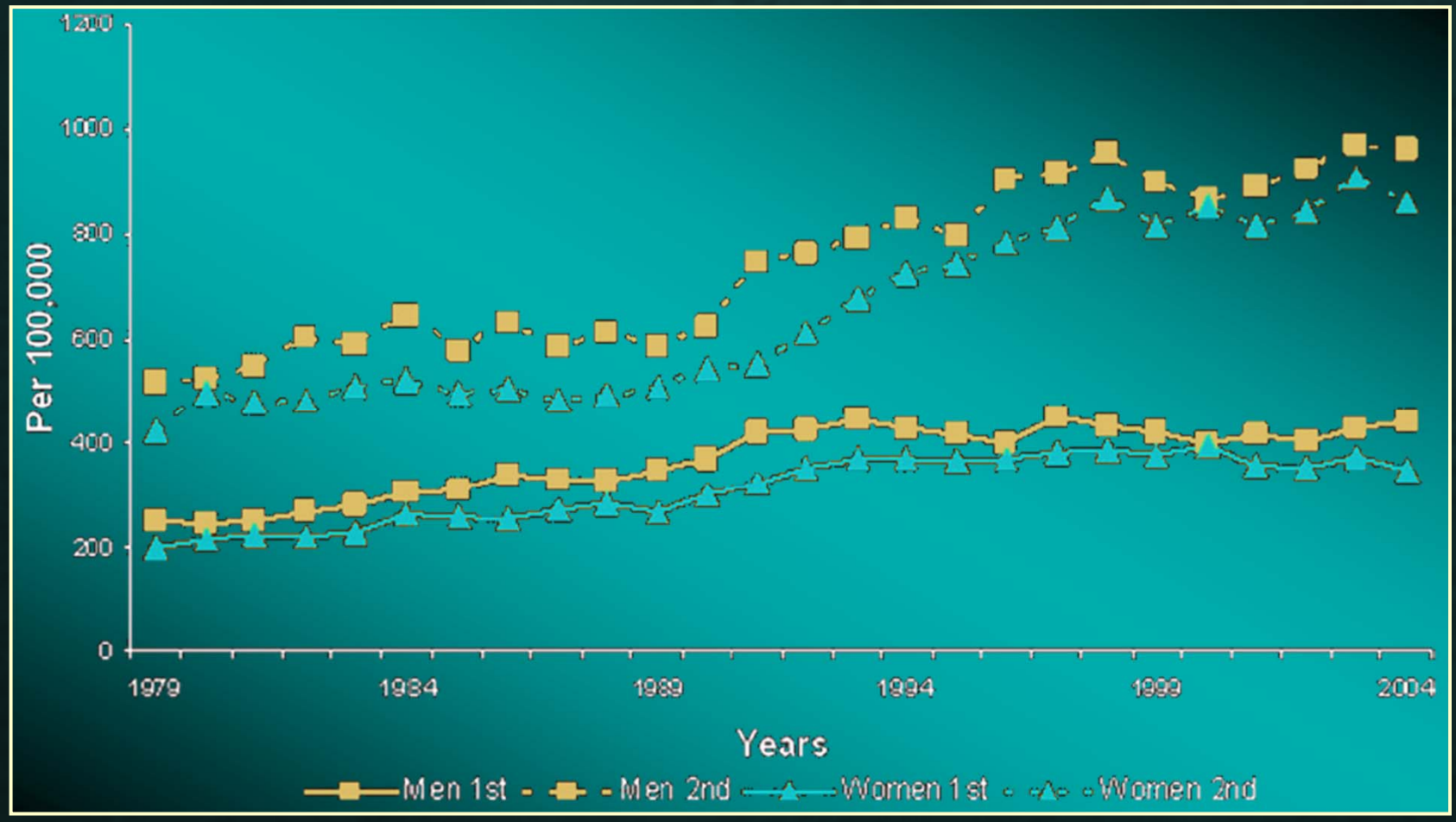
Echo based Management of Heart Failure

Jin-Oh Choi
Sungkyunkwan University
Samsung Medical Center

Recent advance in Heart Failure

- Natriuretic Peptide
  - Diagnosis and prognosis of HF
    - BNP
    - NT-proBNP
- Neurohormonal blockade
  - Treatment of HF
    - RAS inhibitor
    - Beta-blocker
    - Aldosterone inhibitor

Age-Adjusted Hospitalization Rates for Heart Failure. National Hospital Discharge Survey, 1979–2004



Fang et al. JACC 2008;52:428–34

ACC/AHA guideline for the diagnosis and management of HF 2008

- "Comprehensive 2-D and Doppler EchoCG is the single most useful diagnostic test in the evaluation of HF…"
- Accurate and noninvasive measurement of ventricular function and structural abnormality

Echo role in HF

- Make a correct diagnosis of HF
- Find reversible or treatable cause
- Prognostic evaluation
- Guidance in therapeutic decision

Diagnosis of HF

HF is a clinical syndrome in which patients have the followings

- **Symptoms typical of heart failure**

Breathlessness at rest or on exercise, fatigue, tiredness, ankle swelling

and

- **Signs typical of heart failure**

Tachycardia, tachypnea, pulmonary rales, pleural effusion, raised jugular venous pressure, peripheral edema, hepatomegaly

and

- **Objective evidence of a structural or functional abnormality of the heart at rest**

Cardiomegaly, third heart sound, cardiac murmurs, abnormality on the echocardiogram, raised natriuretic peptide concentration

From ESC Guidelines 2008

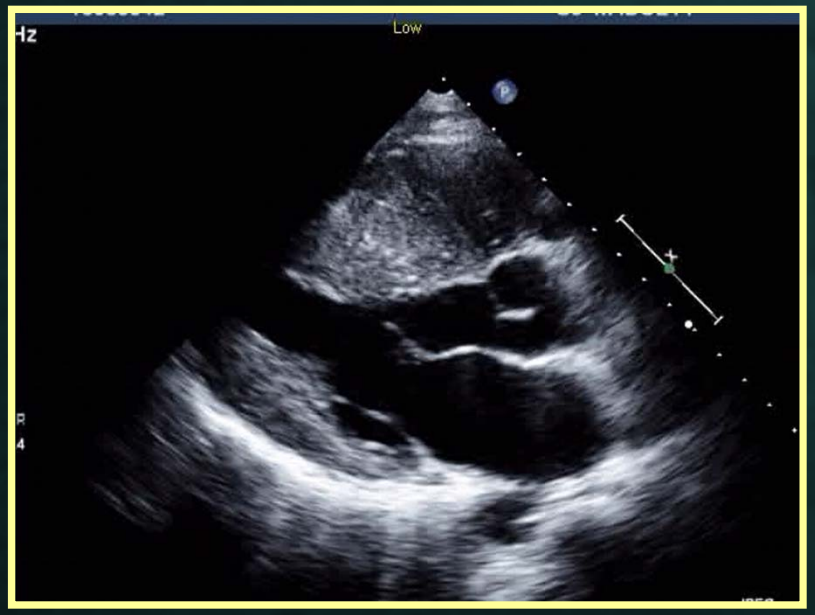
Common echocardiographic abnormalities in HF

Measurement	Abnormality	Clinical implications
LV EF	Reduced (<45–50%)	Systolic dysfunction
LV function, Global and regional	Akinesis, hypokinesis, dyskinesis	Myocardial infarction/ischaemia Cardiomyopathy, myocarditis
LV FS	Reduced (<25%)	Systolic dysfunction
LV EDD	Increased (>55–60 mm)	Volume overload, HF likely
LV ESD	Increased (>45 mm)	Volume overload, HF likely
LA size	Increased (>40 mm)	Increased filling pressures Mitral valve dysfunction, Atrial fibrillation
LV thickness	Hypertrophy (>11–12 mm)	Hypertension, aortic stenosis, HCM
Valve structure and function	Valvular stenosis or regurgitation (especially aortic stenosis and mitral insufficiency)	May be primary cause of HF or complicating factor Assess gradients and regurgitant fraction Assess haemodynamic consequences Consider surgery
Mitral inflow profile	Abnormalities of the early and late diastolic filling patterns	Indicates diastolic dysfunction and suggests mechanism
TR peak velocity	Increased (>3 m/s)	Increased RVSP, Suspect pulmonary hypertension
Pericardium	Effusion, haemopericardium, thickening	Consider tamponade, uremia, malignancy, systemic disease, acute or chronic pericarditis, constrictive pericarditis
Aortic outflow TVI	Reduced (<15 cm)	Reduced low stroke volume
Inferior vena cava	Dilated Retrograde flow	Increased RA pressures, RV dysfunction Hepatic congestion

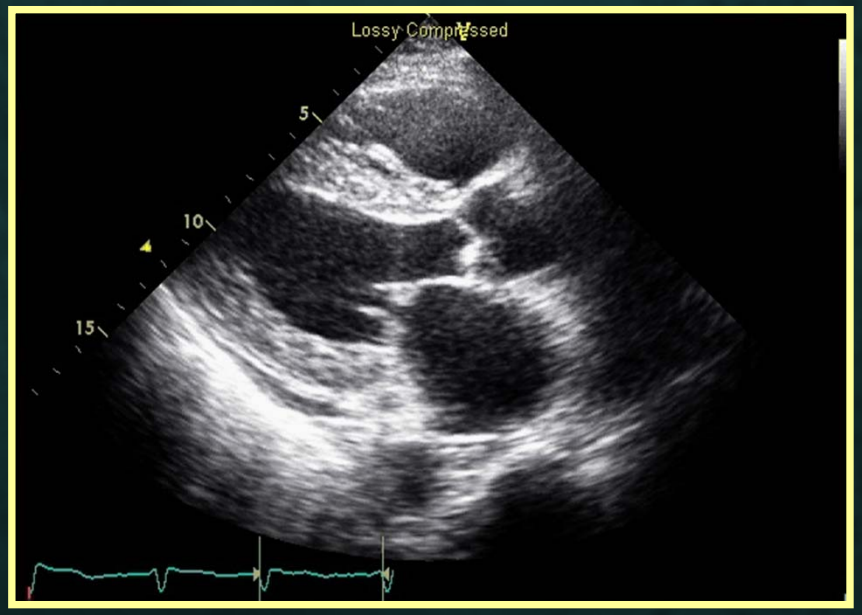
Three fundamental questions must be addressed at evaluation of HF

1) Is LV EF preserved or reduced?
2) Is LV structure normal or abnormal?
3) Are there other structural abnormalities such as valvular, pericardial, or RV abnormalities that could account for the clinical presentation?

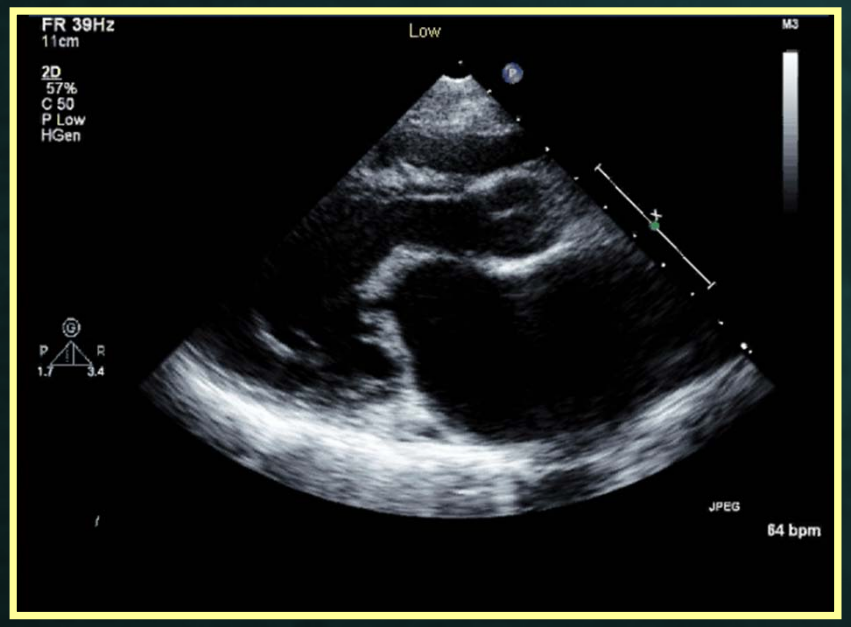
HCM



Infiltration

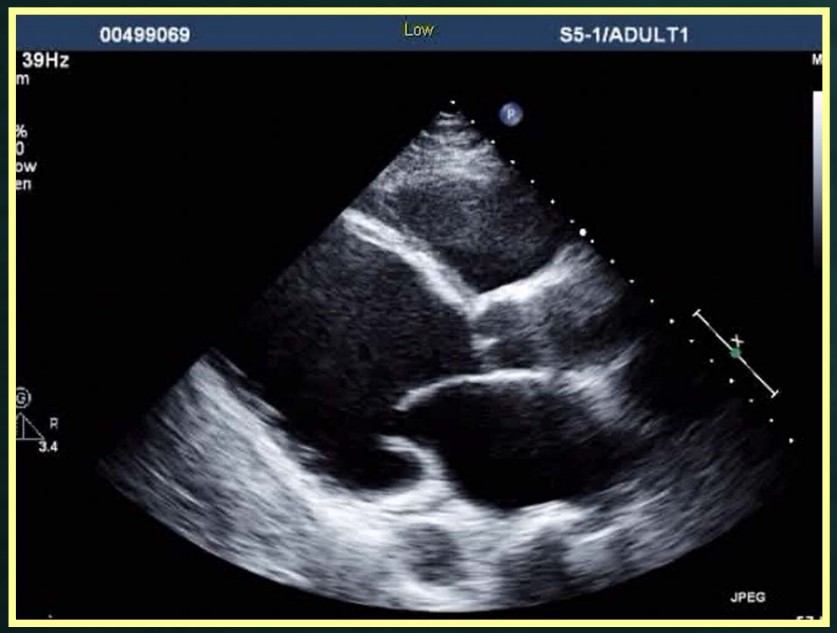


Valve disease

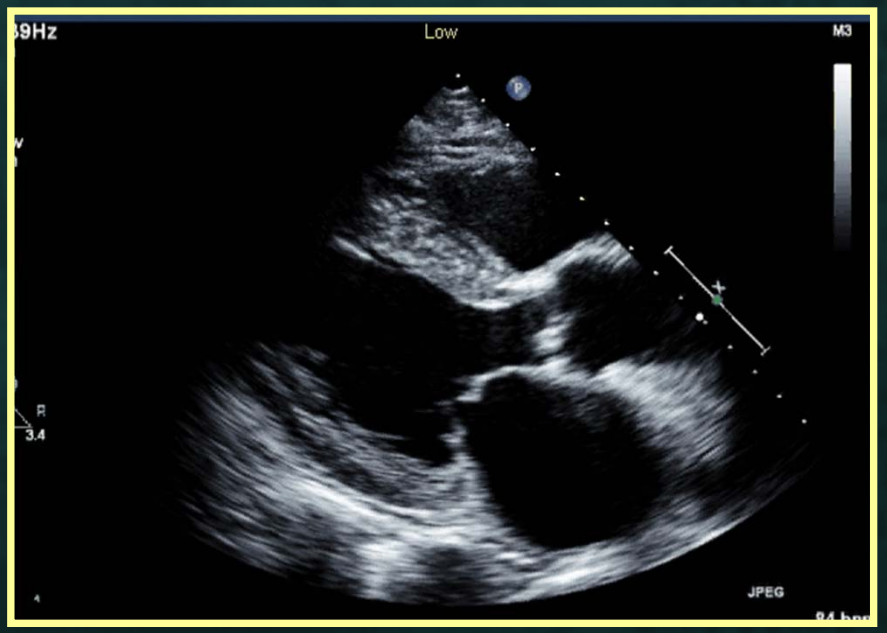


Constriction

Reduced LVEF



Preserved LVEF



Classification of HF

- Systolic HF vs Diastolic HF
  - HF with reduced EF
    - LVEF < 40-45%
  - HF with preserved EF
    - LVEF > 45-50%

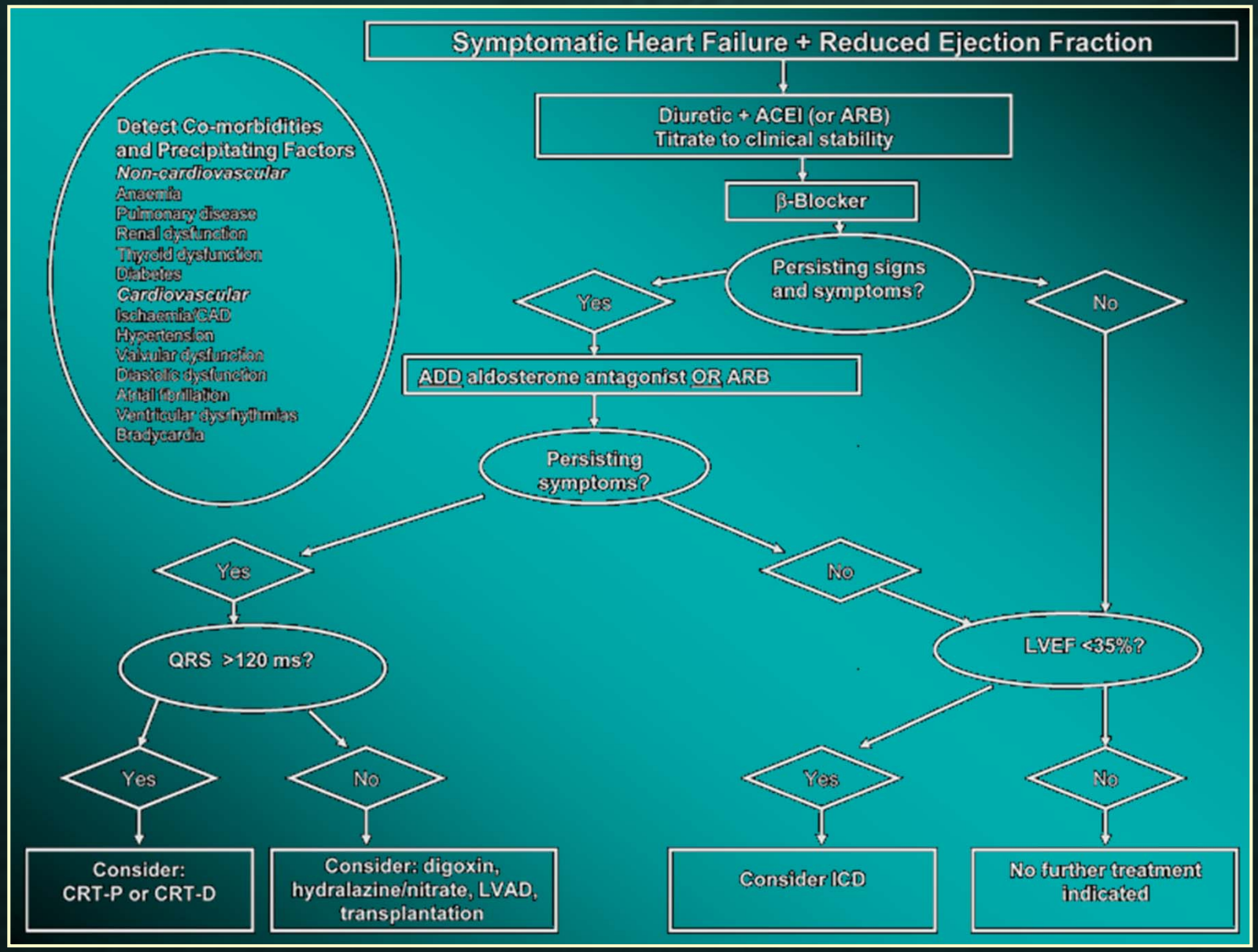
Classification of HF

- **Systolic HF vs Diastolic HF**
  - **HF with reduced EF**
    - **LVEF < 40-45%**
  - **HF with preserved EF**
    - **LVEF > 45-50%**

Common echocardiographic abnormalities in HF

Measurement	Abnormality	Clinical implications
LV EF	Reduced (<45–50%)	Systolic dysfunction
LV function, Global and regional	Akinesis, hypokinesis, dyskinesis	Myocardial infarction/ischaemia Cardiomyopathy, myocarditis
LV EDD	Increased (>55–60 mm)	Volume overload, HF likely
LV ESD	Increased (>45 mm)	Volume overload, HF likely
LV FS	Reduced (<25%)	Systolic dysfunction
LA size	Increased (>40 mm)	Increased filling pressures Mitral valve dysfunction, Atrial fibrillation
LV thickness	Hypertrophy (>11–12 mm)	Hypertension, aortic stenosis, HCM
Valve structure and function	Valvular stenosis or regurgitation (especially aortic stenosis and mitral insufficiency)	May be primary cause of HF or complicating factor Assess gradients and regurgitant fraction Assess haemodynamic consequences Consider surgery
Mitral inflow profile	Abnormalities of the early and late diastolic filling patterns	Indicates diastolic dysfunction and suggests mechanism
TR peak velocity	Increased (>3 m/s)	Increased RVSP, Suspect pulmonary hypertension
Pericardium	Effusion, haemopericardium, thickening	Consider tamponade, uremia, malignancy, systemic disease, acute or chronic pericarditis, constrictive pericarditis
Aortic outflow TVI	Reduced (<15 cm)	Reduced low stroke volume
Inferior vena cava	Dilated Retrograde flow	Increased RA pressures, RV dysfunction Hepatic congestion

Treatment algorithm for HF with REF



Indication of medical Tx for HF

- **ACE inhibitors**
  - LV dysfunction (EF ≤ 40%) with or without Sx
- **Beta blockers**
  - Compensated HF with LV dysfunction (EF ≤ 40%)
- **Aldosterone inhibitors**
  - Fc III-IV HF with EF ≤ 35% or post MI EF ≤ 40%

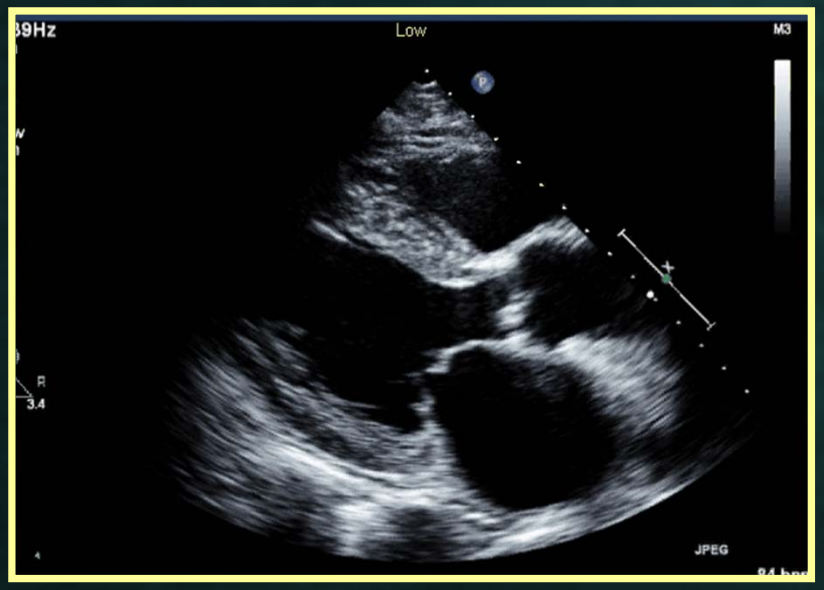
Indication of Device Tx for HF

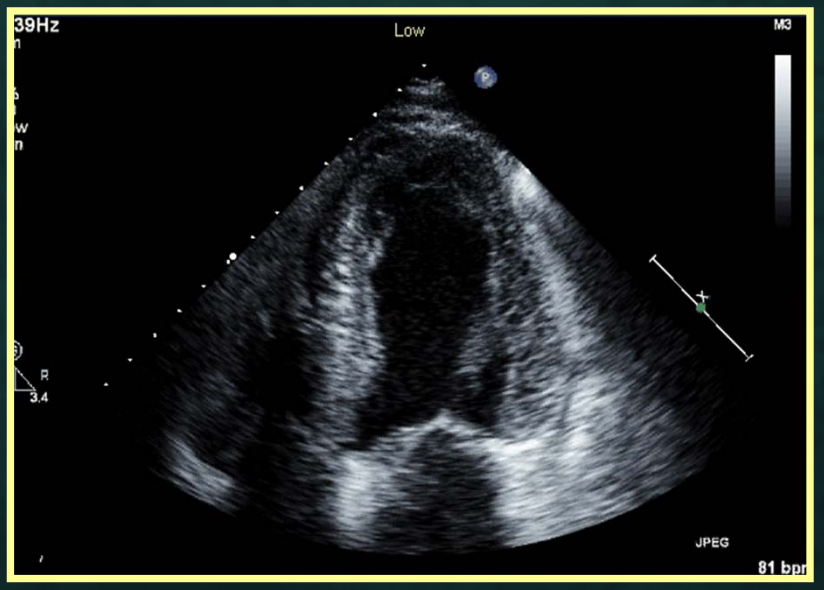
- **ICD indication**
  - LV EF ≤ 35%, after 40 days AMI or optimal HF medical therapy
  - Fc II-III Sx
  - For sudden death prevention
- **CRT indication**
  - LVEF ≤ 35%
  - Fc III-IV Sx on optimal Tx
  - Cardiac dyssynchrony (QRS duration ≥ 120msec)

Classification of HF

- Systolic HF vs Diastolic HF
  - HF with reduced EF
    - LVEF < 40-45%
  - HF with preserved EF
    - LVEF > 45-50%

Normal LVEF but…





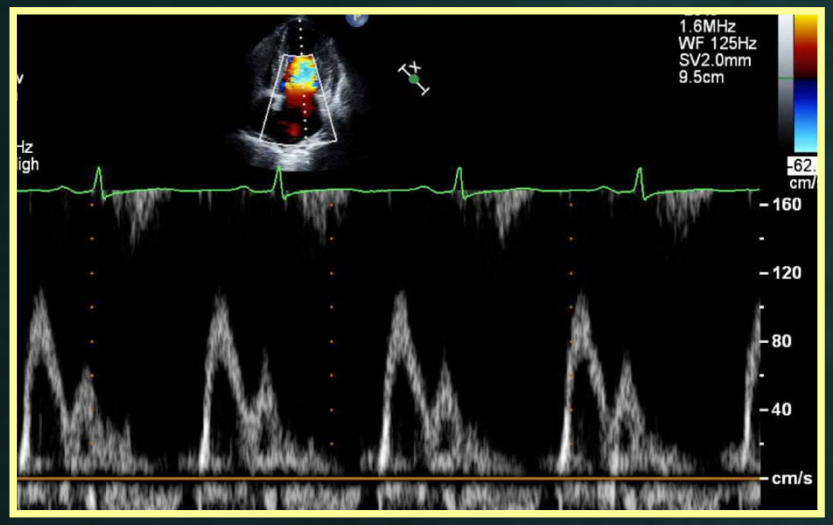
Common echocardiographic abnormalities in HF

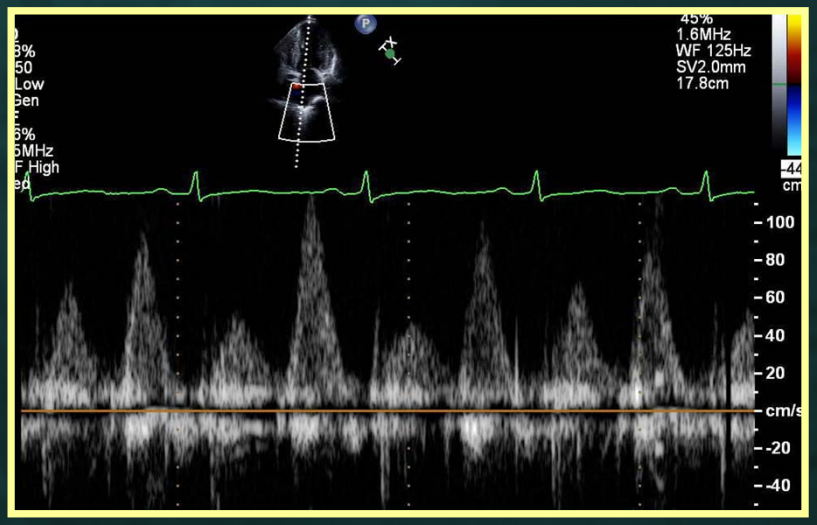
Measurement	Abnormality	Clinical implications
LV EF	Reduced (<45–50%)	Systolic dysfunction
LV function, Global and regional	Akinesis, hypokinesis, dyskinesis	Myocardial infarction/ischaemia Cardiomyopathy, myocarditis
LV EDD	Increased (>55–60 mm)	Volume overload, HF likely
LV ESD	Increased (>45 mm)	Volume overload, HF likely
LV FS	Reduced (<25%)	Systolic dysfunction
LA size	Increased (>40 mm)	Increased filling pressures Mitral valve dysfunction, Atrial fibrillation
LV thickness	Hypertrophy (>11–12 mm)	Hypertension, aortic stenosis, HCM
Valve structure and function	Valvular stenosis or regurgitation (especially aortic stenosis and mitral insufficiency)	May be primary cause of HF or complicating factor Assess gradients and regurgitant fraction Assess haemodynamic consequences Consider surgery
Mitral inflow profile	Abnormalities of the early and late diastolic filling patterns	Indicates diastolic dysfunction and suggests mechanism
TR peak velocity	Increased (>3 m/s)	Increased RVSP, Suspect pulmonary hypertension
Pericardium	Effusion, haemopericardium, thickening	Consider tamponade, uremia, malignancy, systemic disease, acute or chronic pericarditis, constrictive pericarditis
Aortic outflow TVI	Reduced (<15 cm)	Reduced low stroke volume
Inferior vena cava	Dilated Retrograde flow	Increased RA pressures, RV dysfunction Hepatic congestion

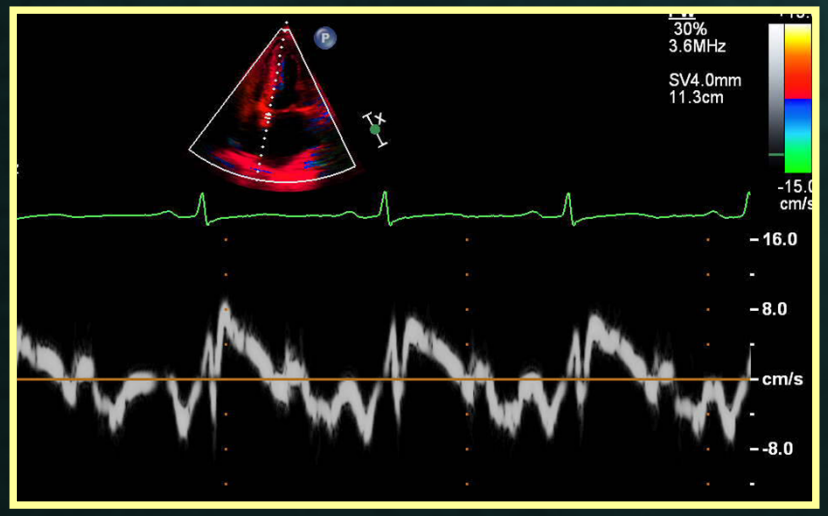
Doppler-echocardiographic indices and ventricular filling

Doppler indices	Pattern	Consequence
E/A waves ratio	Restrictive (>2, short DT<115 to 150 ms)	High filling pressures Volume overload
	Slowed relaxation (<1)	Normal filling pressures Poor compliance
	Normal (>1)	Inconclusive as may be pseudo-normal
E/Ea	Increased (>15)	High filling pressures
	Reduced (<8)	Low filling pressures
	Intermediate (8–15)	Inconclusive
A_{dur} mit – pul	>30 ms	Normal filling pressures
	<30 ms	High filling pressures
PV S wave	>D wave	Low filling pressures
	<D wave	High filling pressures
Vp	<45 cm/s	Slow relaxation
E/Vp	>2.5	High filling pressures
	<2	Low filling pressures
Valsalva maneuver	Change of the pseudonormal to abnormal filling pattern	Unmasks high filling pressure in the setting of systolic and diastolic dysfunction

Normal LVEF but…





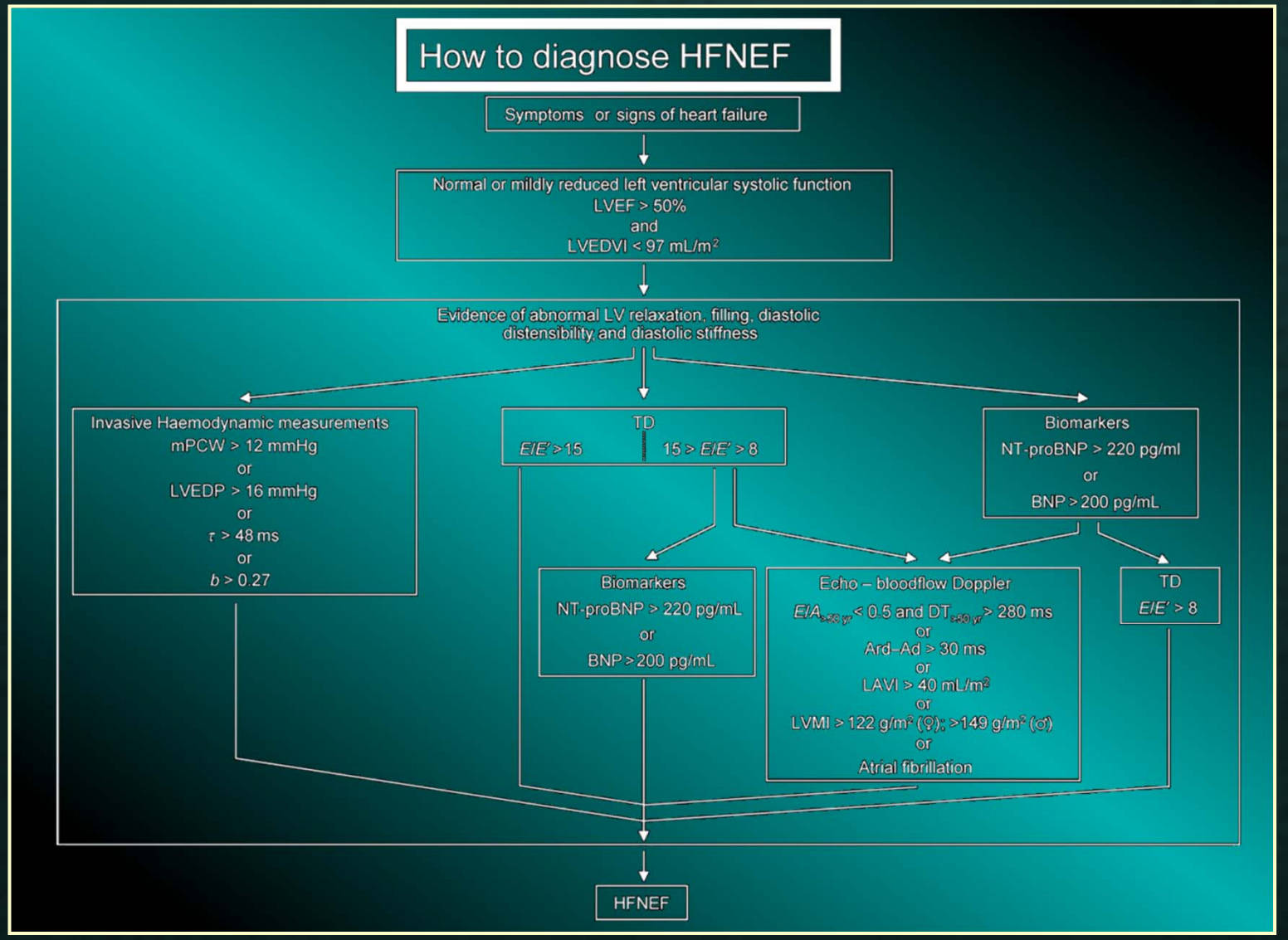


E/A>1.5

E/E'=22

PVd 》PVs

How to diagnose diastolic HF

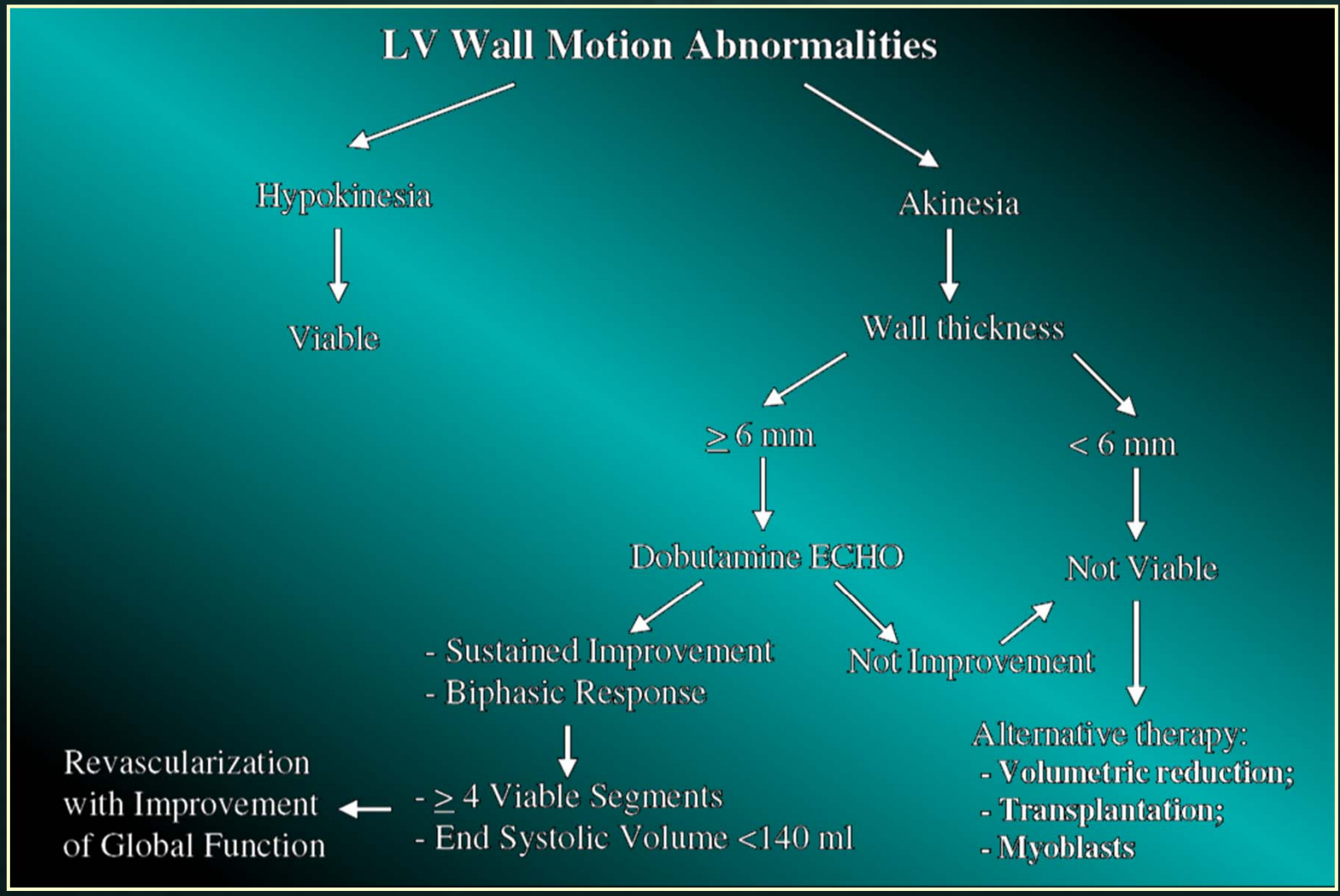


EHJ(2007) 28, 2539–2550

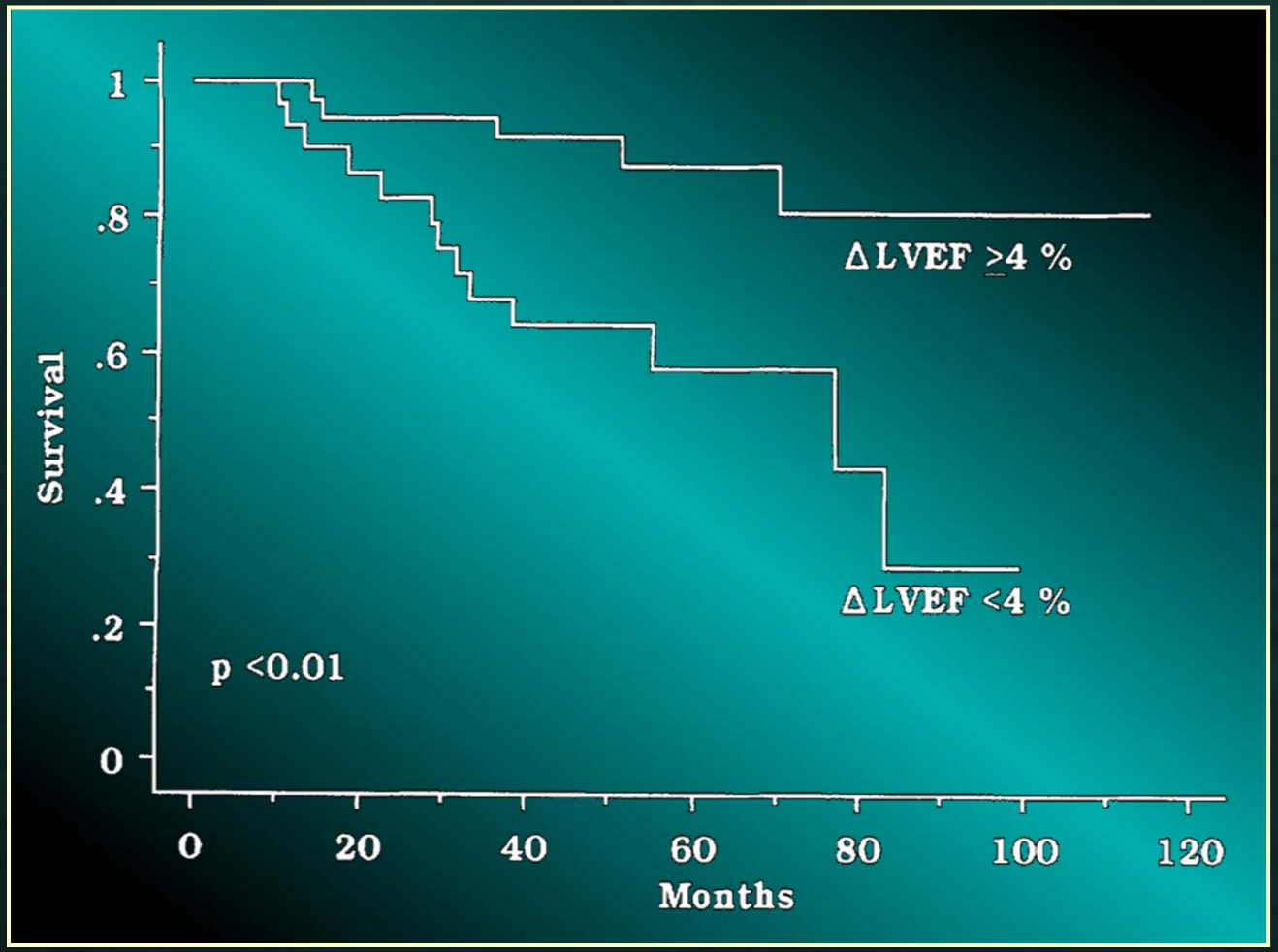
Stress echocardiography in HF

- Potential parameters obtainable during stress echocardiography
  - Myocardial viability in ischemic cardiomyopathy
  - Functional capacity
  - Contractile reserve
  - Mitral valve function
  - Pulmonary systolic pressure
  - RV function
  - Diastolic function

Flow chart for searching segmental and global systolic function in chronic Ischemic CMP



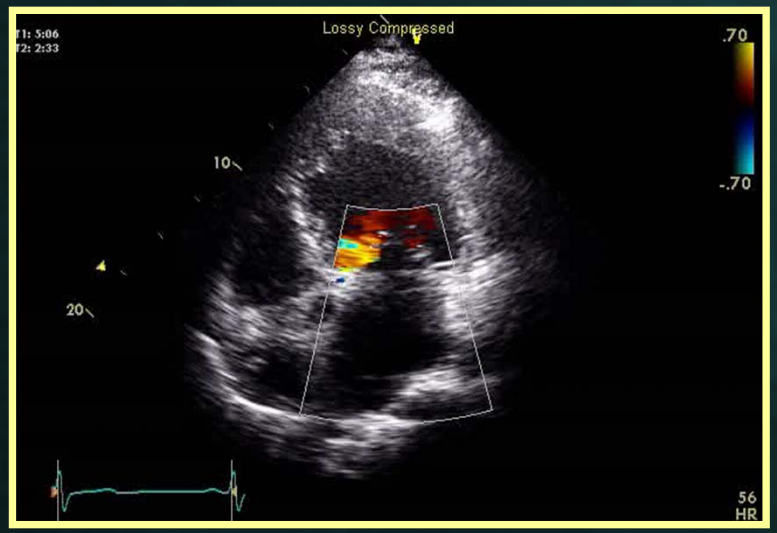
Myocardial Contractile Reserve as Prognostic Determinant in Patients With Idiopathic DCM



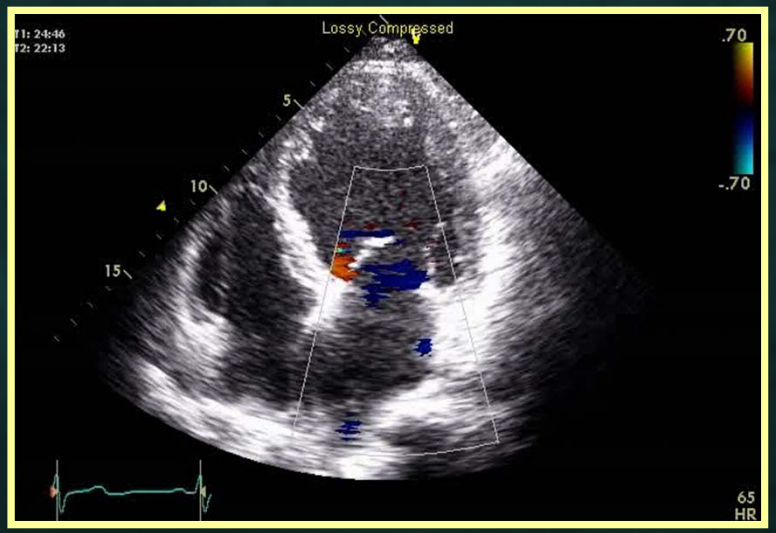
CHEST 1997; 111:344-50

Aggravated MR after exercise
Ischemic MR

Before exercise

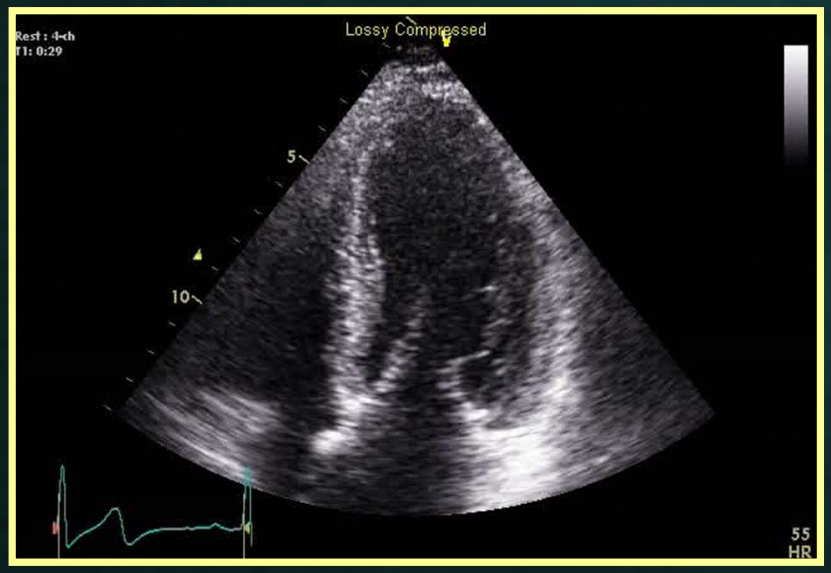


After exercise

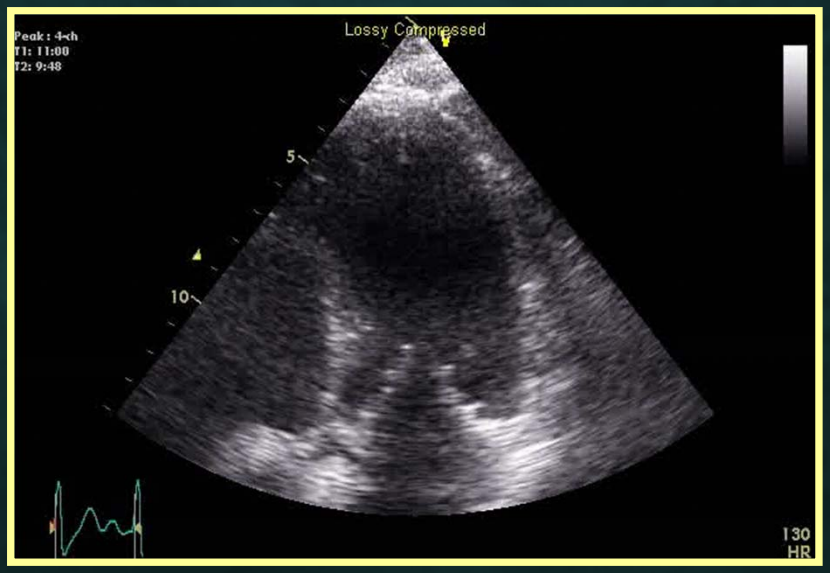


Aggravated MR after exercise HCM with SAM

Before exercise

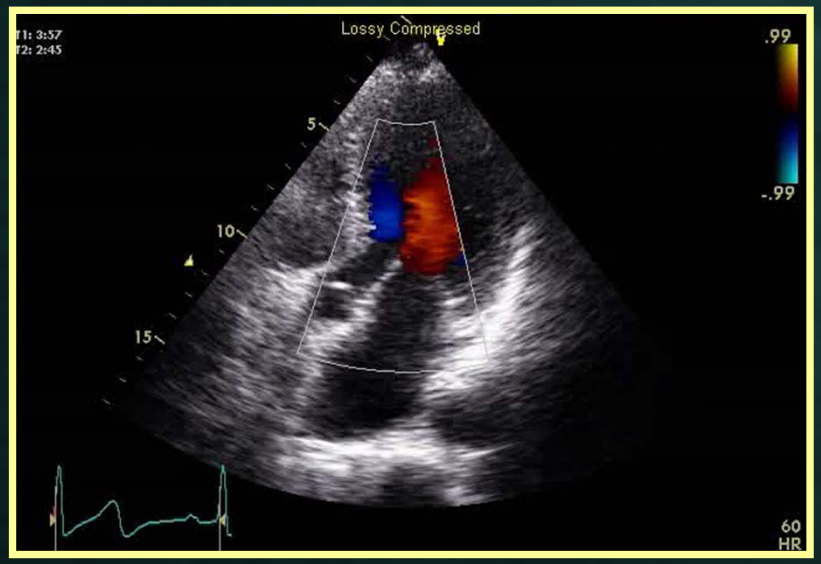


After exercise

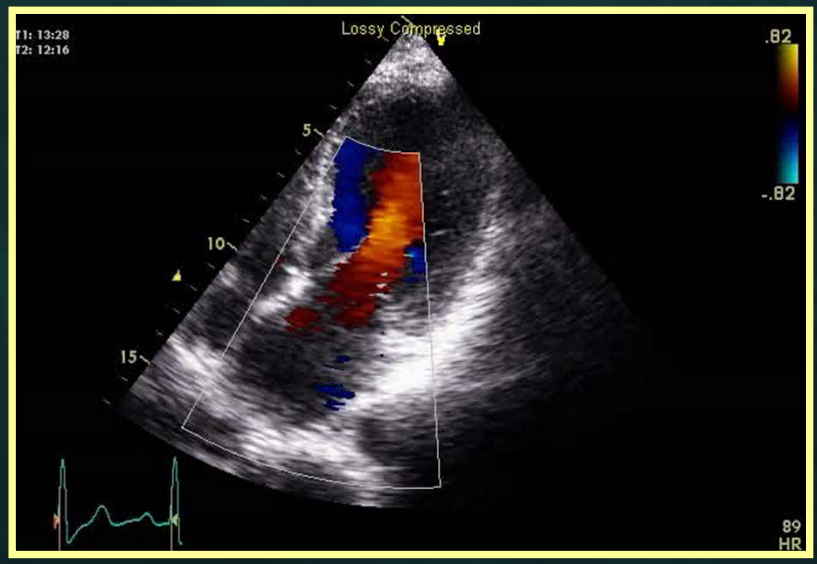


Aggravated MR after exercise HCM with SAM

Before exercise

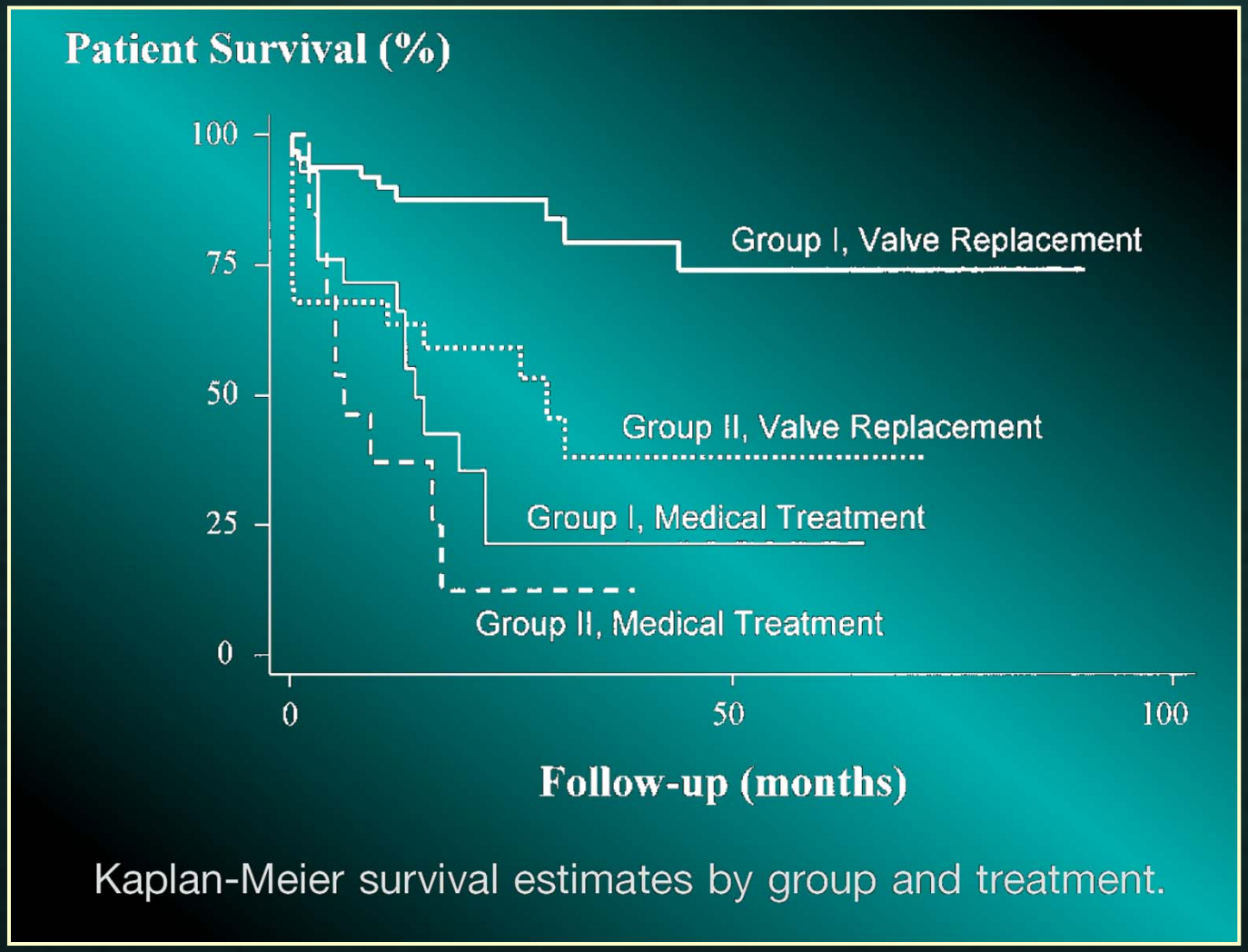


After exercise



Low-Gradient Aortic Stenosis

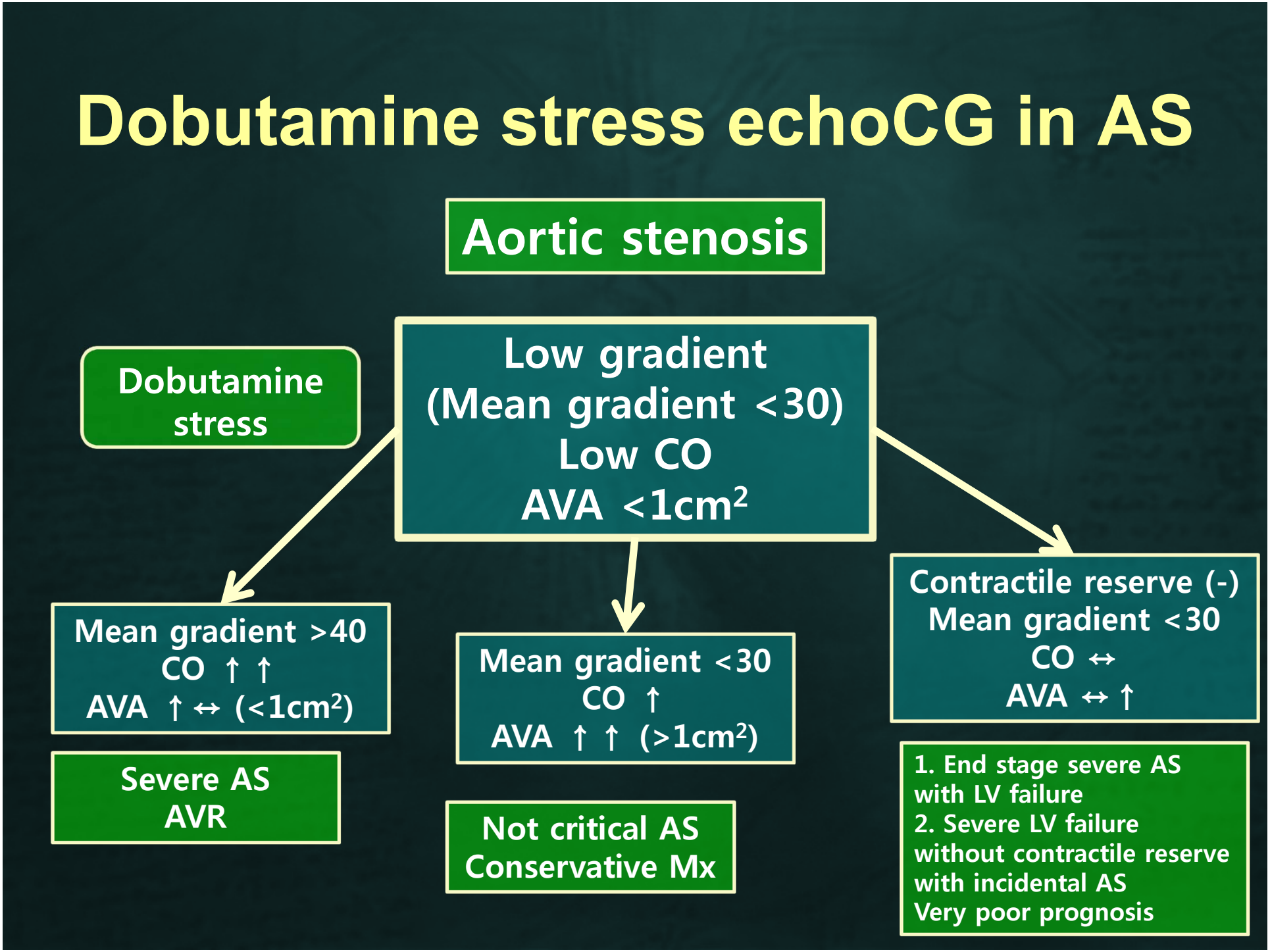
Operative Risk Stratification and Predictors for Long-Term Outcome: A Multicenter Study Using Dobutamine Stress Hemodynamics



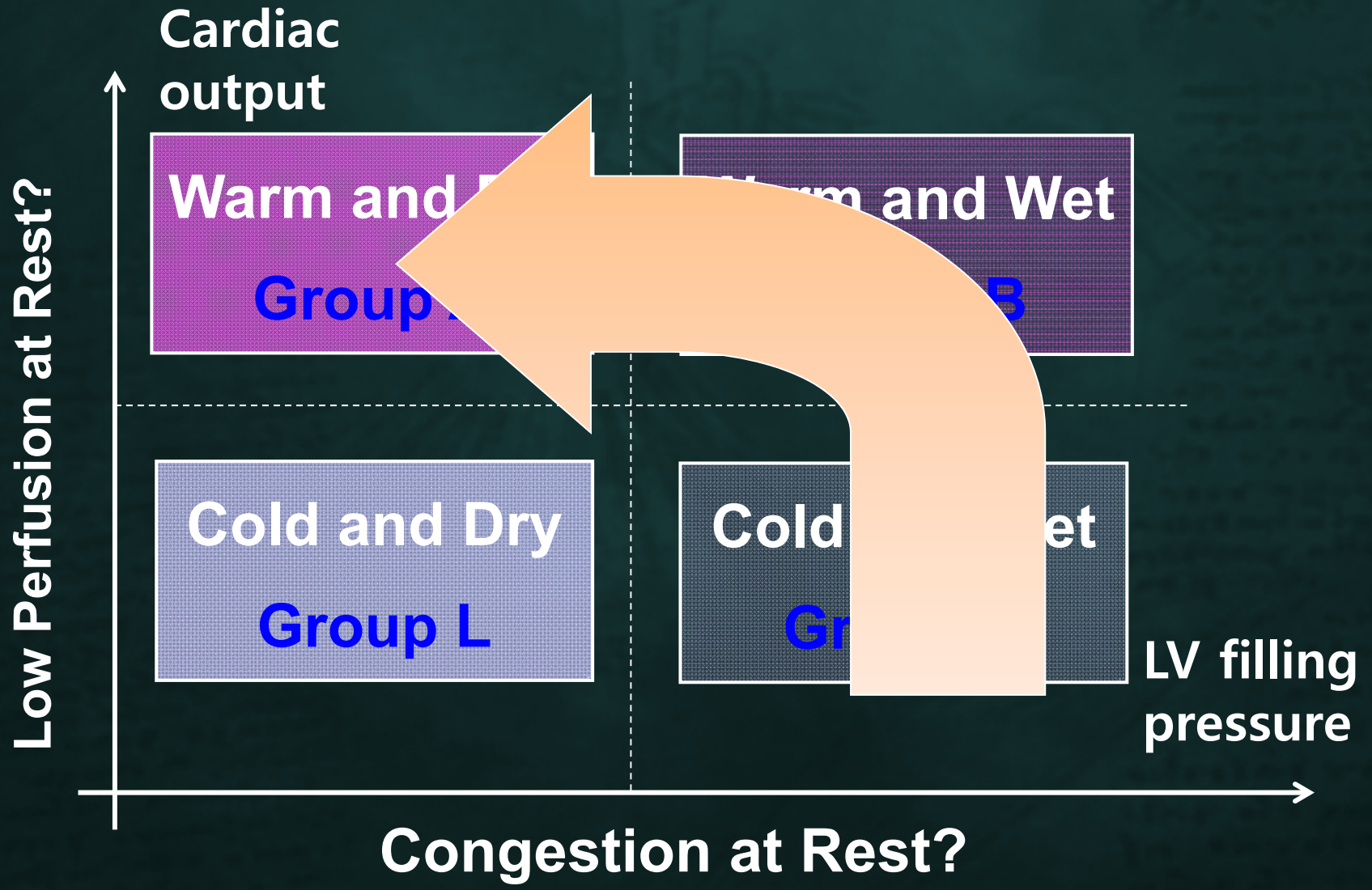
Kaplan-Meier survival estimates by group and treatment.

Circ. 2003;108:319-324.

Dobutamine stress echoCG in AS



Clinical Severity Classification



PAC guided HF treatment
- ESCAPE trial -

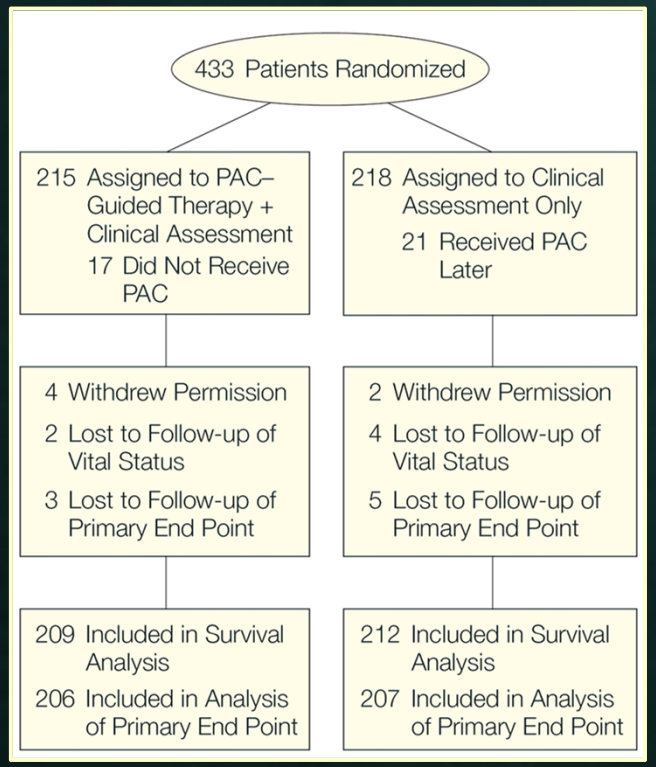
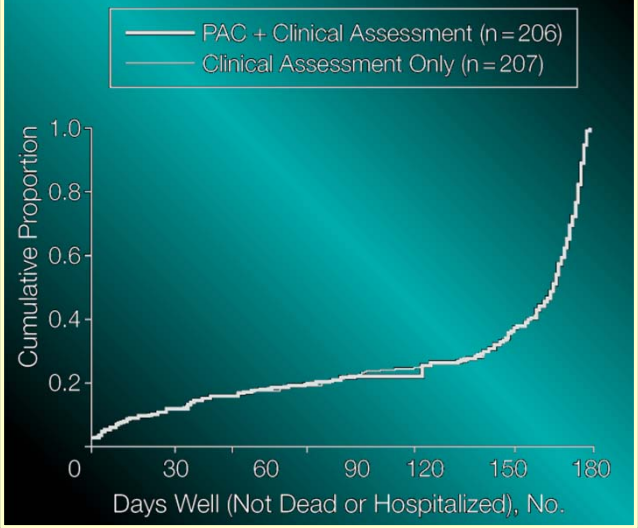


Table 2. Impact of Therapy Guided by Pulmonary Artery Catheterization During the Course of Hospitalization*

Hemodynamic Measurement	Baseline	Final†
Right atrial pressure, mm Hg	14 (10)	10 (7)
Pulmonary capillary wedge pressure, mm Hg	25 (9)	17 (7)
Cardiac index, L/min/m^2	1.9 (0.6)	2.4 (0.7)
Cardiac output, L/min	3.8 (1.2)	4.8 (2.1)
Systemic vascular resistance, dynes × sec/cm^5	1500 (800)	1100 (500)

*Data are expressed as mean (SD).
†$P<.001$ for all variables. The final hemodynamics are those measured just before removal of the pulmonary artery catheter, which occurred at a median of 1.9 days after insertion.

Figure 2. Cumulative Primary End Point (Days Alive and Out of Hospital)



JAMA. 2005;294(13):1625-1633

PAC guided HF treatment
- ESCAPE trial -

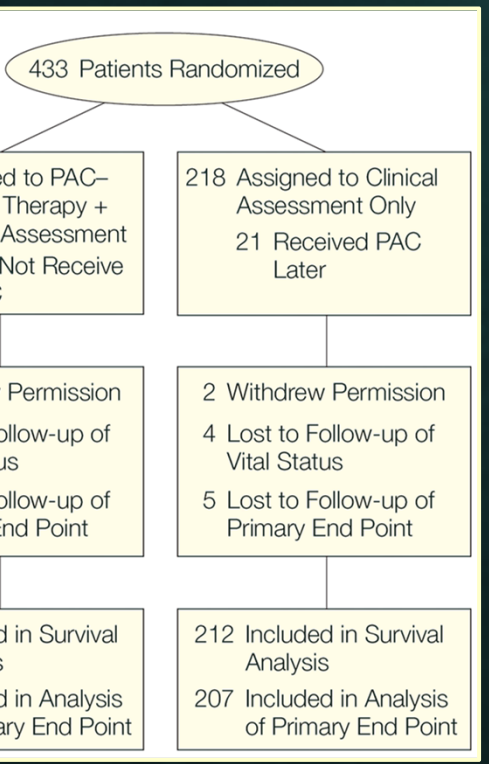
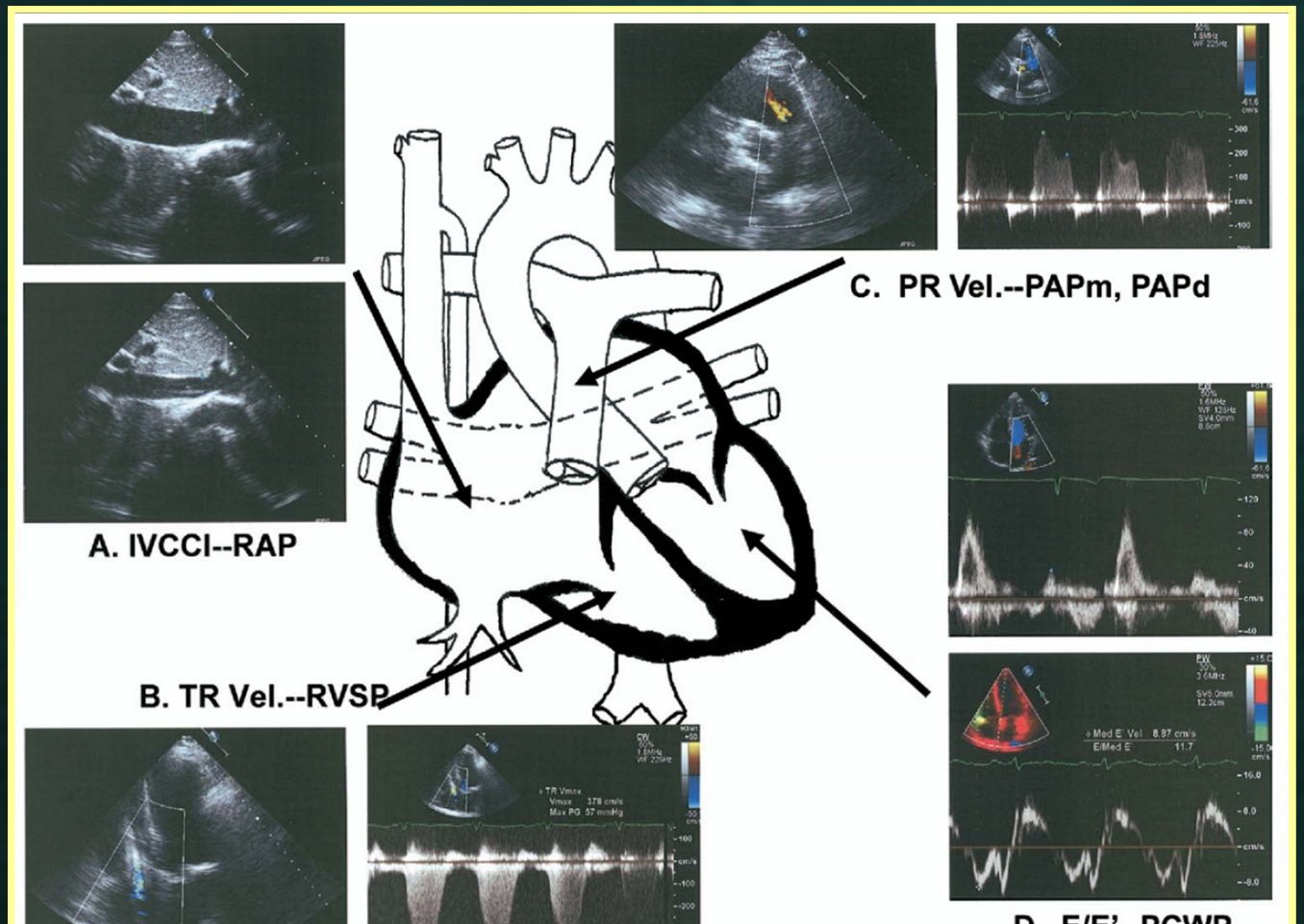


Table 6. Adverse Events In-hospital

Adverse Event	No. (%) PAC Group (n = 215)	No. (%) Clinical Assessment Group (n = 218)	*P* Value*
Implantable cardioverter-defibrillator firing	5 (2.3)	1 (0.5)	.08
Cardiogenic shock	6 (0.5)	2 (0.9)	.12
Ischemia/angina	9 (4.2)	4 (1.8)	.13
PAC infection	4 (1.9)	0 (0.0)	.03
Myocardial infarction	0 (0.0)	1 (0.5)	.75
Stroke or transient ischemic attack	1 (0.5)	0 (0.0)	.75
Cardiac arrest	9 (4.2)	5 (2.3)	.23
Infection	27 (12.6)	20 (9.2)	.25
Patients with at least 1 adverse event	47 (21.9)	25 (11.5)	.04

Abbreviation: PAC, pulmonary artery catheter.
**P* values calculated as Fisher exact mid-*P* values.

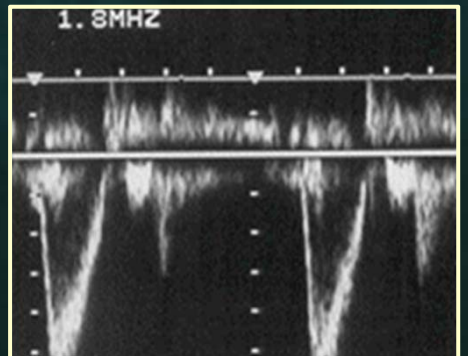
Echo as Right Heart Catheterization

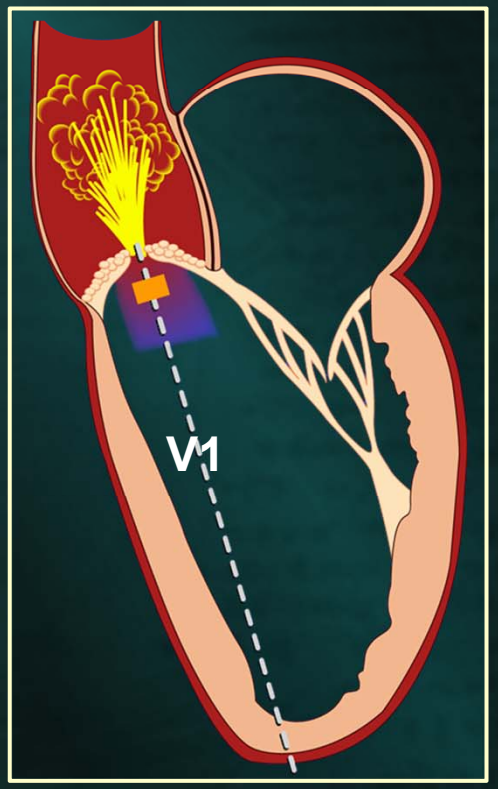


Doppler of LVOT

se apical window

- W Doppler
- lace sample volume in LVOT
- void flow convergence
- ormal LVOT TVI:
  - 18-22 cm
  - elocity ≈ 1 m/s





Cardiac Output

- CO = SV × heart rate
- Normal CO = 4-7 L/min
- SVR = (MAP-RAP)/CO

RA pressure estimation

IVC size	Change with respiration (phlethora)	RA pressure (mmHg)
Normal IVC	Decrease by >50%	5-10
Normal IVC	Decrease by <50%	10-15
ted IVC (2.0cm)	Decrease by <50%	15-20
C dilation with atic vein dilation	No change	20-

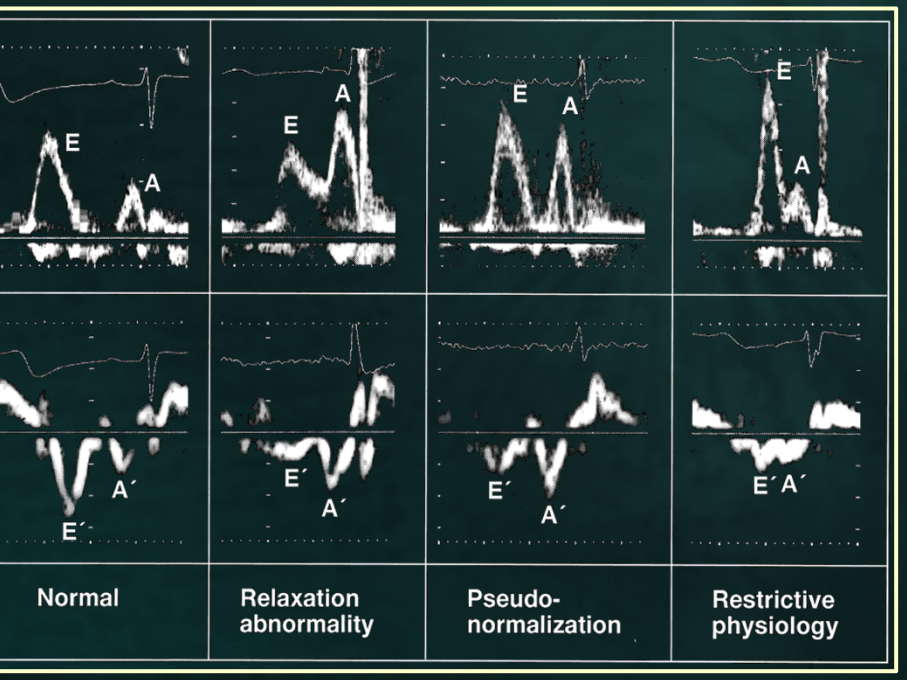
Estimation of RVSP and/or PAP

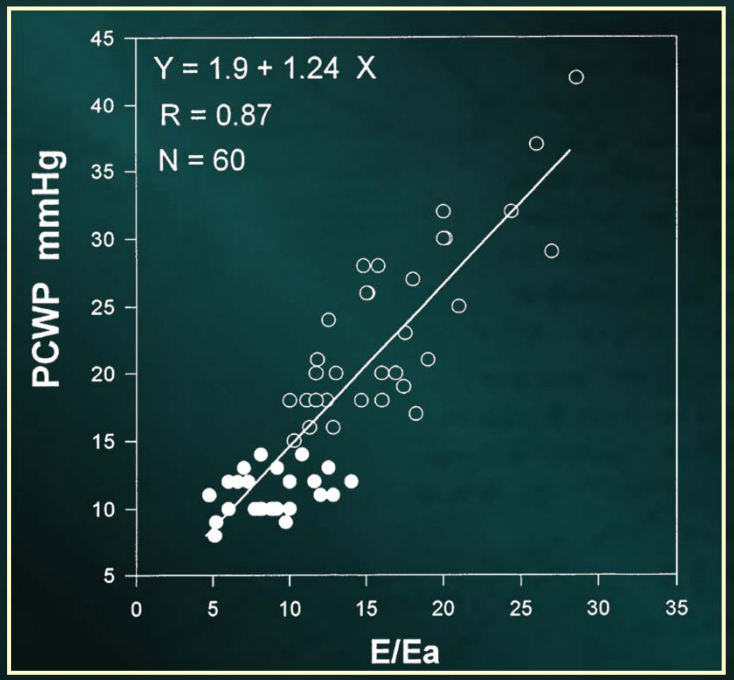
RV-RA Pressure gradient

$$= 4 \times (\text{TR Vmax})^2$$

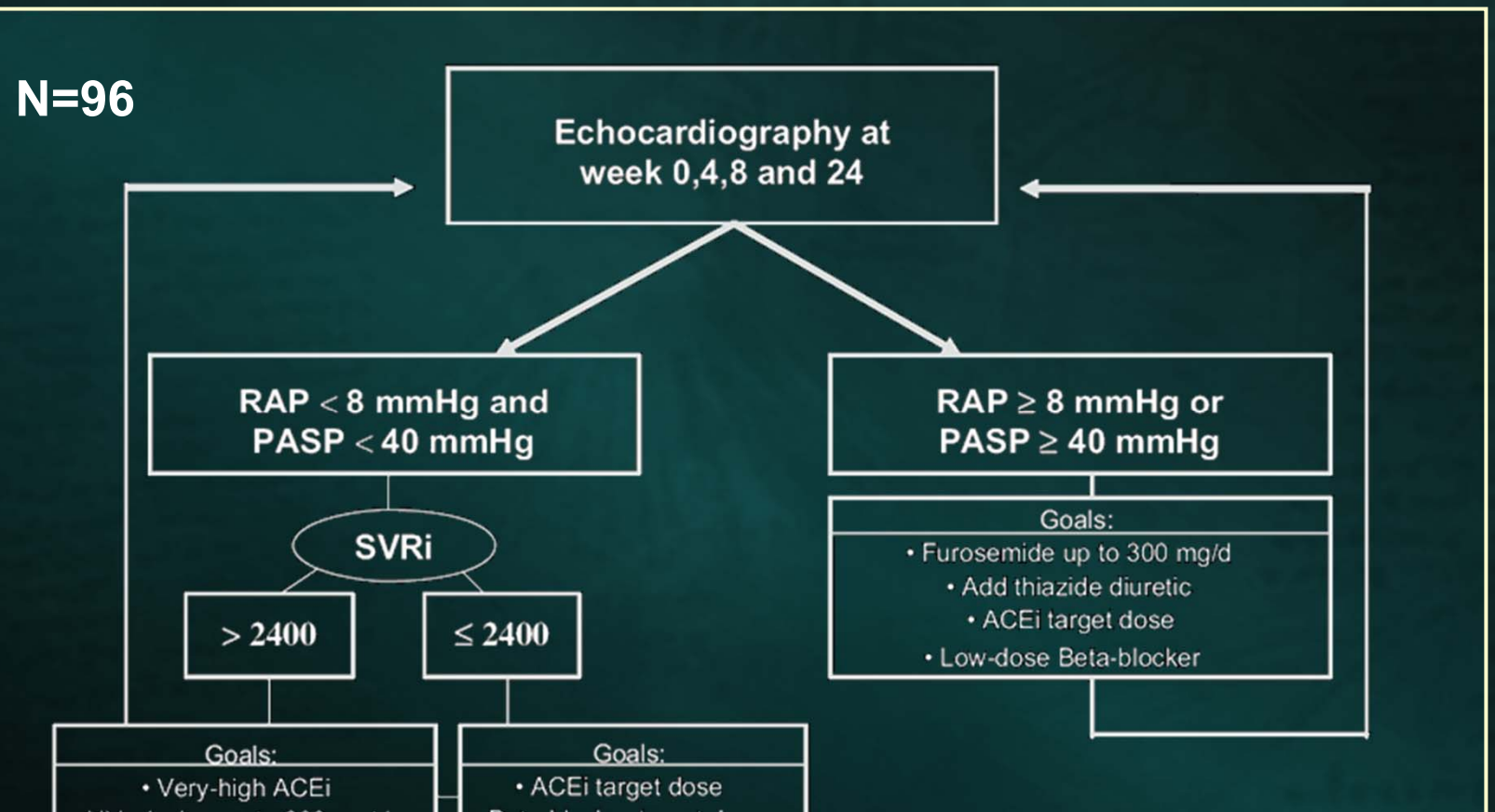
$$\text{RVSP} = \text{RAP} + 4 \times (\text{TR Vmax})^2$$

ssue Doppler imaging estimating LV filling pressure



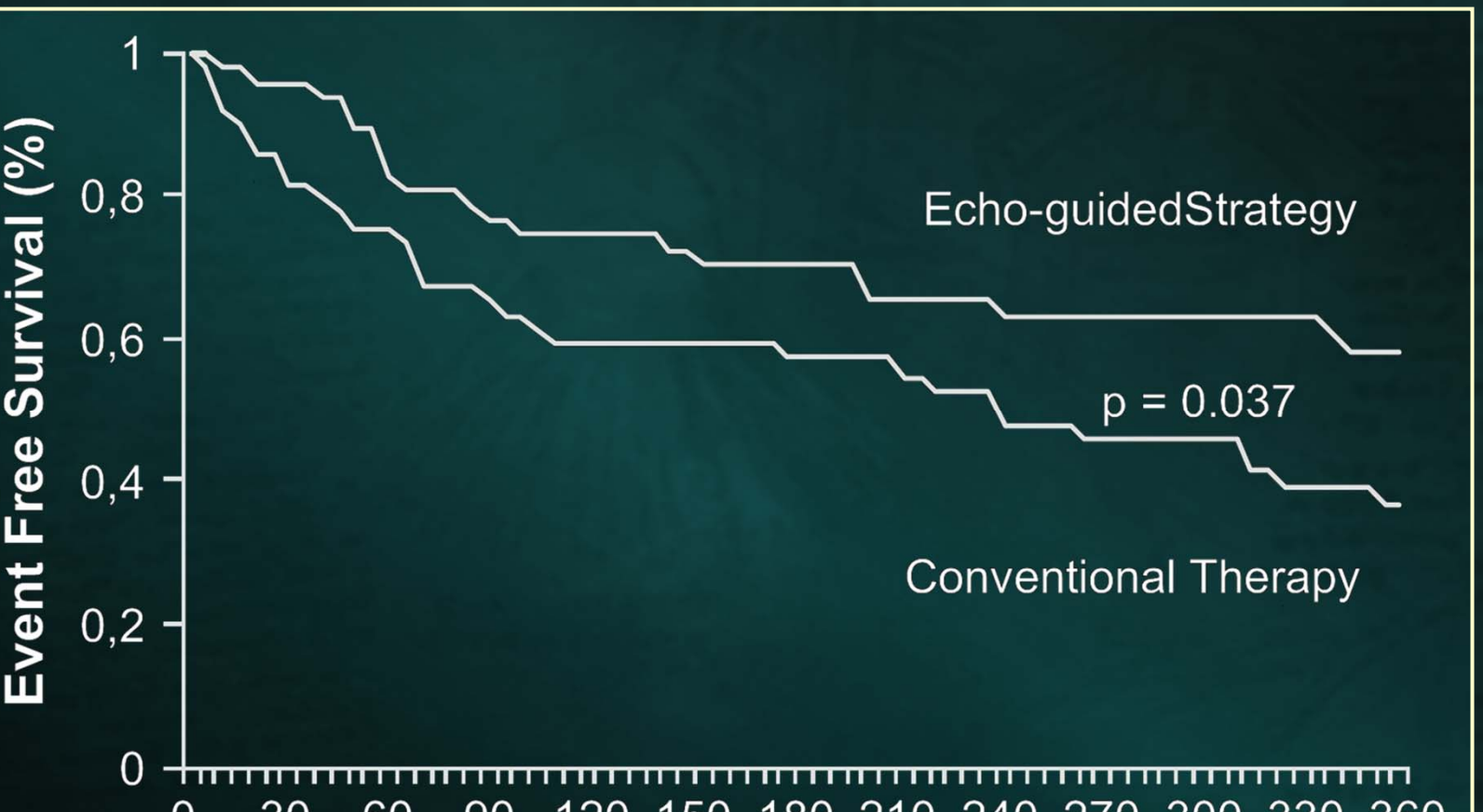


EchoCG guided HF treatment

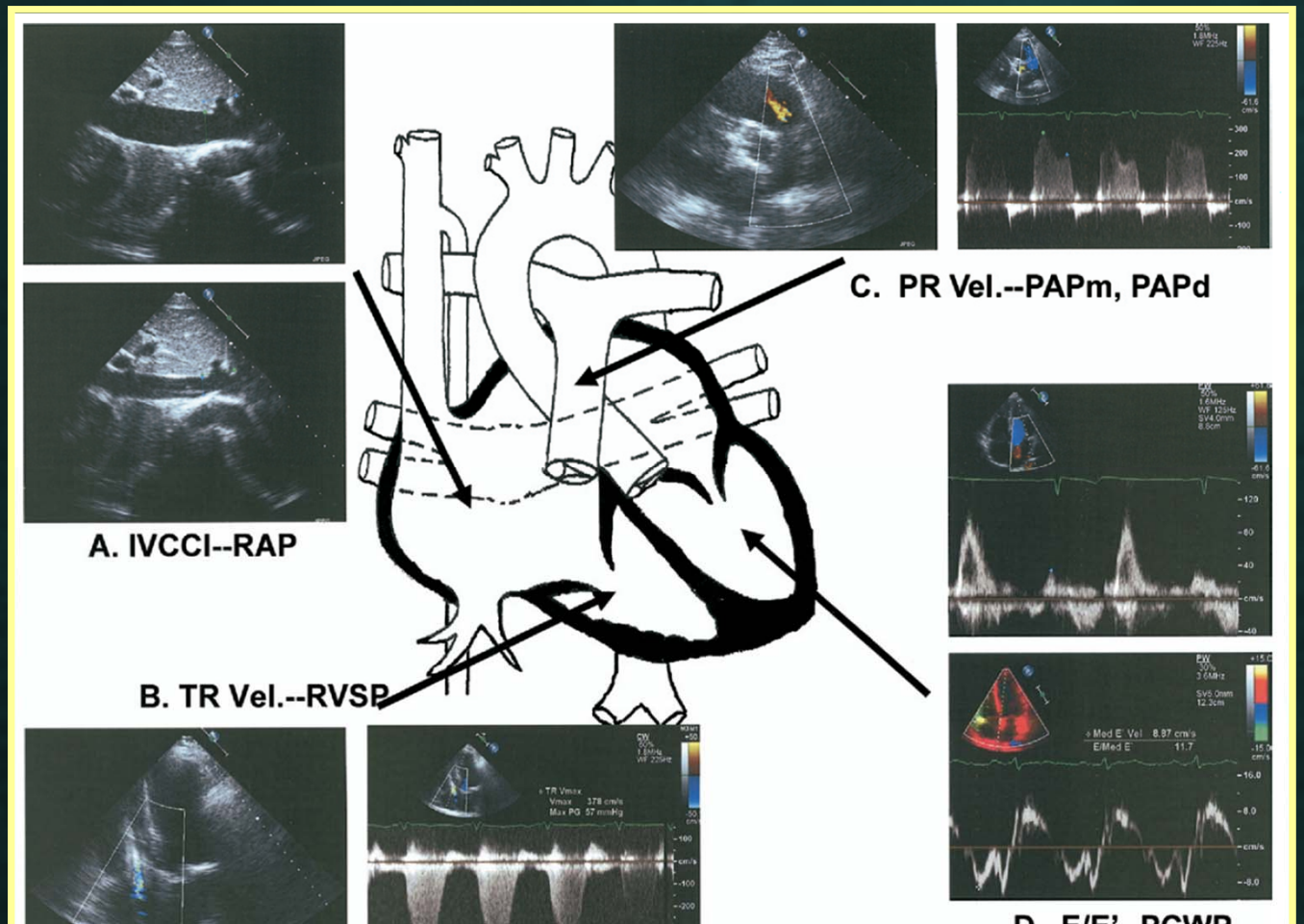


Samsung Medical Center
Cardiac & Vascular Center

EchoCG guided HF treatment



Echo as non-invasive PAC



Echo role in HF

Make a correct diagnosis of HF

Find reversible or treatable cause

Prognostic evaluation

Guidance in therapeutic decision

Using 2D, Doppler and stress echoCG