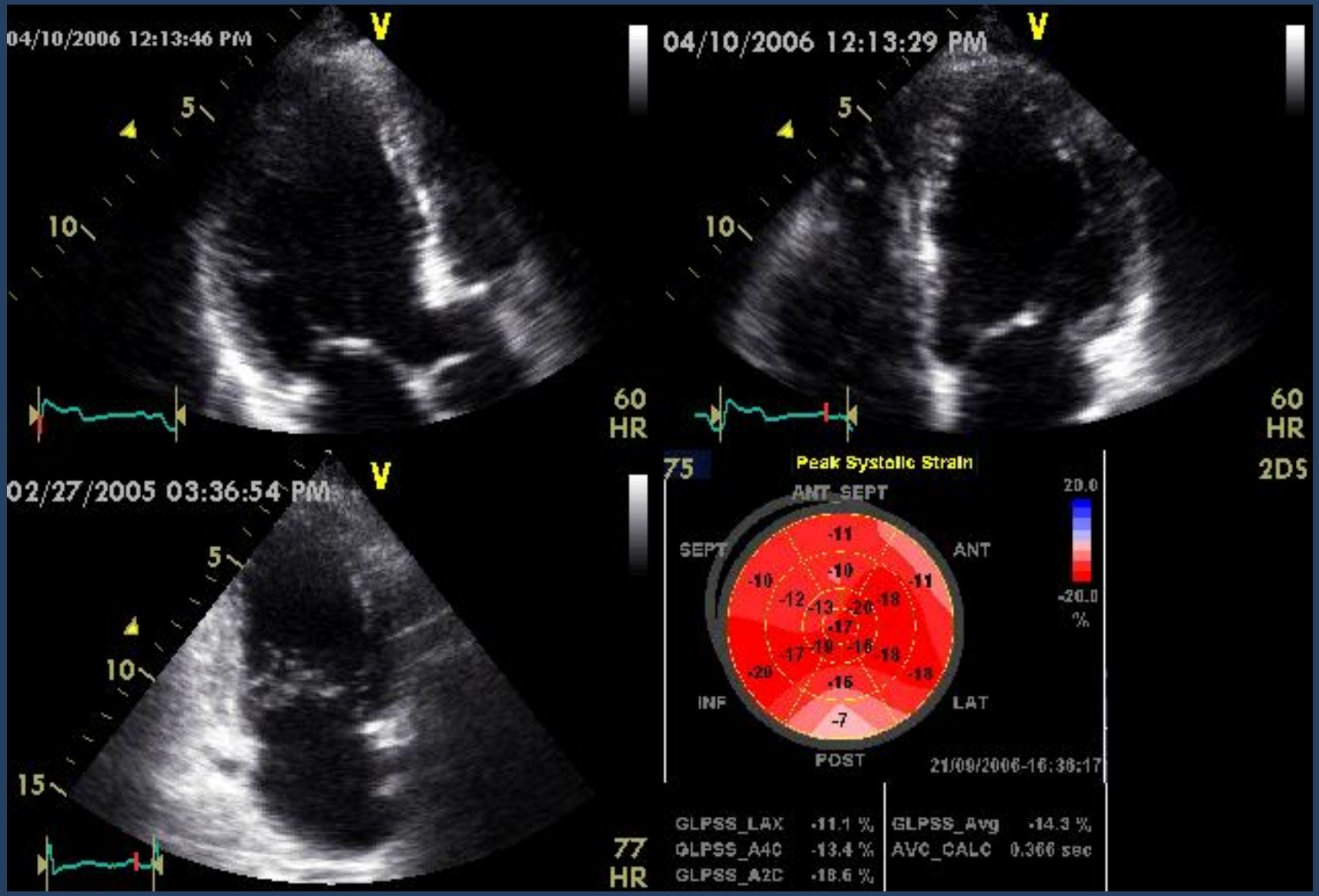
Diastolic Dysfunction and Mortality in CHARM



Persson et al; JACC, 2007

Step Approach to Diastole (E/E’)

- Consider only E/E’ > 15
  - 12 if lateral included
- Evaluate corroborating findings
  - Particularly LA size
- Combine all findings and include clinical picture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Peak Systolic Strain
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21/09/2006-16:36:17
GLPSS_LAX -11.1 %
GLPSS_A4C -13.4 %
GLPSS_A2C -18.6 %
GLPSS_Avg -14.3 %
AVC_CALC 0.366 sec

PROGNOSTIC FACTORS IN CHF

- Clinical class
- Age
- Diabetes
- Etiology
- LV size and function
- Cardiac pressures
- Ventricular arrhythmias
- Electrolyte and neurohormonal abnormalities

Table 3. Predictors of Cardiac Death by Cox Proportional Hazards Model

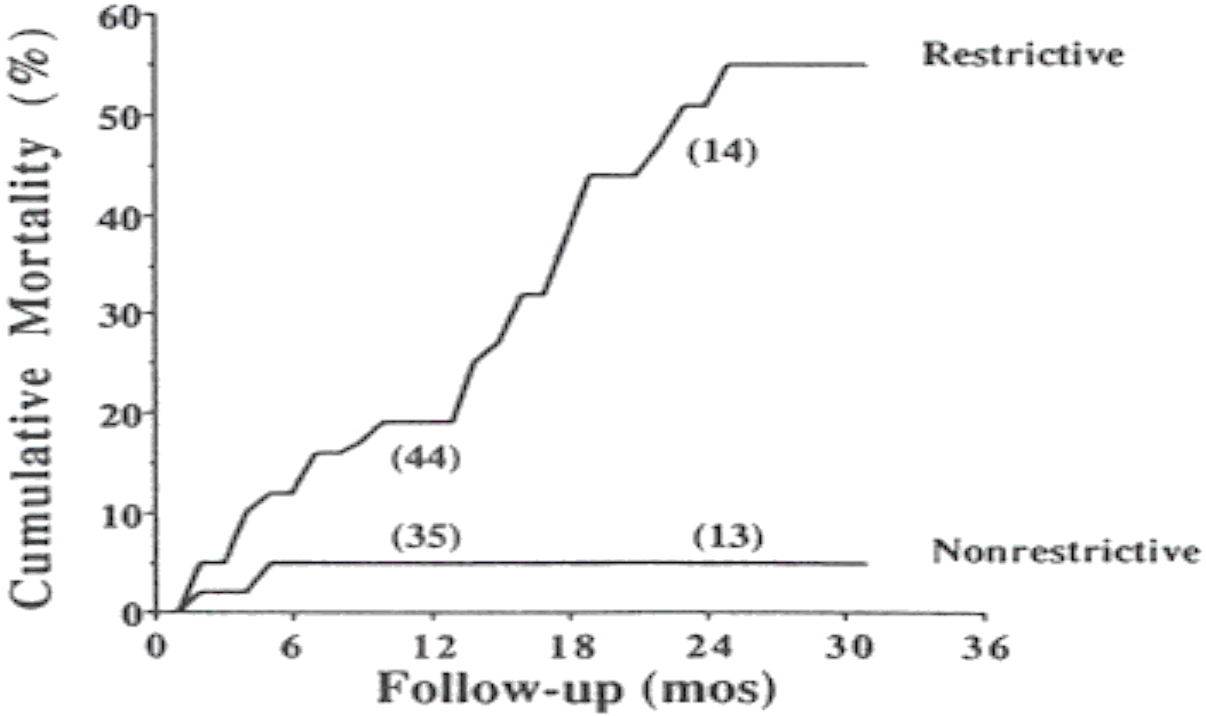
Variable	Chi-Square Value	p Value
TMF (restrictive vs. nonrestrictive)	6.99	0.008
Patient gender (F vs. M)	4.59	0.03
NYHA functional class (IV vs. II)	3.95	0.05
LVEF	2.97	0.08
NYHA functional class (IV vs. III)	1.71	0.19

LVEF = left ventricular ejection fraction; TMF = transmitral flow pattern; other abbreviations as in Table 2.

JACC Vol. 24, No. I July 1994:132-9

XIE ET AL
.MITRAL FLOW PATTERNS PREDICT CARDIAC MORTALITY

Figure 7. Effect of transmitral flow patterns on cumulative cardiac mortality. The 1-year mortality rate was 19% in the restrictive group and 5% in the nonrestrictive group ($p < 0.05$). Note the wide divergence of two mortality rate curves after 1 year, resulting in a 2-year mortality rate of 51% in the restrictive group but only 5% in the nonrestrictive group ($p < 0.01$). **Numbers in parentheses** = number of survivors at 12 and 24 months.



Differences Between Echocardiograms According to Parameter

Parameter	Absolute difference	Relative difference
Δ Left ventricular EF	8.1% ± 11.5%	17% ± 30%
Δ Left atrial area	4.0 ± 5.2 cm^2	17% ± 23%
Δ Tissue Em	2.1 ± 2.7 cm/s	27% ± 36%
Δ E/e′	5.0 ± 7.0	46% ± 64%

Em = mitral annular tissue diastolic velocity.

Marwick; JNM: 2015
Thavendiranathan et al; JACC: 2013
Jenkins et al; JACC: 2004

Biphasic Response to Dobutamine for Viability

2009 Focused Update Incorporated Into the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in Adults

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