



Is normal ejection fraction equivalent to normal systolic function?

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No



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Special article

How to diagnose diastolic heart failure: a consensus statement on the diagnosis of heart failure with normal left ventricular ejection fraction by the Heart Failure and Echocardiography Associations of the European Society of Cardiology

2nd criterion (out of 3) for the diagnosis of HFNEF:

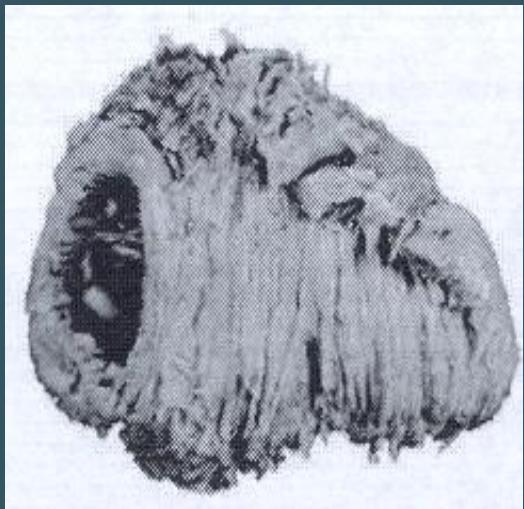
"Normal or mildly abnormal systolic LV function"

Topics

- How?
- Why?
- Implications?

LV structure and function

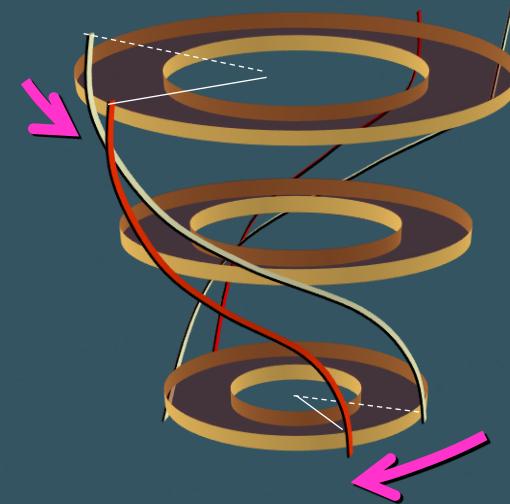
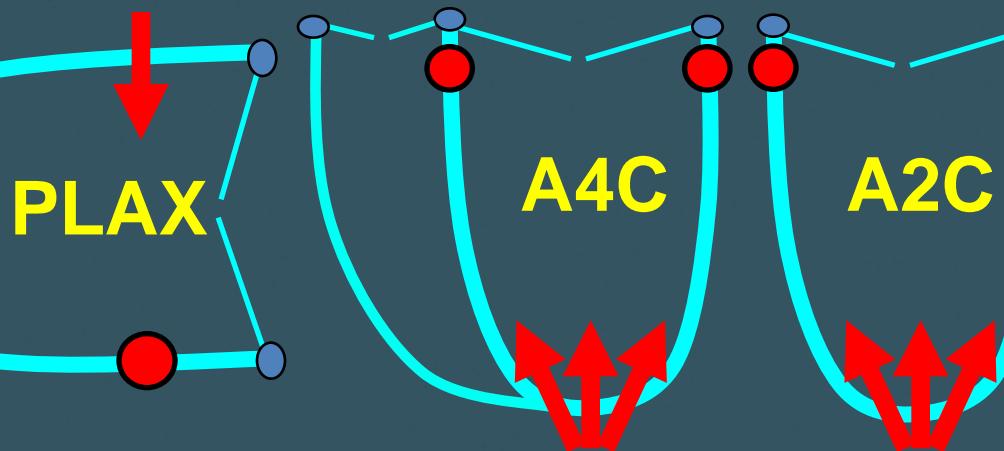
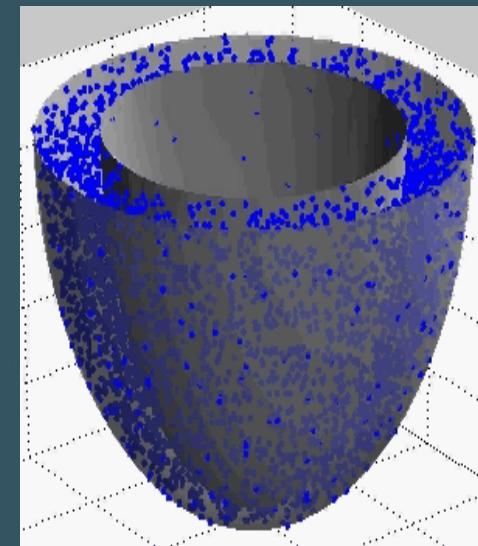
Radial



Longitudinal

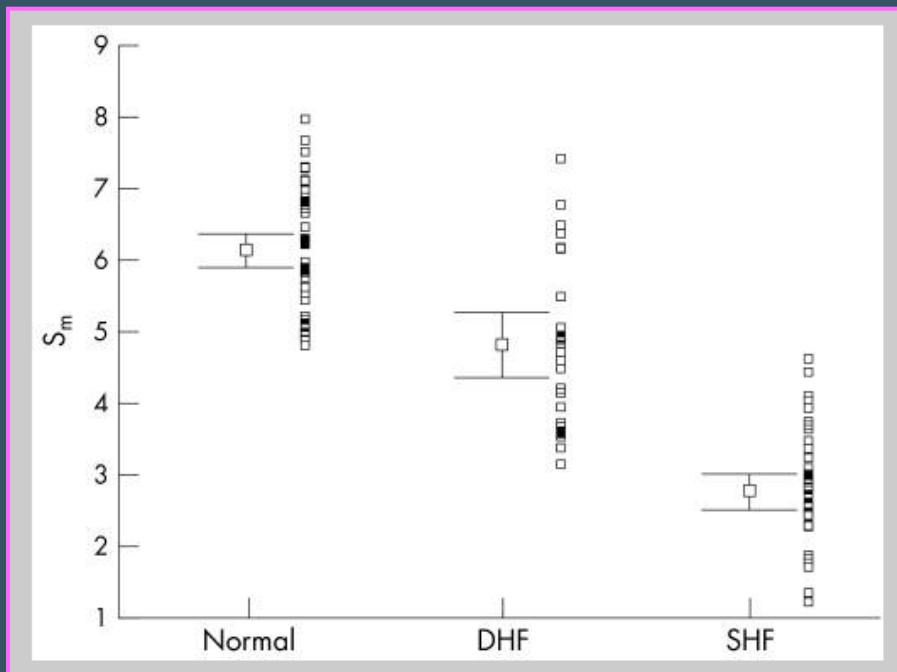


Torsion

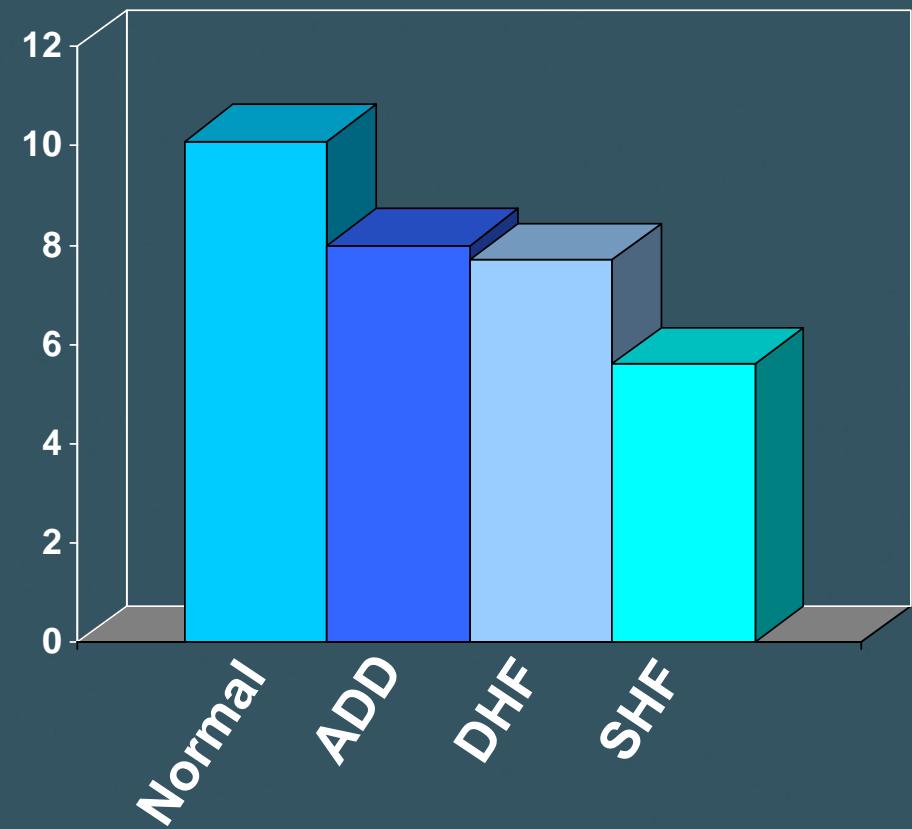


Decreased longitudinal at rest

Systolic velocity (cm/s)



Systolic velocity (cm/s)

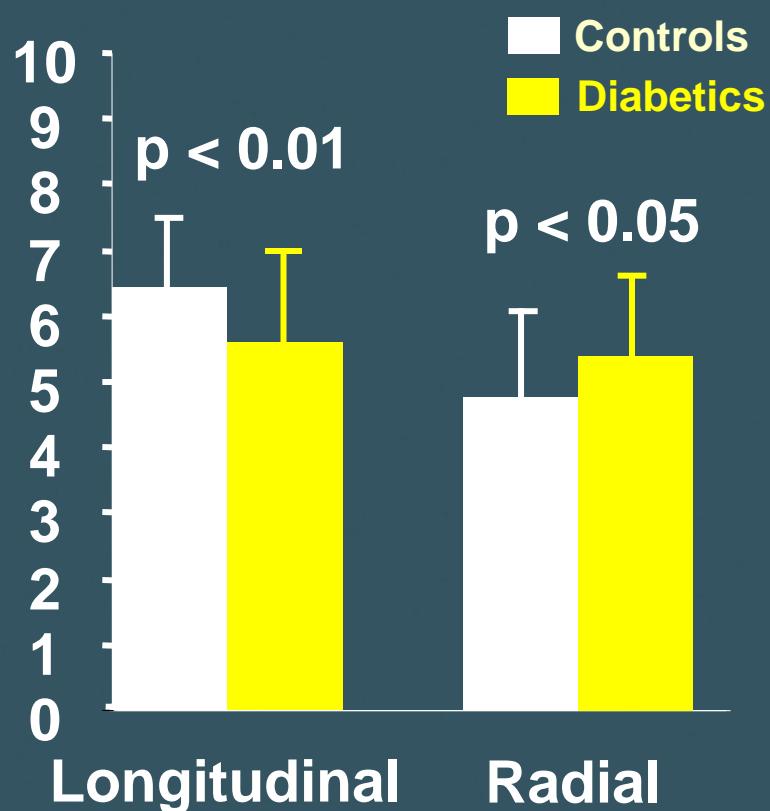


Yip et al. Heart 2002.

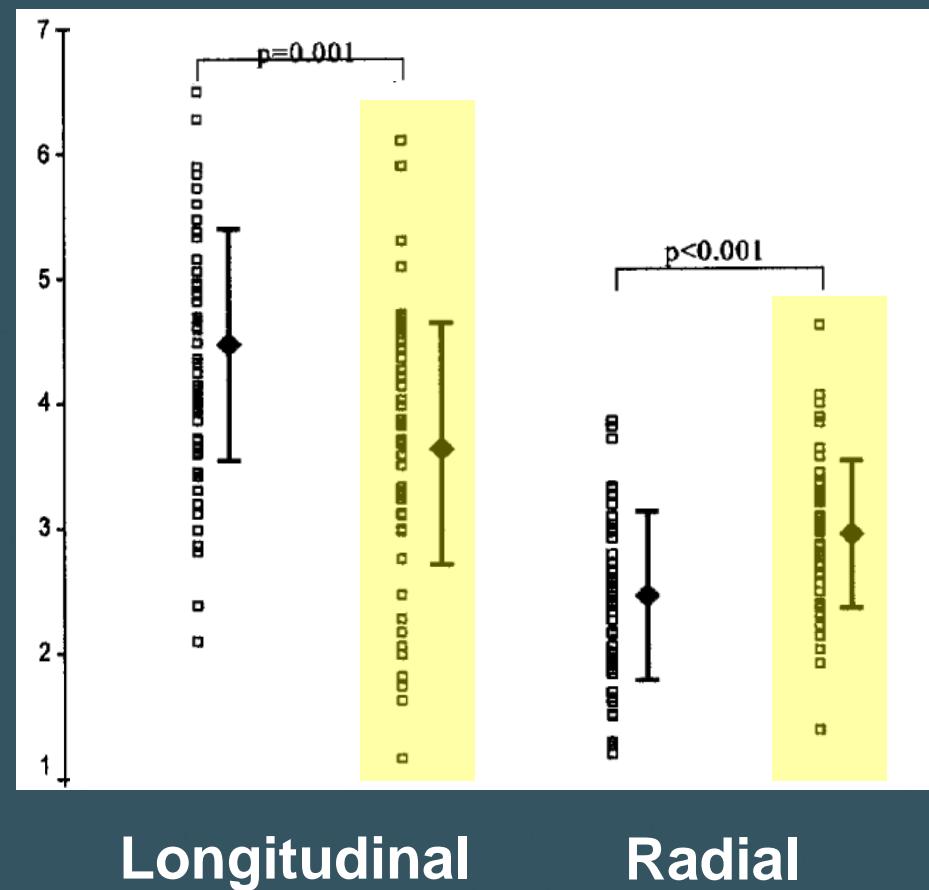
Vinereanu et al. Eur J Heart Fail 2005.

Increased radial at rest

Systolic velocity cm/s



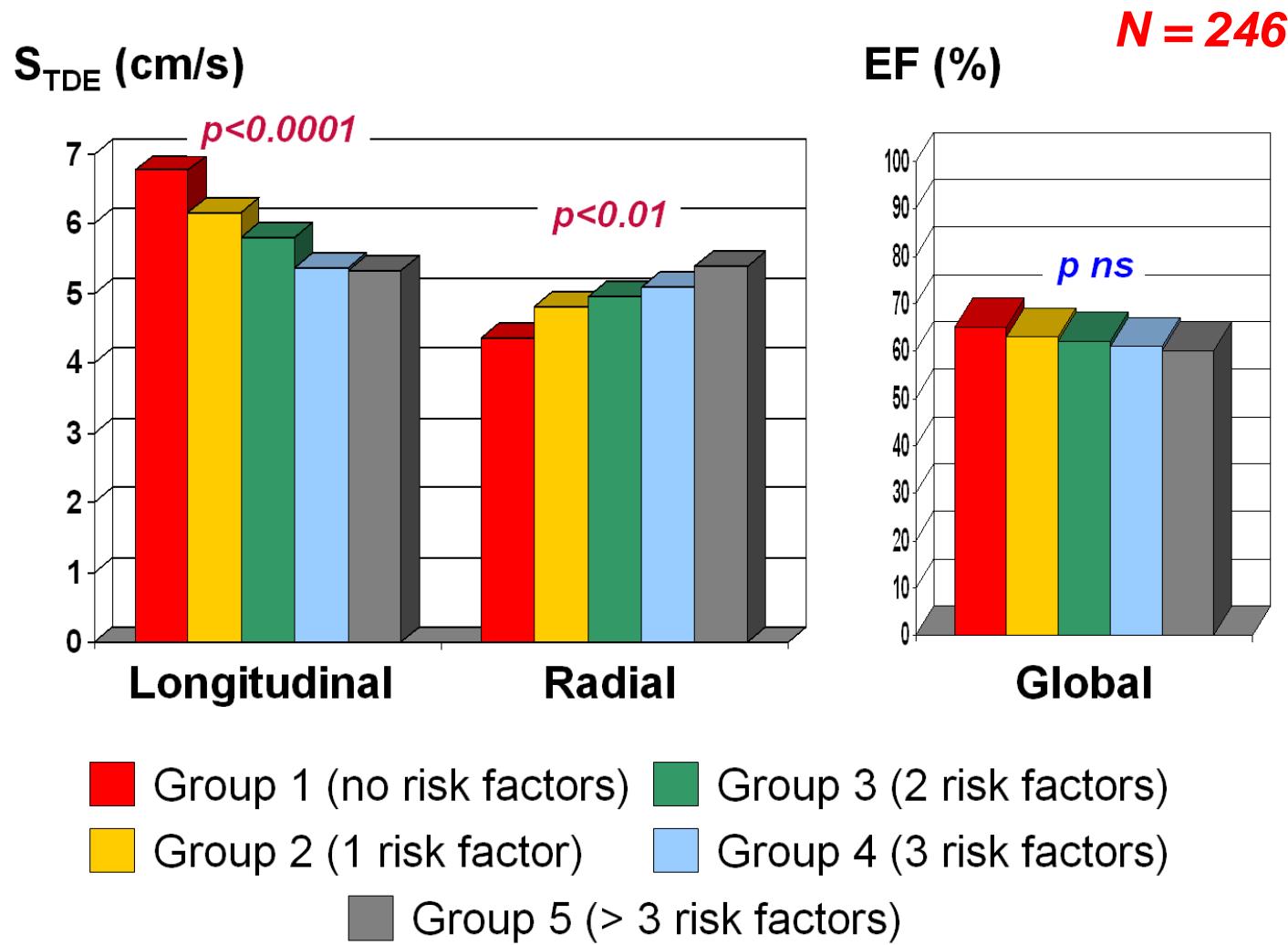
Systolic velocity cm/s



Vinereanu et al. *Clin Sci* 2003.

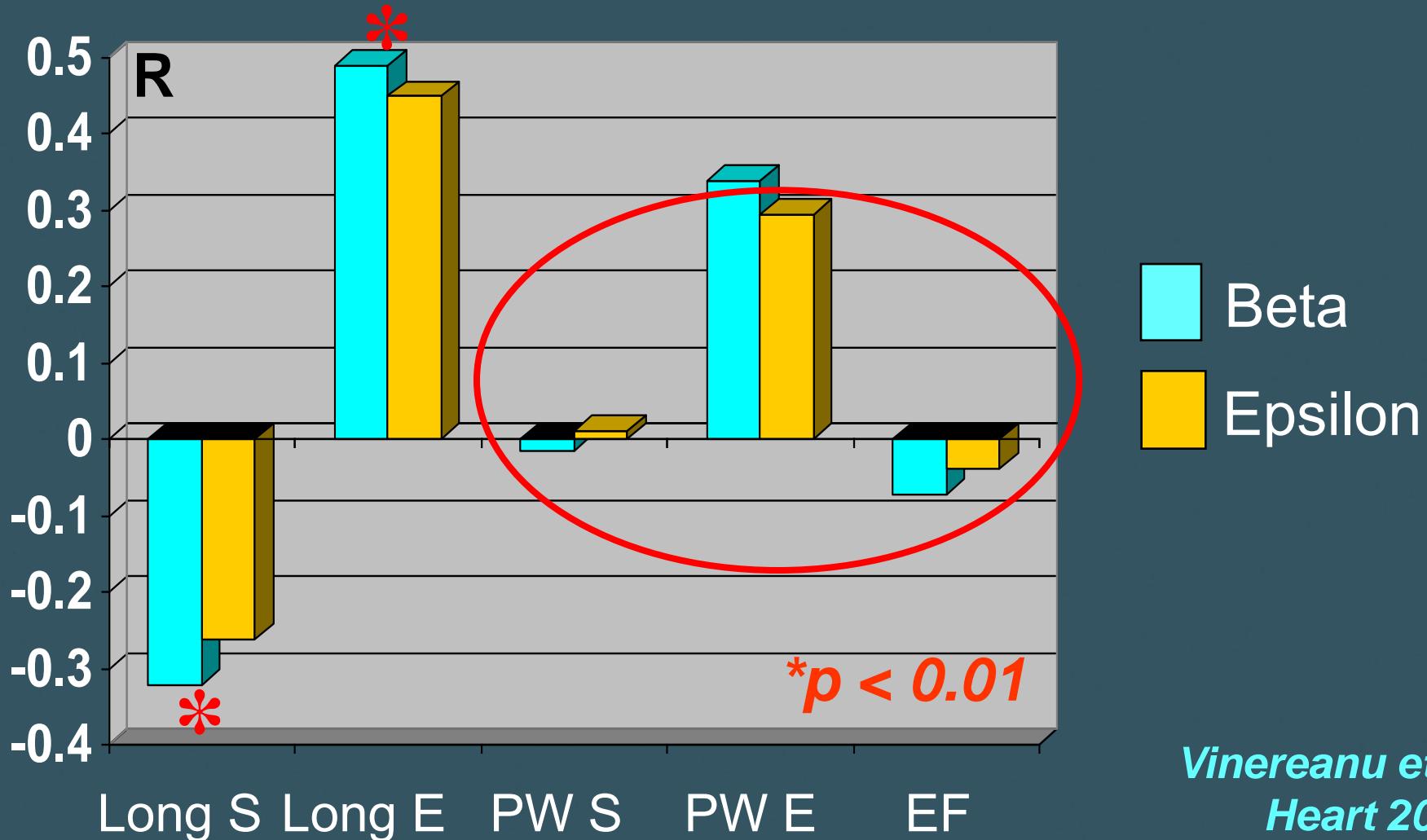
Fang et al. *Clin Sci* 2004.

Preserving EF



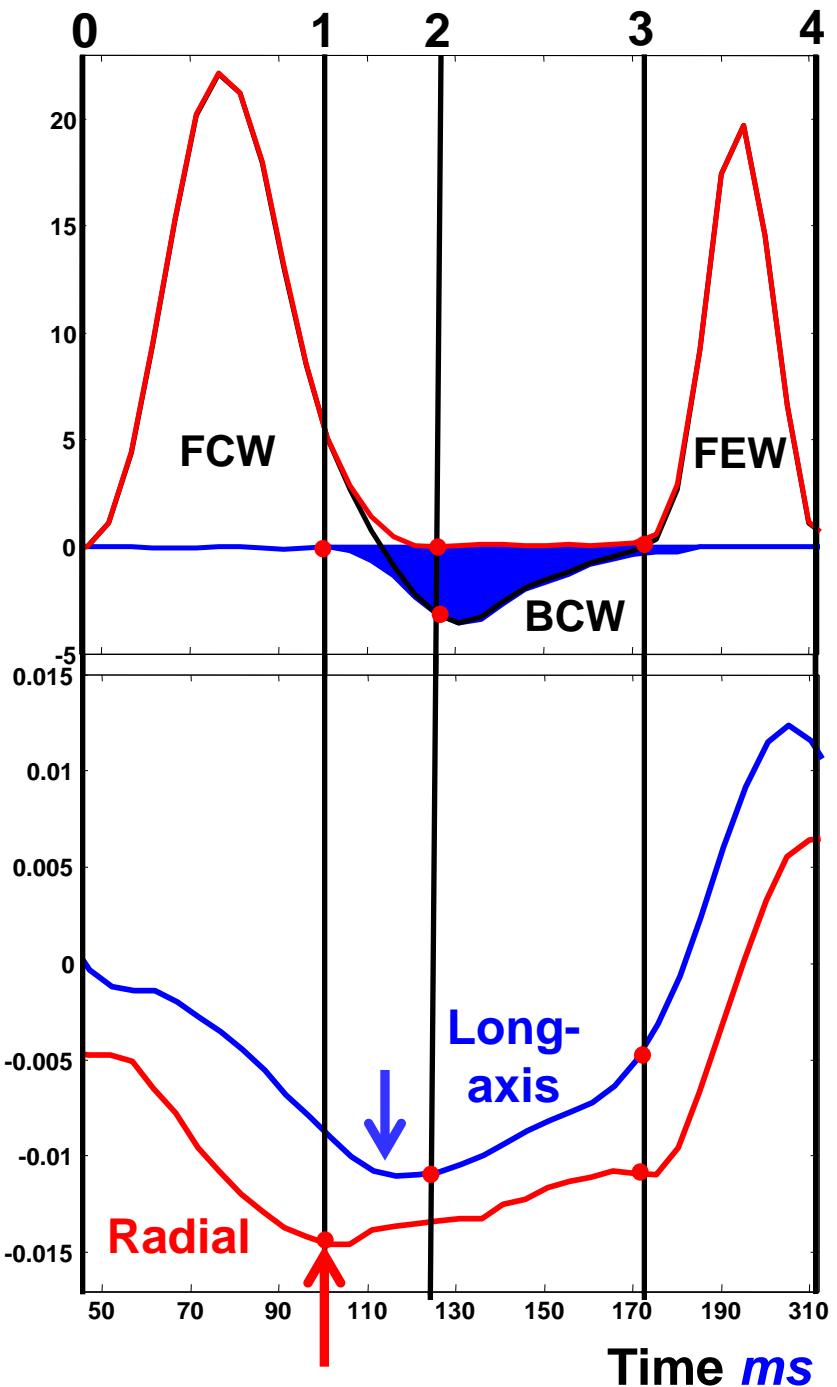
Why longitudinal but not radial?

1. LV longitudinal, but neither radial function or EF, is related to arterial stiffness



Wave intensity in the ascending aorta
 W/m^2

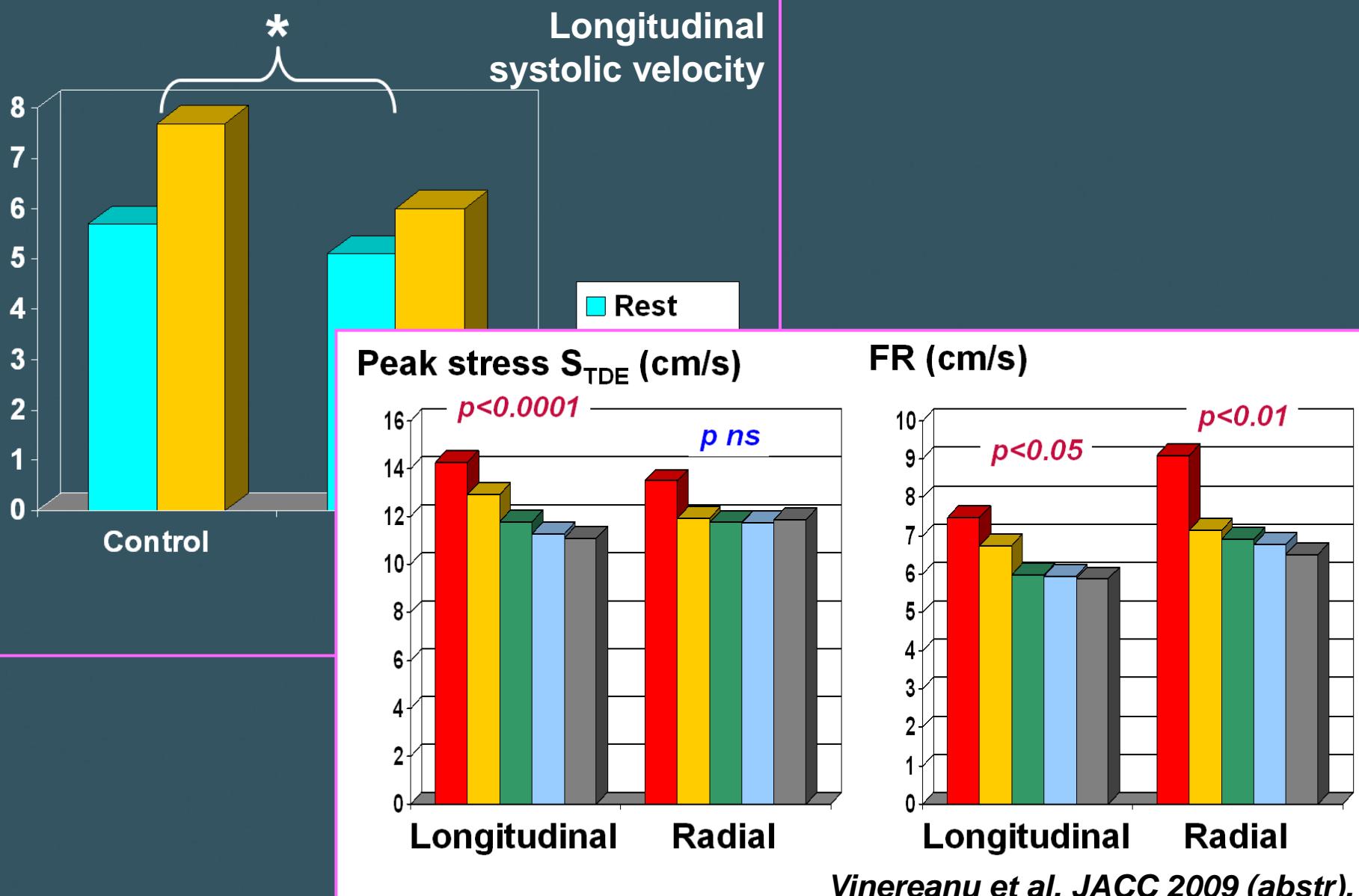
Velocity of shortening
 m/s



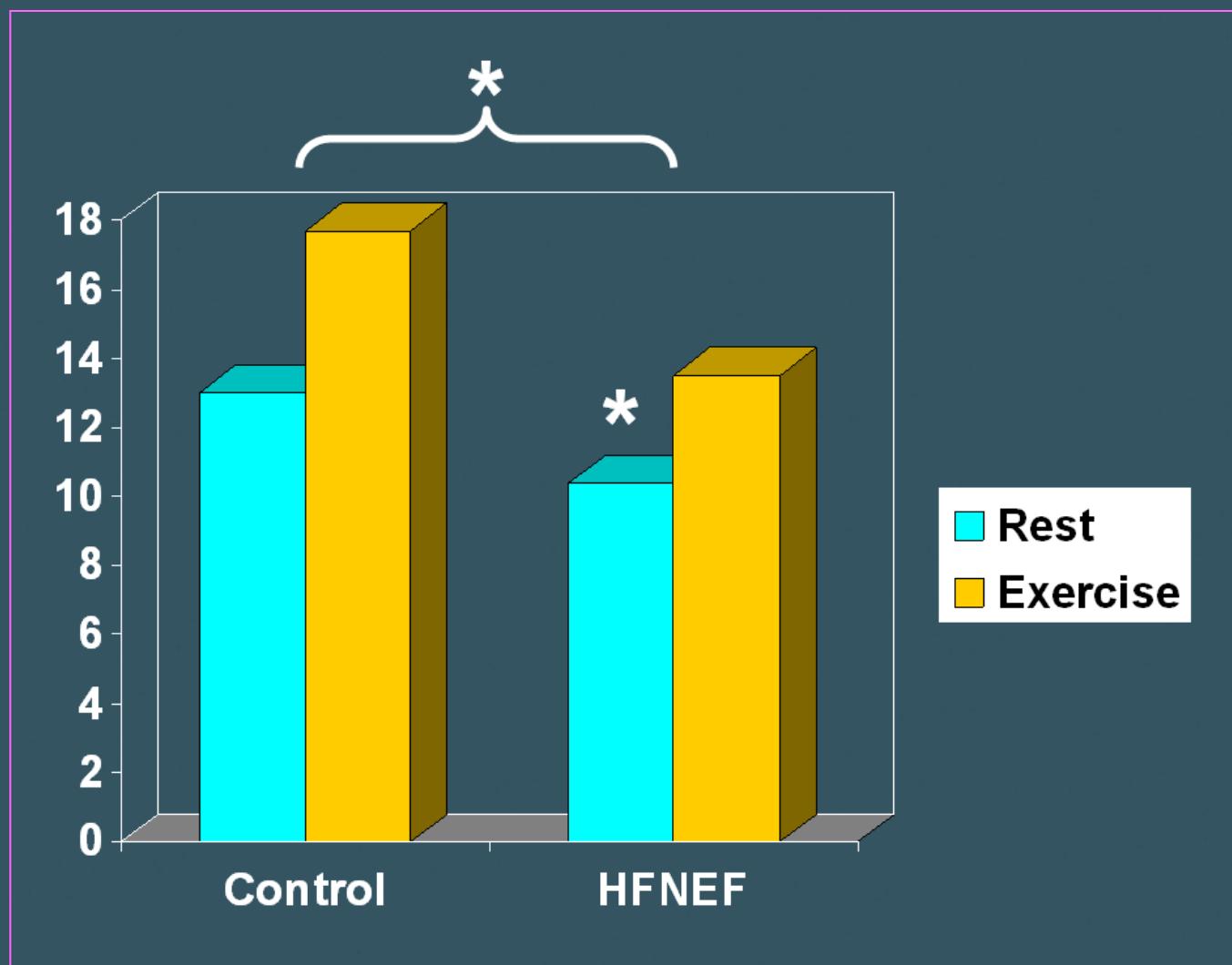
2. Peak velocity of radial shortening of the left ventricle coincides with arrival of reflected waves

3. Generation of longitudinal shortening persists against reflections

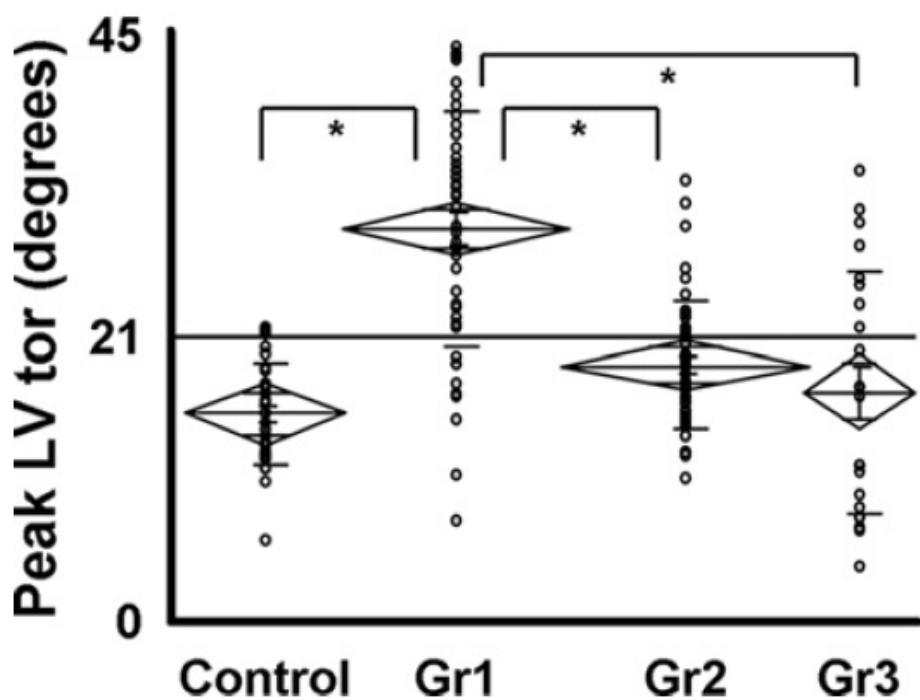
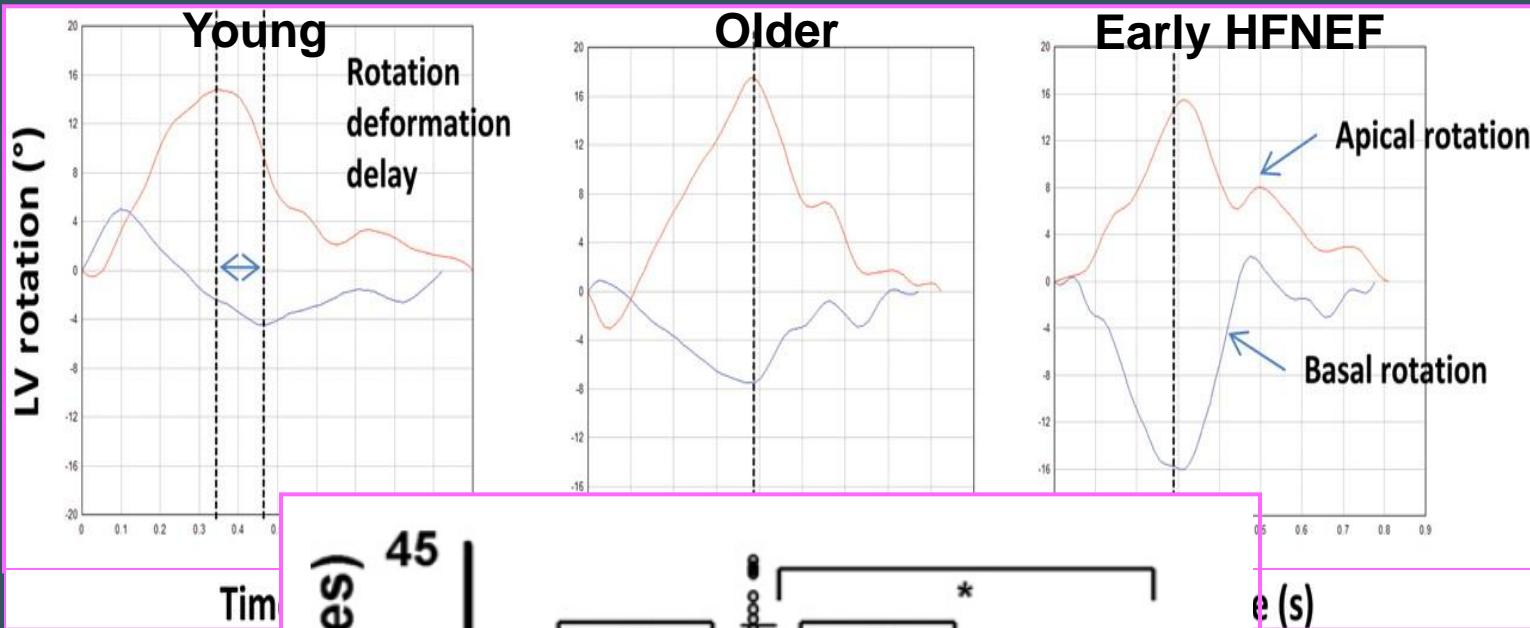
Longitudinal/radial at stress



Torsion at rest/stress



But biphasic pattern



Why increased in early stages?

1. Reduction of rotational deformation delay, because apical rotation occurs later in systole, close to the peak basal rotation (due probably to fibrosis of the conduction system);
2. Compensatory increase of the mid-wall and epicardial torque, unopposed by the affected subendocardial longitudinal fibers.

*Tan et al. JACC 2009.
Phan et al. EJE 2009.*

Summary

Systolic function in HFNEF

Rest

Stress

Longitudinal function



Radial function

N/↑



Torsion

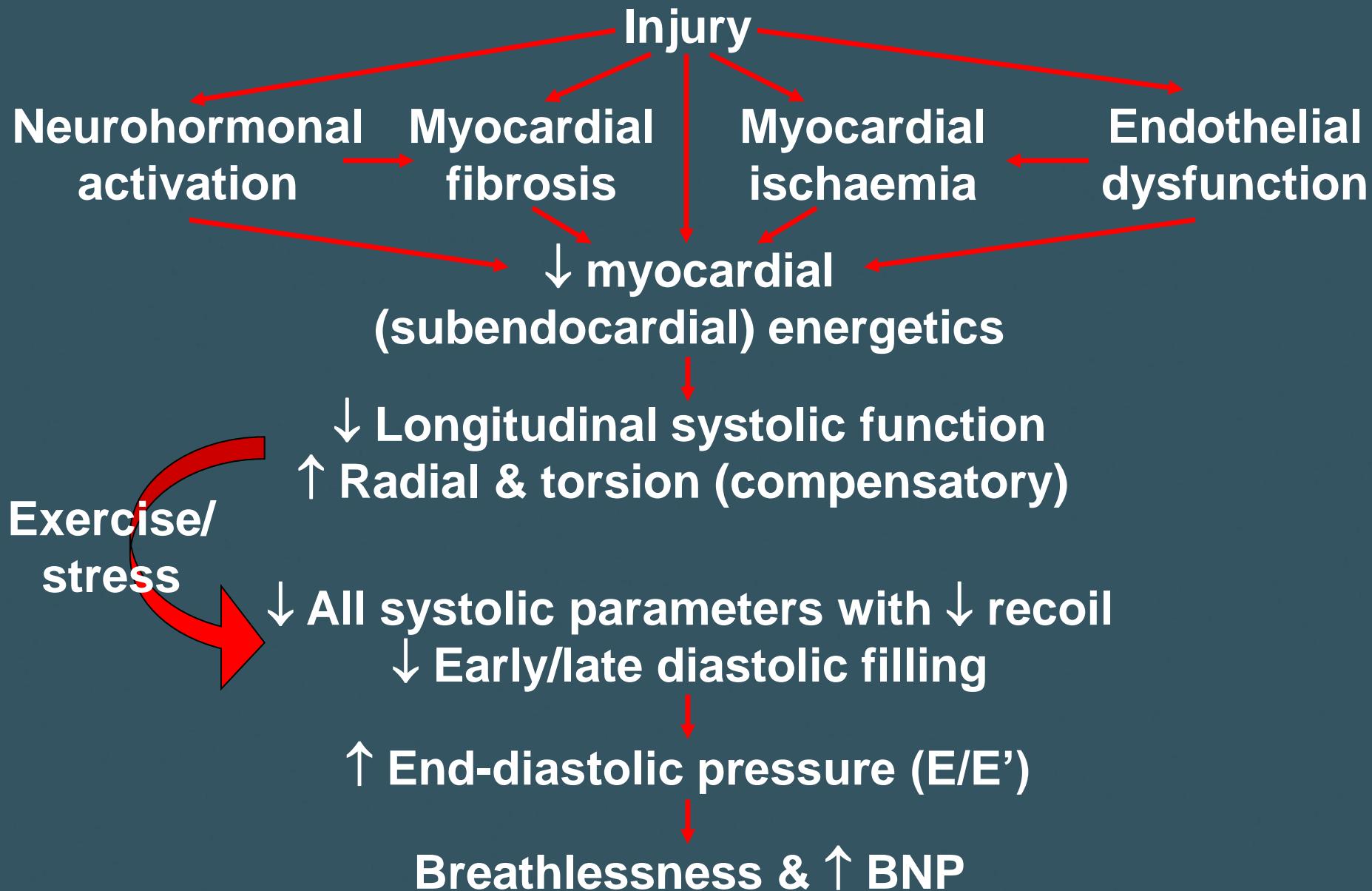
↑ (early stages)



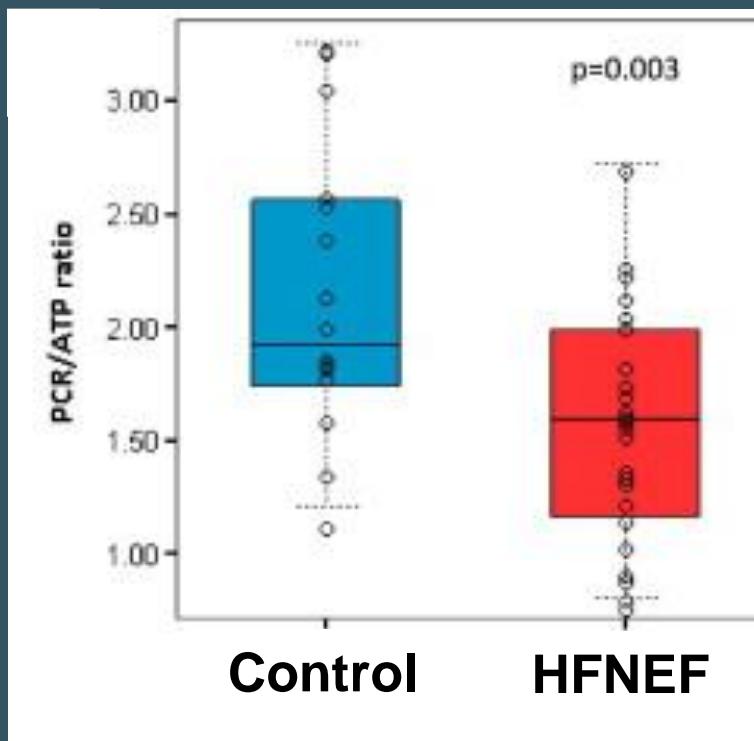
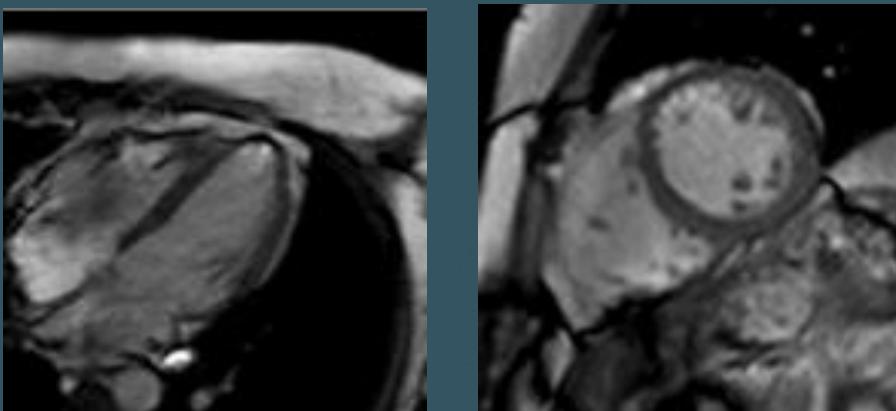
↓ (advanced stages)



Mechanisms of HFNEF?



↓ Myocardial energetics



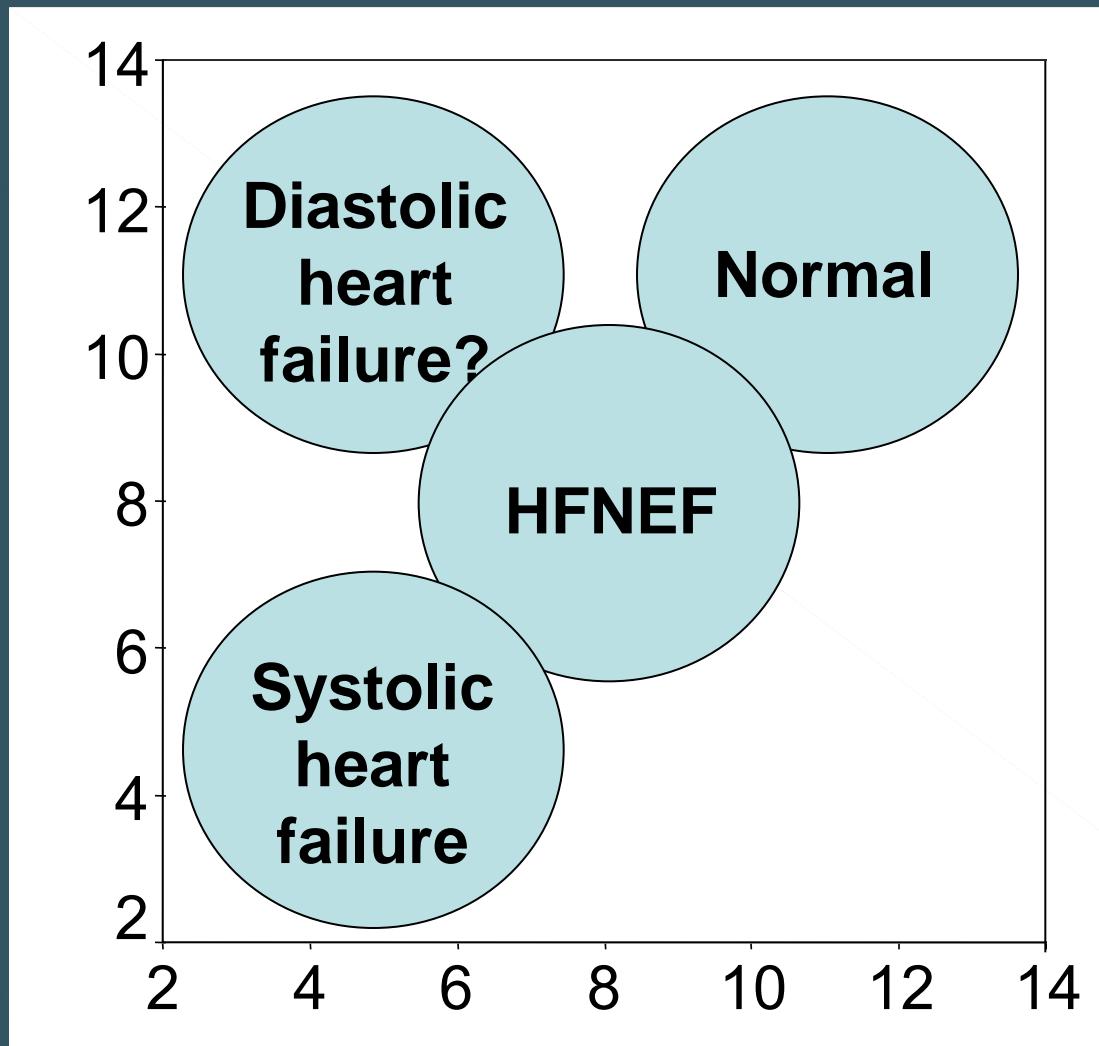
Phan et al.
JACC 2009.

Implications?

- Definition of HFNEF
- Diagnosis
- Prognosis
- Treatment

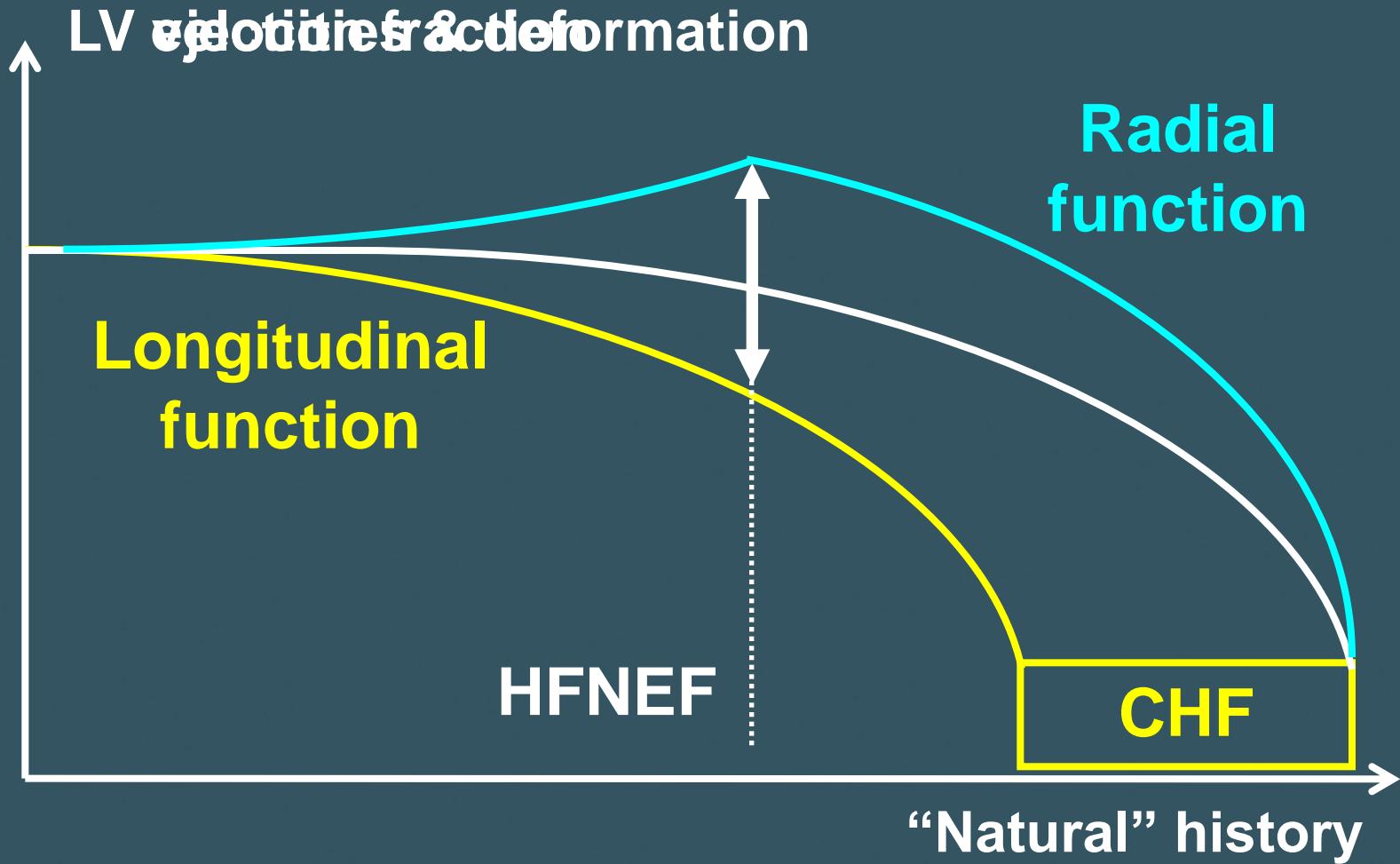
Definition of HFNEF

Systolic velocity *of long-axis function*



Diastolic velocity *of long-axis function*

HF = continuous spectrum



Preserved ejection fraction = regional (long-axis) systolic dysfunction
Measuring only global function or radial Fr Sh is misleading

Diagnosis

“Assessment of longitudinal (subendocardial) systolic function
=
probably the most sensitive measure of ventricular function.”

Yip et al. Heart 2009.

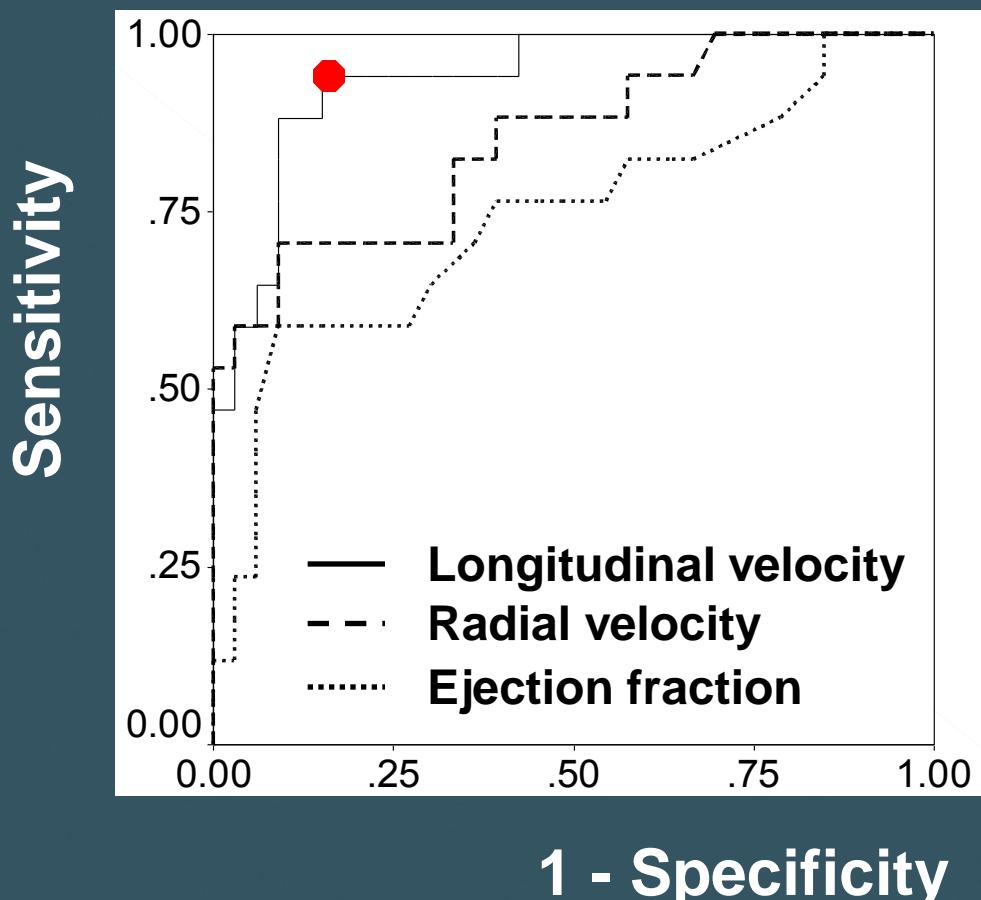
Criteria to rule out heart failure

- LVEF > 50%
- LVEDI < 76 ml/m²
- LAVI < 29 ml/m²
- No atrial fibrillation
- No LVH
- No valvular/pericardial disease
- E/E' < 8
- *Longitudinal S > 6.5 cm/s*

Paulus et al. Eur Heart J 2007.

Longitudinal S versus elevated BNP

*Longitudinal S = best accuracy for the diagnosis of HF
(increased BNP)*



Receiver operating characteristics AUC

Longitudinal systolic velocity 0.94

Radial systolic velocity 0.85

Global ejection fraction 0.74

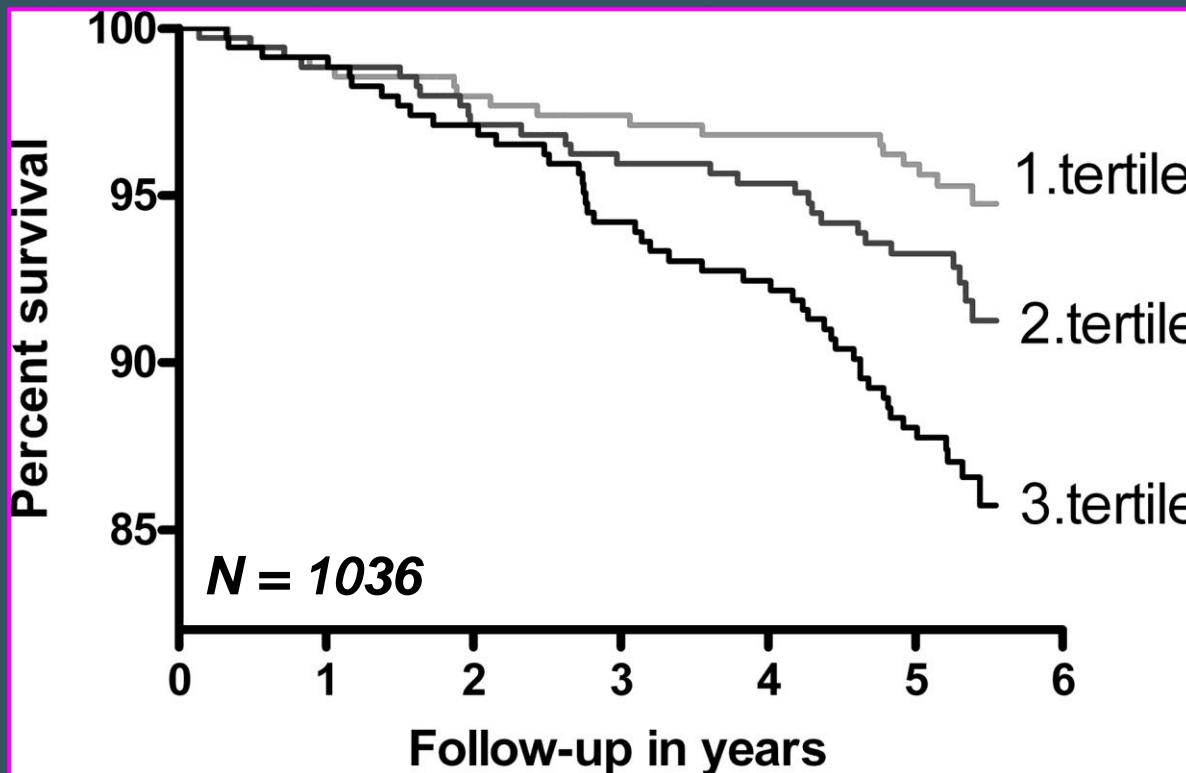
Prognosis (1)

Best predictor of mortality in the general population

=

combined systolic & diastolic index

$$Eas = E'/(A'+S'); HR = 1.71$$



Kaplan-Meier survival curves by tertiles of the eas index

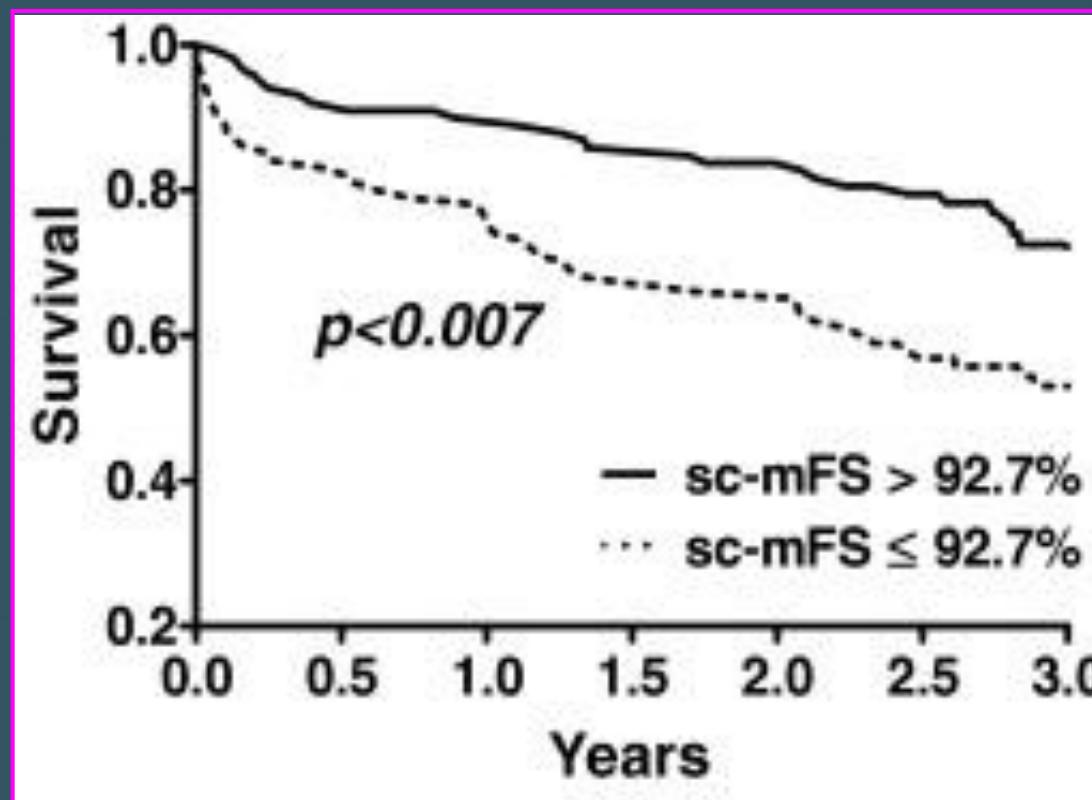
Mogelvang et al. Circulation 2009.

Prognosis (2)

Best predictor of mortality in HFNEF

=

stress-corrected midwall fractional shortening (sc-mFS)



Treatment

New targets: longitudinal function instead of EF

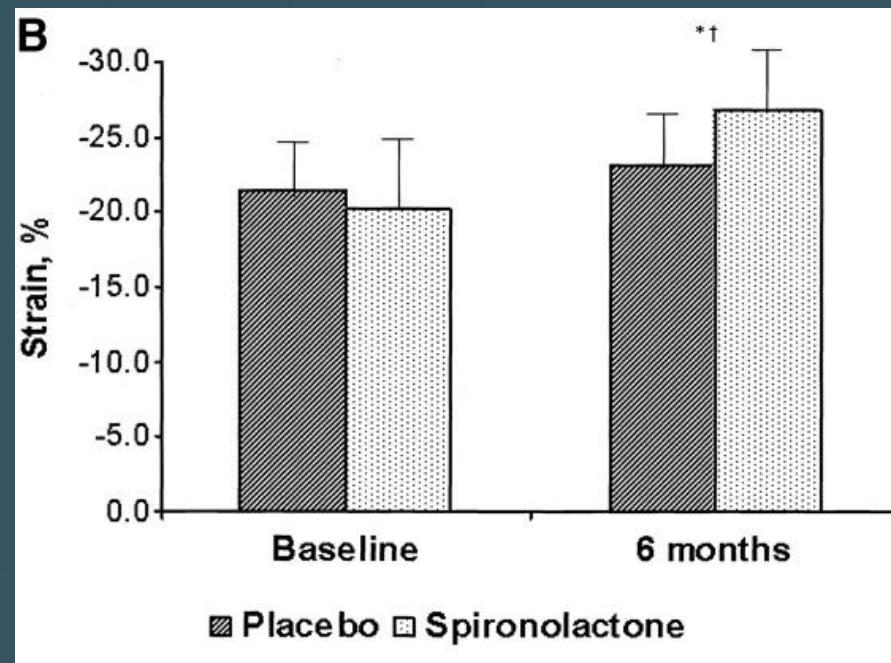
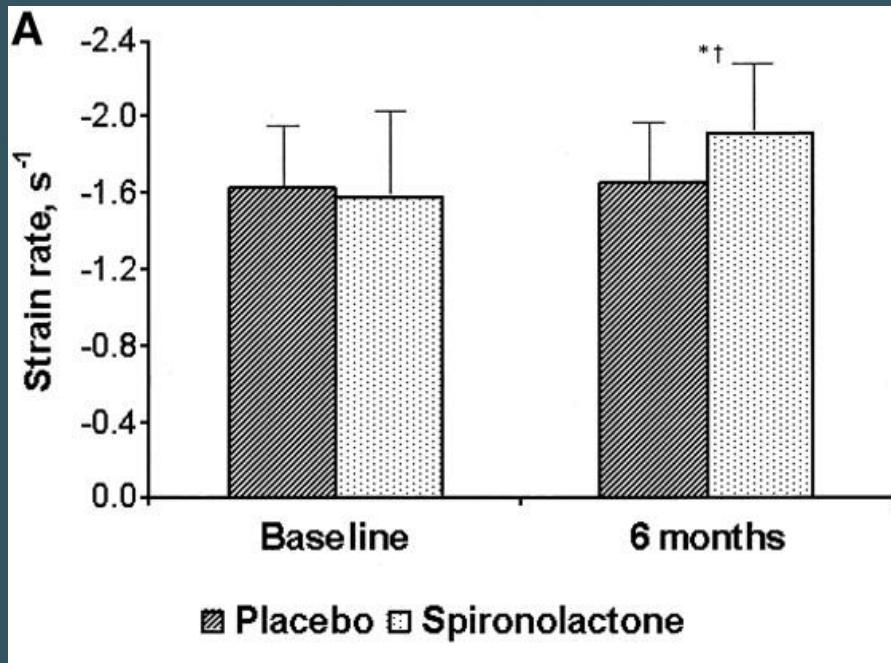
New assessment of “conventional” therapies:

- SRAA antagonists: ACEI, ARB
- Vasodilatatory BB: Nebivolol
Carvedilol

New strategies:

- Aldosterone antagonists: Spironolactone
Eplerenone
- Renin inhibitors: Aliskiren
- Endothelin receptor A antag.: Sitaxsentan
- AGE-products breakers: Alagebrium
- Metabolic agents: Ranolazine
Perhexiline

Longitudinal strain & spironolactone



Mottram et al. Circulation 2004.

Conclusions

1. Resting LV systolic function is impaired in patients with HFNEF:
 - decrease of longitudinal function
 - compensatory increase of radial function
 - biphasic pattern of torsion
2. Functional reserve (longitudinal, radial, and torsion) is impaired
3. Mechanisms are related to inefficient ventriculo-arterial coupling

Diagnosis of HF as a continuum

- Assessment of long-axis function most sensitive
- Exercise/stress might be necessary

Treatment

- New targets
- New assessment of conventional therapies
- New strategies

Prognosis

- Systolic function most powerful