
# DISFUNZIONE ATRIALE SINISTRA: SEMPRE DIPENDENTE DAL VENTRICOLO SOTTOSTANTE?

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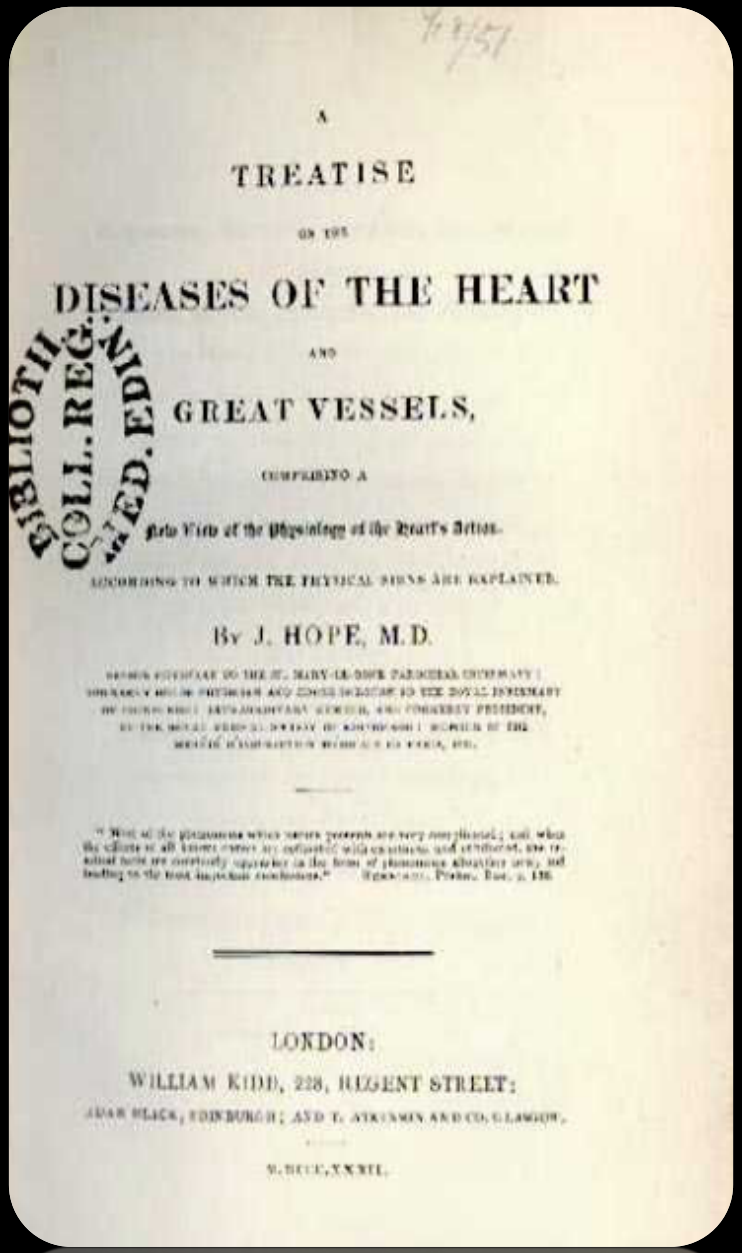
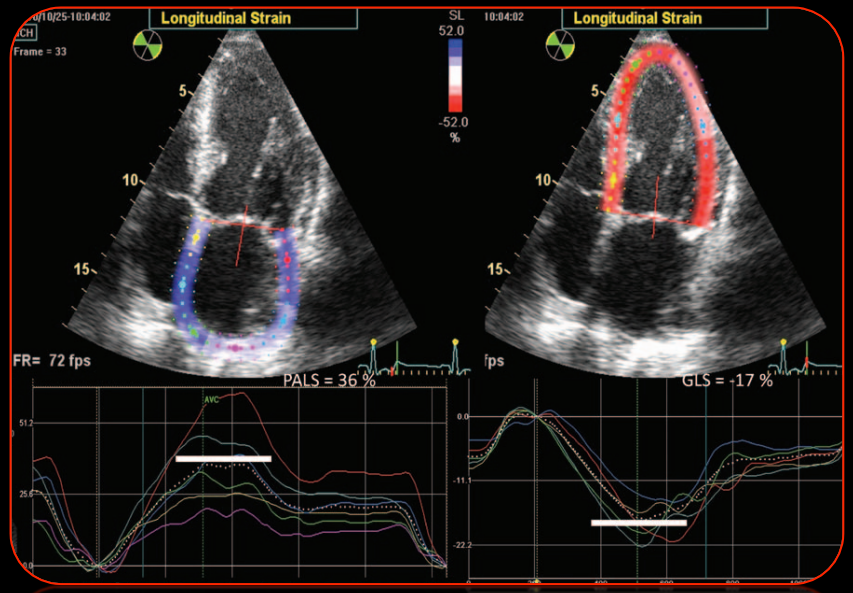



**“ Quando il ventricolo sinistro perde la capacità di svuotarsi, il sangue si accumula e la pressione sale nell’atrio e nel sistema venoso che si svuotano in esso”**

**James Hope, Treatise on the disease of the heart, 1832**

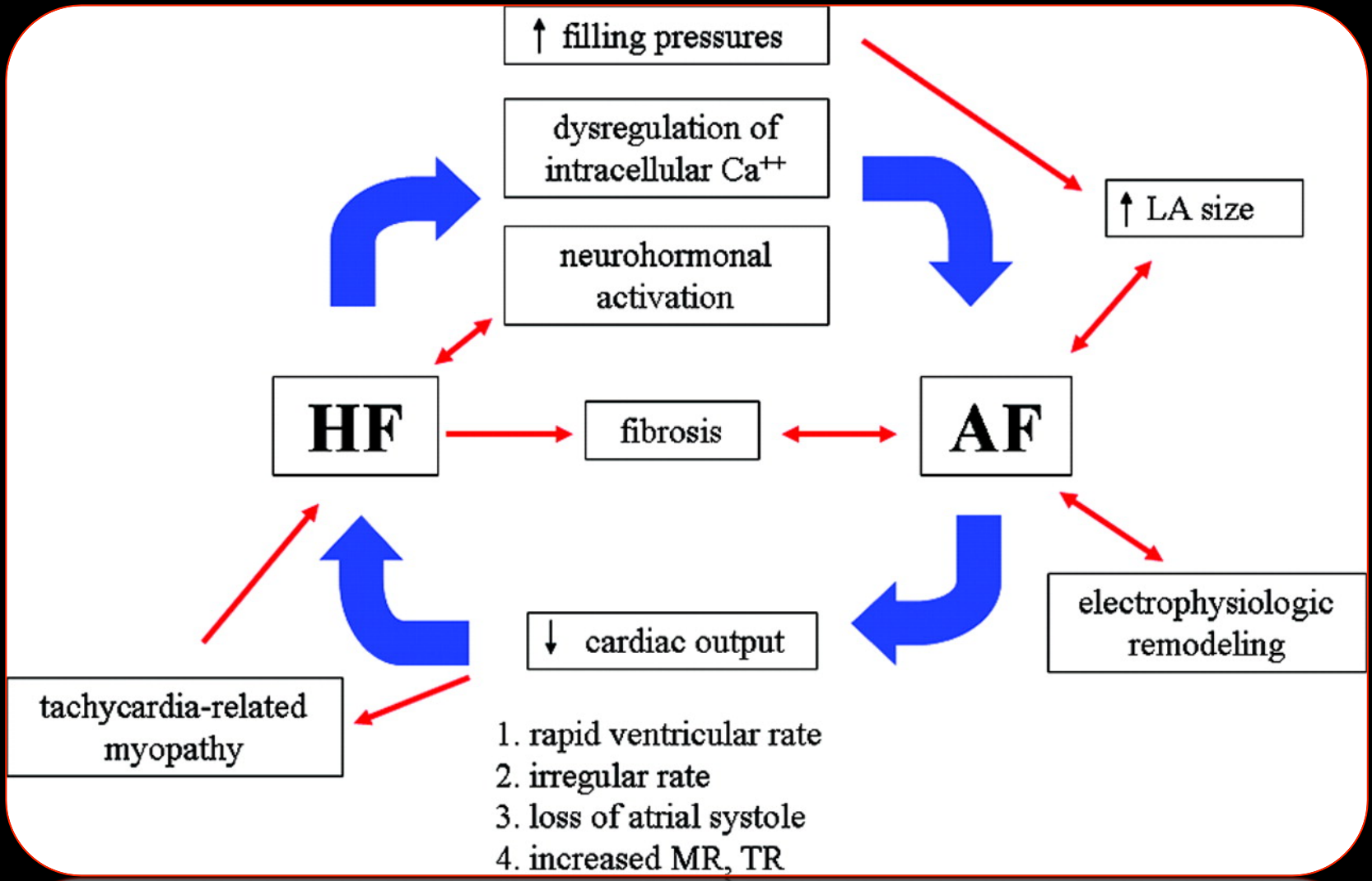
# Do left atrial function reflect intrinsic atrial function or is determined by left ventricular function?




- The LA and LV share the common mitral annulus
- LA and LV longitudinal function are closely inter-related, and changes in LA and LV volumes are nearly identical but opposit

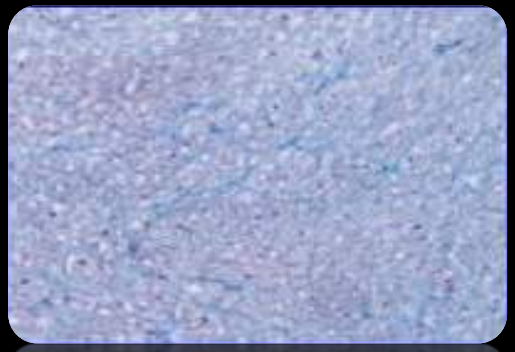
Appleton CP et al, Circ Cardiovasc Imaging 2009

# LV and LA remodeling due to Heart Failure



# Structural remodeling due to Heart Failure

dog model of ventricular pacing induced heart failure



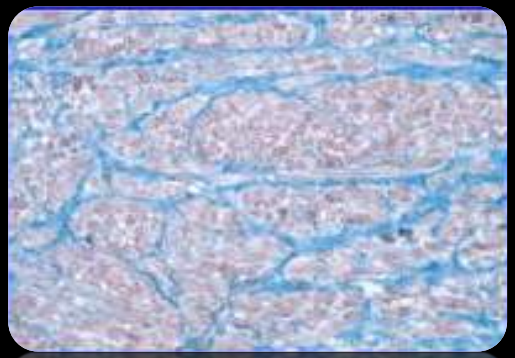
CHF

↓

Atrial fibrosis

↓

heterogeneity of CV → duration of AF ↑



Enalapril reduced AF duration due to

less fibrosis

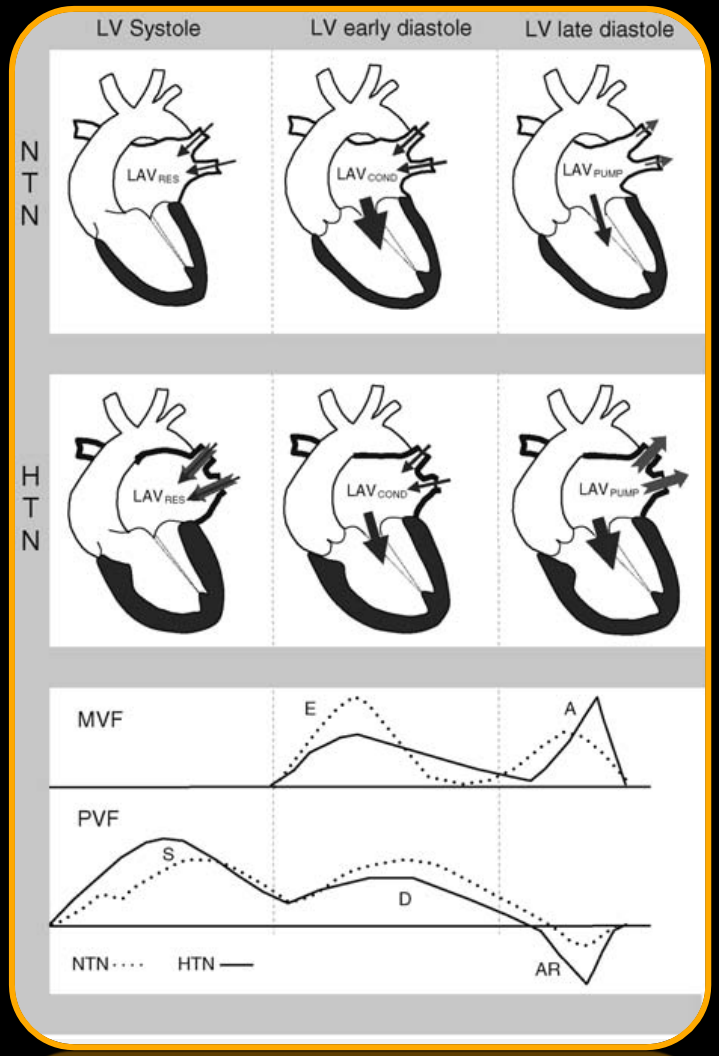
Less atrial dilatation

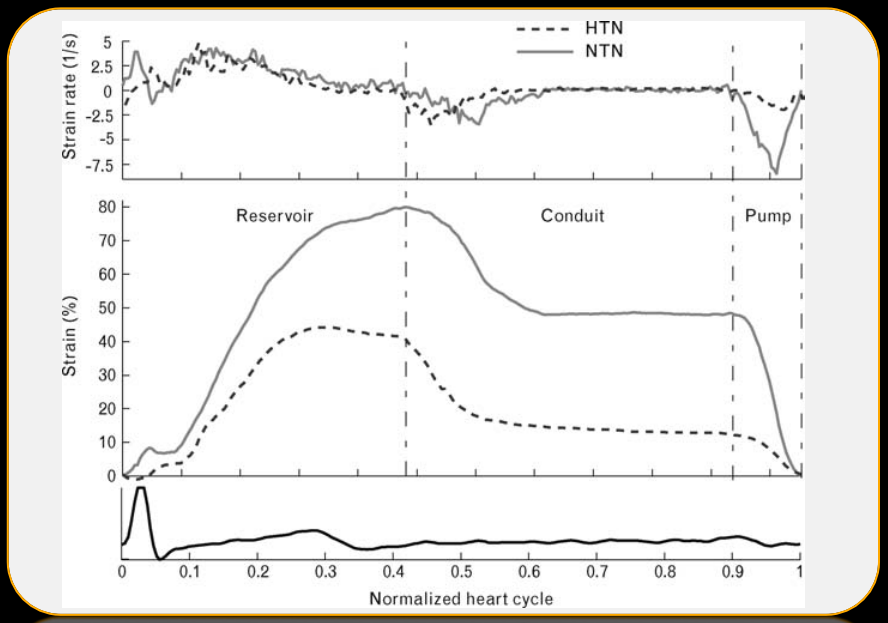
Li, et al. Circulation 1999 and 2001

Yanfen S, et al. Cardiovasc Res 2002

# Effect of LV relaxation on LA function

## Atrial remodeling due to Hypertension

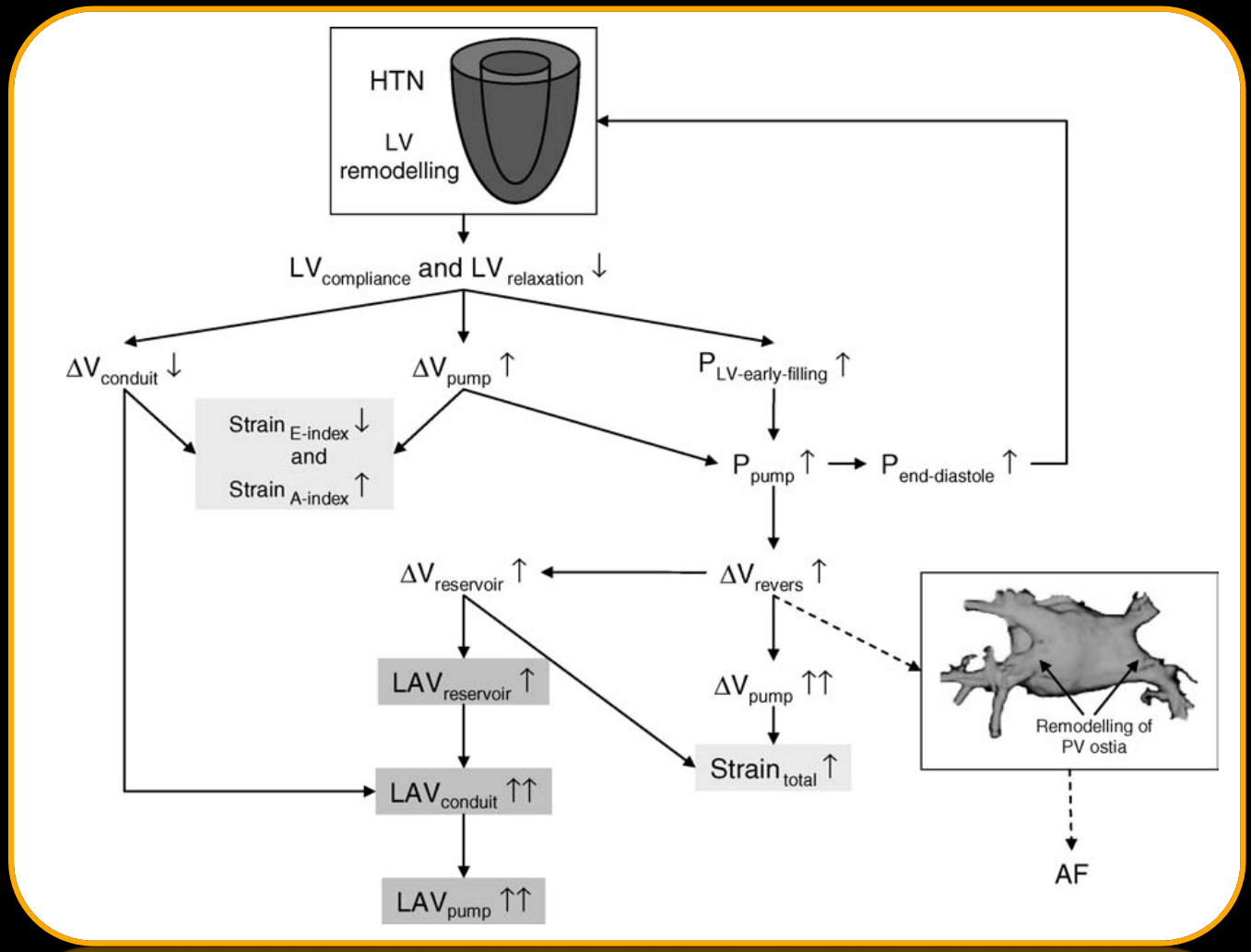



Baltabaeva A, et al. J Hypertension 2009

# Effect of LV relaxation on LA function

## Atrial remodeling due to Hypertension

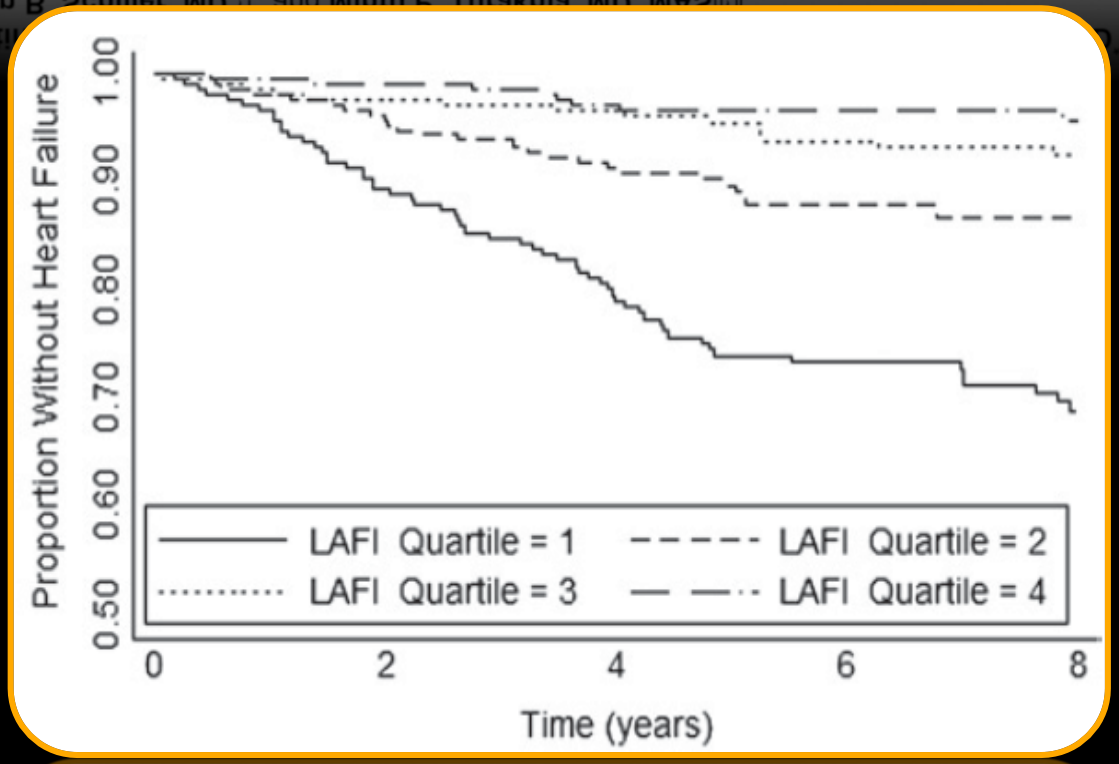



Baltabaeva A, et al. J Hypertension 2009

*J Am Coll Cardiol*. 2012 February 14; 59(7): 673–680. doi:10.1016/j.jacc.2011.11.012.

# Left Atrial Function Predicts Heart Failure Hospitalization in Subjects with Preserved Ejection Fraction and Coronary Heart Disease: Longitudinal Data from the Heart and Soul Study

**Christine C. Welles, MD**[*,†], **Ivy A. Ku, MD**[‡], **Damon M. Kwan, MD**[§], **Mary A. Whooley, MD**[*,†], **Nelson B. Schiller, MD**[*,†], and **Mintu P. Turakhia, MD, MAS**[‖,¶]

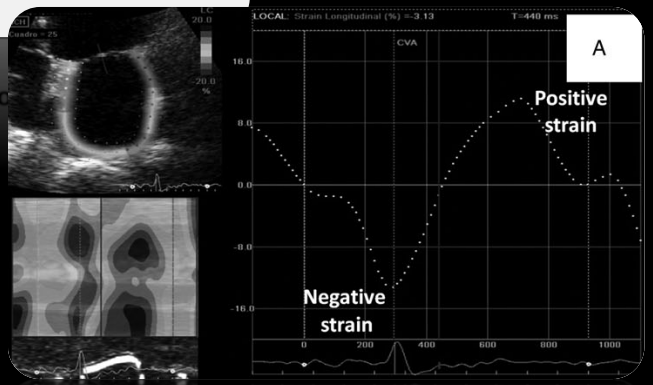


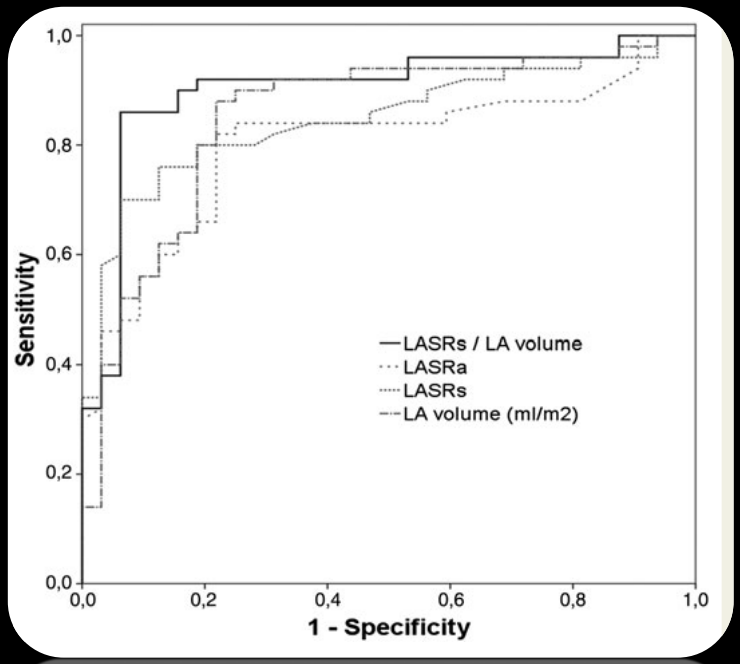

Welles, et al. JACC 2012;59: 673-680

European Heart Journal – Cardiovascular Imaging (2015) **16**, 62–67
doi:10.1093/ehjci/jeu165

# Left atrial dysfunction relates to symptom onset in patients with heart failure and preserved left ventricular ejection fraction

**Laura Sanchis[1]*, Luigi Gabrielli[1,2], Rut Andrea[1], Carles Falces[1], Nicolas Duchateau[1], Felix Perez-Villa[1], Bart Bijnens[3], and Marta Sitges[1]**




Sanchis L et al EHJ Card Imaging 2015

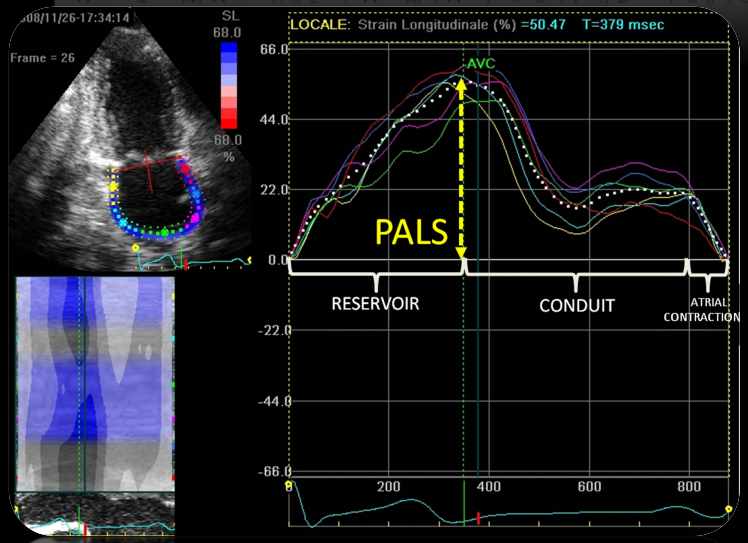
Cameli *et al. Cardiovascular Ultrasound* 2010, **8**:14
http://www.cardiovascularultrasound.com/content/8/1/14

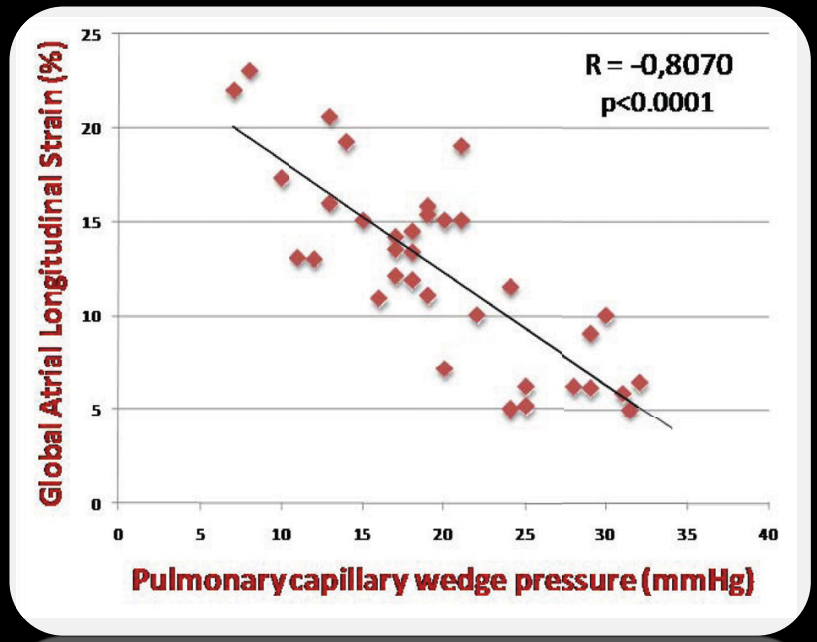
CARDIOVASCULAR ULTRASOUND

**RESEARCH** **Open Access**

# Left atrial longitudinal strain by speckle tracking echocardiography correlates well with left ventricular filling pressures in patients with heart failure

Matteo Cameli*[1], Matteo Lisi[1], Sergio Mondillo[1], Margherita Padeletti[1], Piercarlo Ballo[2], Charilaos Tsioulpas[3], Sonia Bernazzali[3] and Massimo Maccherini[3]



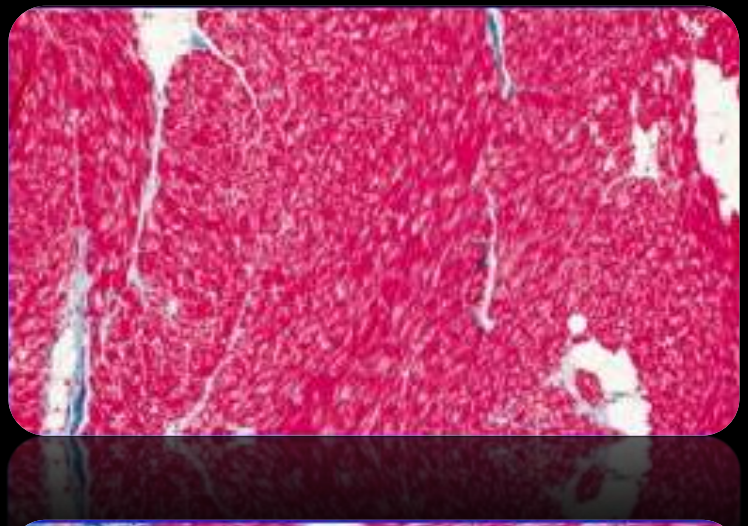



# LA dysfunction related to LA Remodeling

*LA remodeling is progressive and related to*

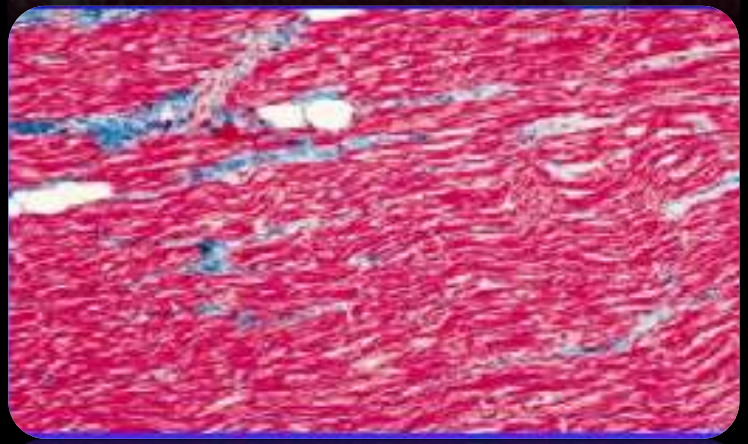
- Aging
- Progression of heart disease
- Tachicardia induced remodeling

# Remodeling due to ageing



Atria of young vs old dogs

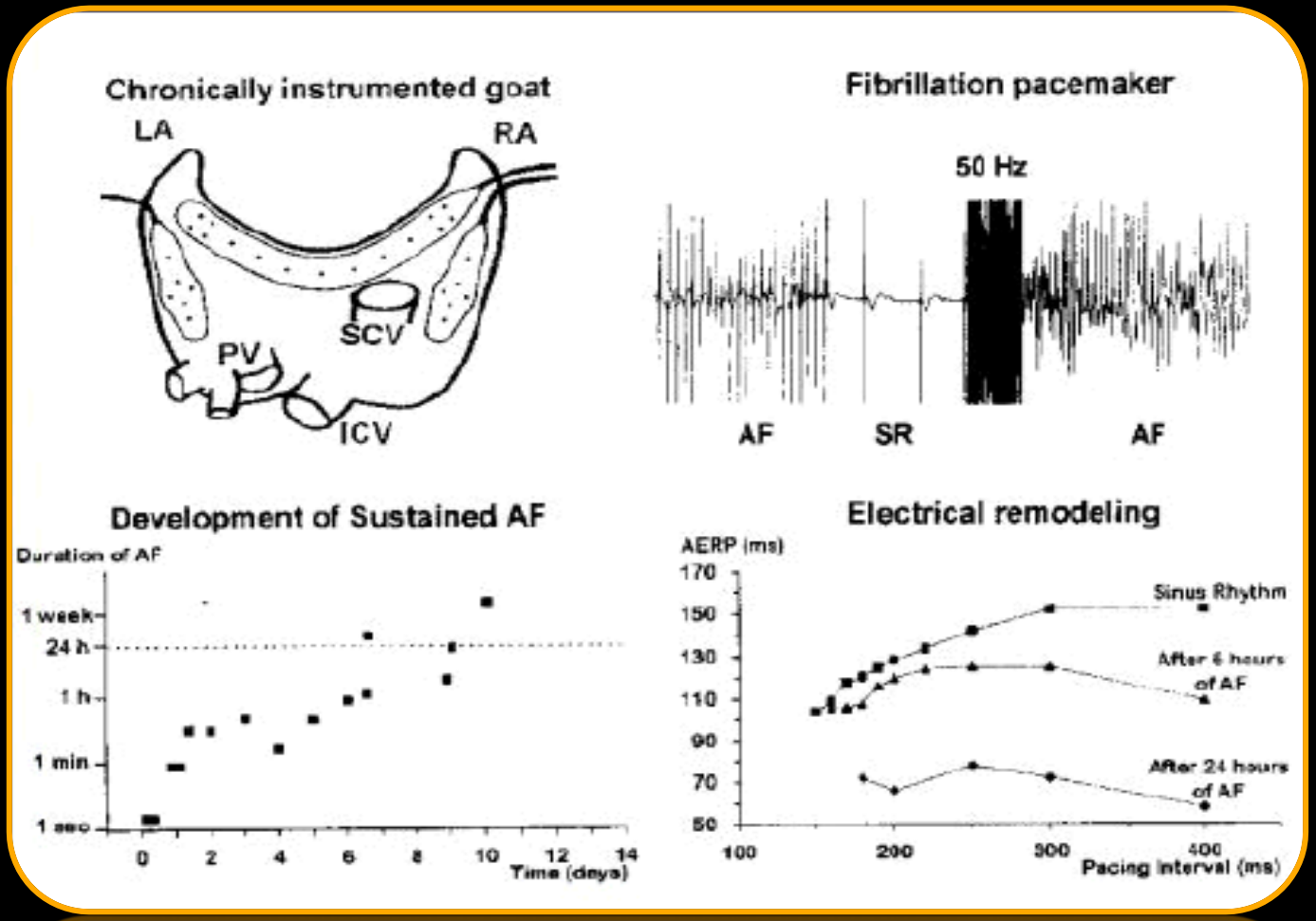
twofold increase in fibrosis



- Slow conduction of early premature impulses
- Increase of pathlenght for reentry

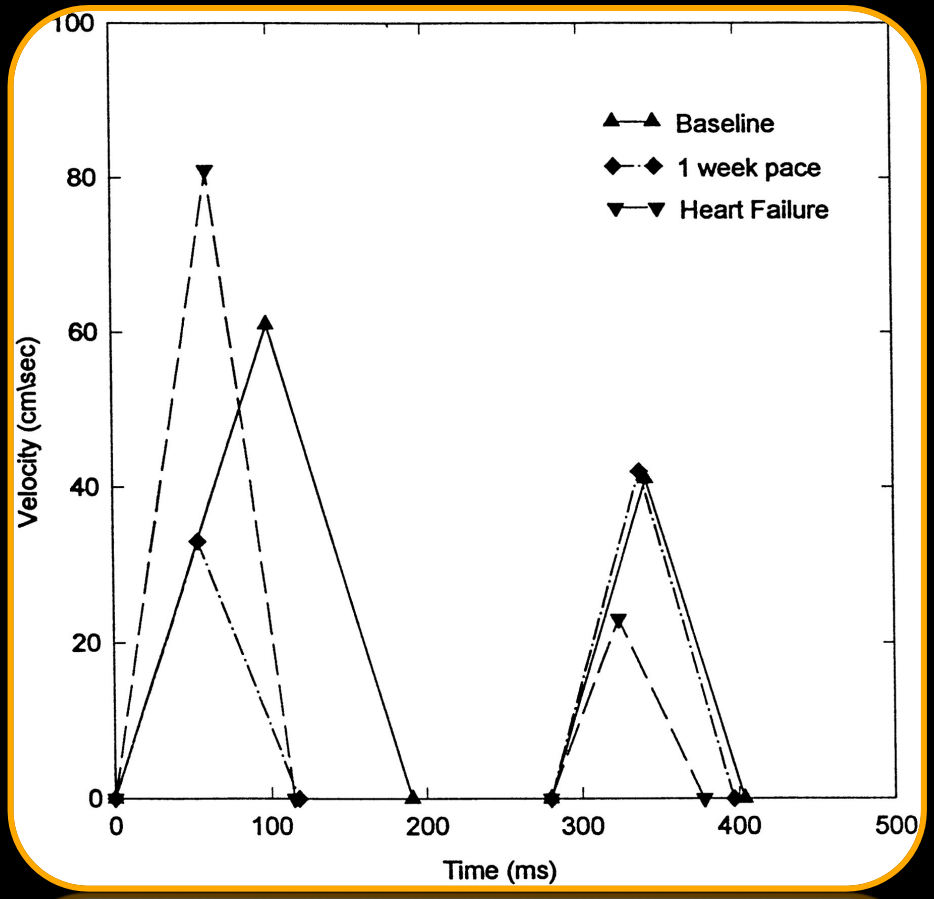
**Anyukovsky, et al. Cardiovasc res 2002**

# Atrial Fibrillation begets Atrial Fibrillation



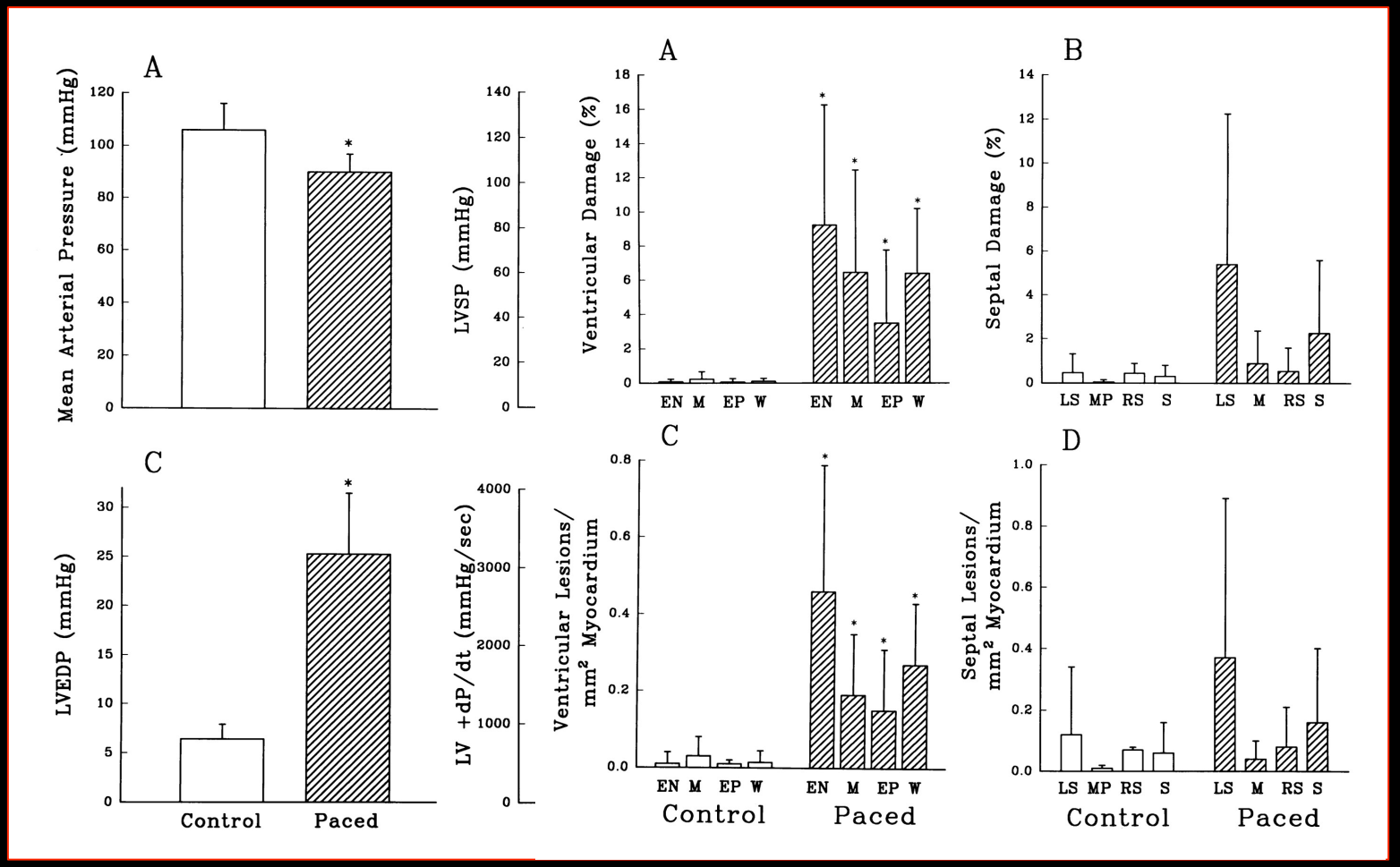

Wijffels, et al. Circulation 1995

# LV diastolic function of remodeled myocardium in dogs with pacing-induced heart failure



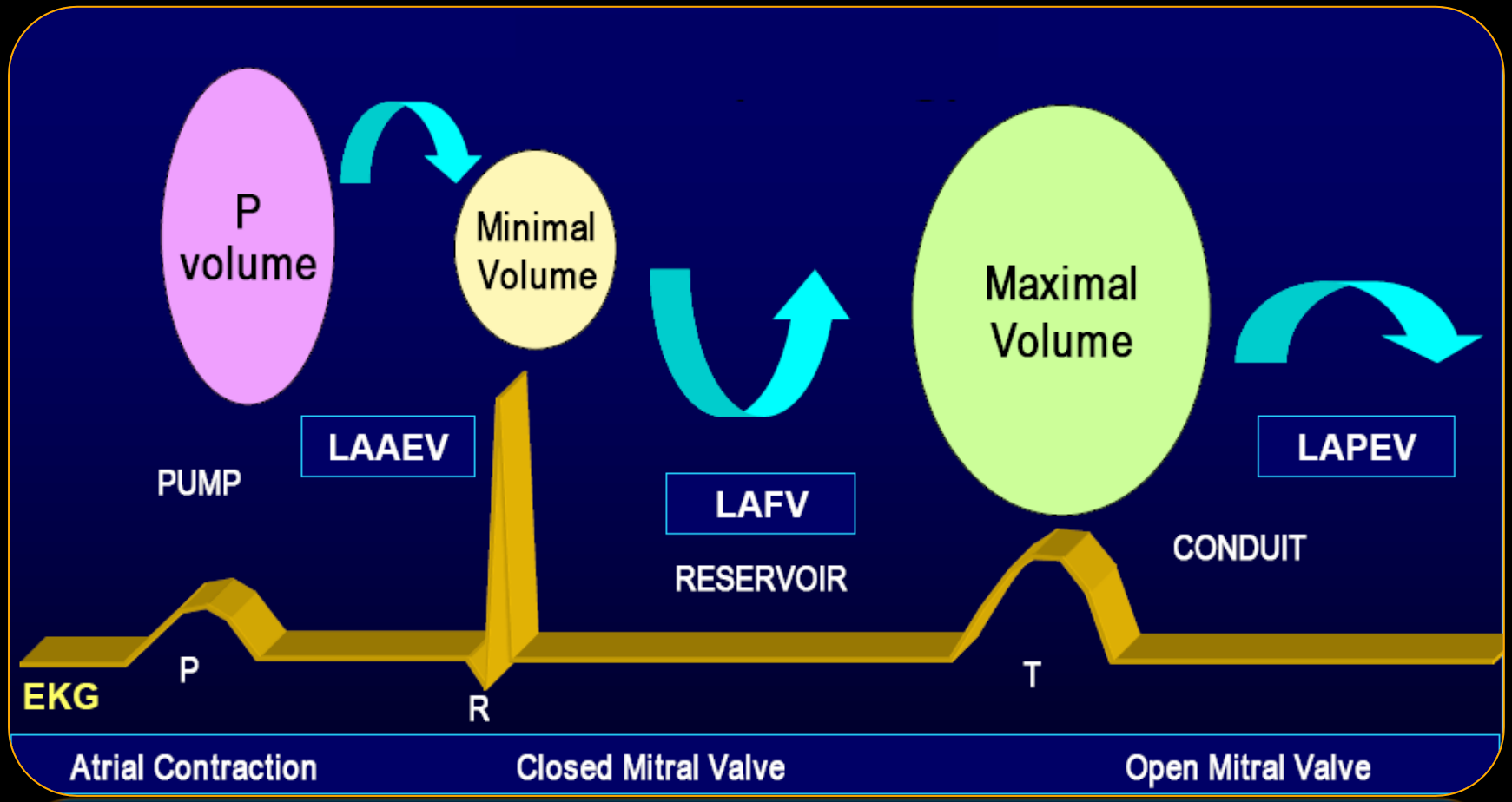

Solomon et al, AJPh 1998

# The cellular basis of pacing-induced dilated cardiomyopathy



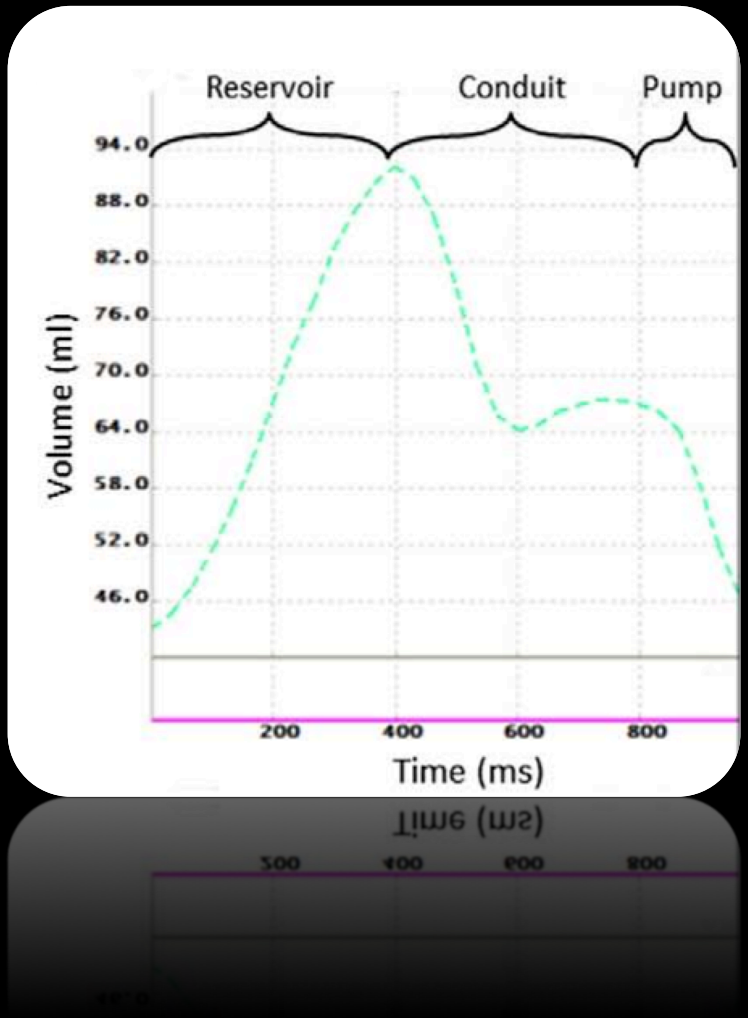

Kajstura et al, Circ 1995

# Left atrial physiology




Nikitin et al Eur Heart J 2003

# Left atrial physiopathlogy



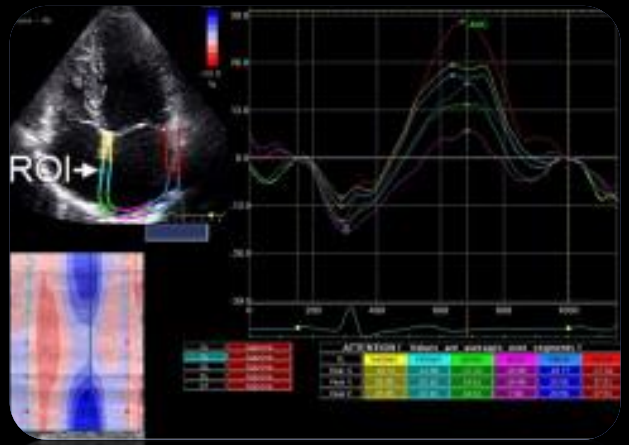

Reservoir function* influenced by:
- LV contraction, (affects the ascent of mitral annulus)
- LV relaxation
- influenced by preload
- LA myocardial relaxation and stiffness (lesser degree)

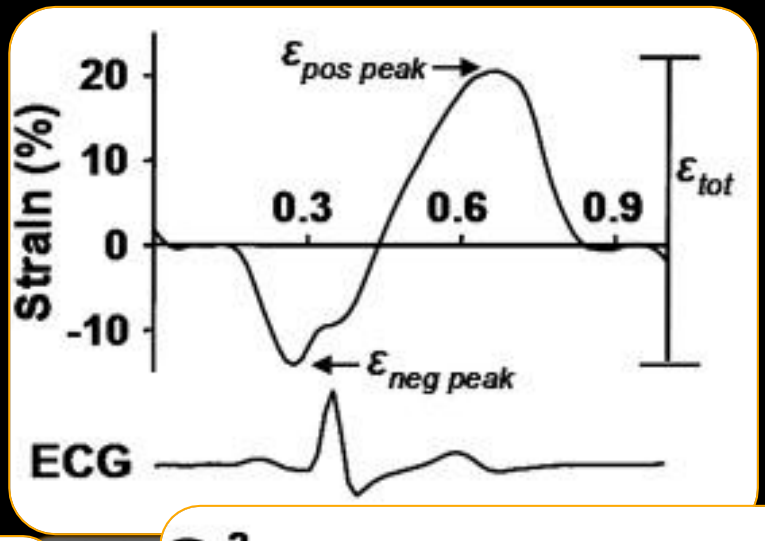
Conduit function*
- reflects LV relaxation
- influenced by preload

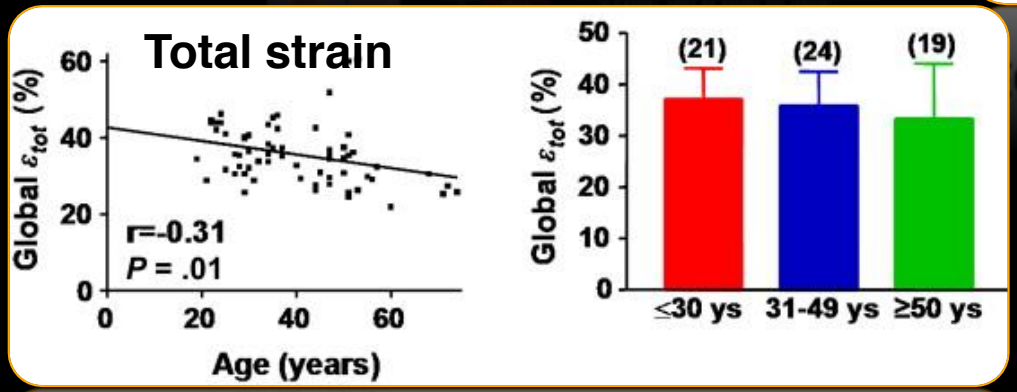
LA contractile function determined by
- LV compliance,
- LV filling pressures (LA afterload),
- pulmonary vascular capacitance
- intrinsic LA contractility

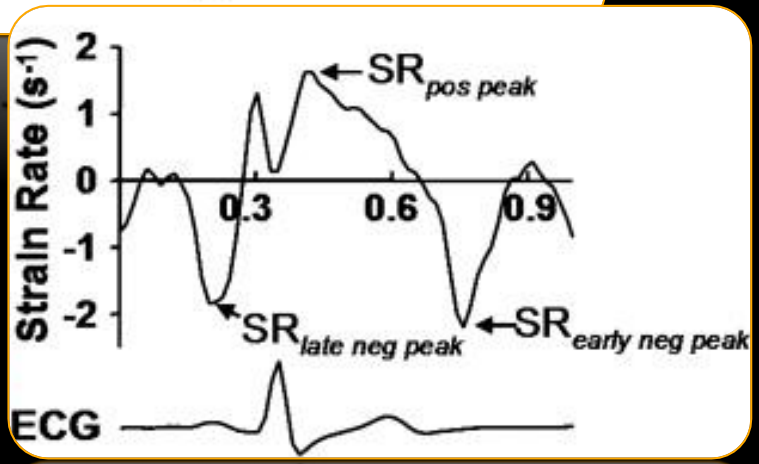
# LA Strain and Strain Rate

*Application of Speckle Tracking*



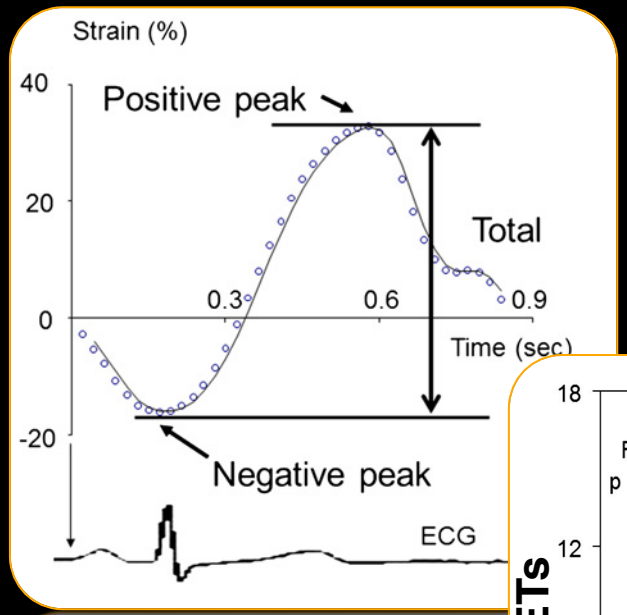



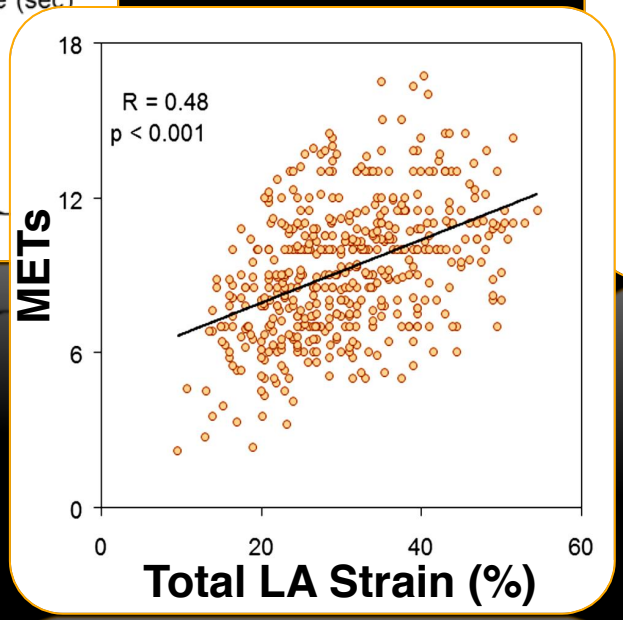



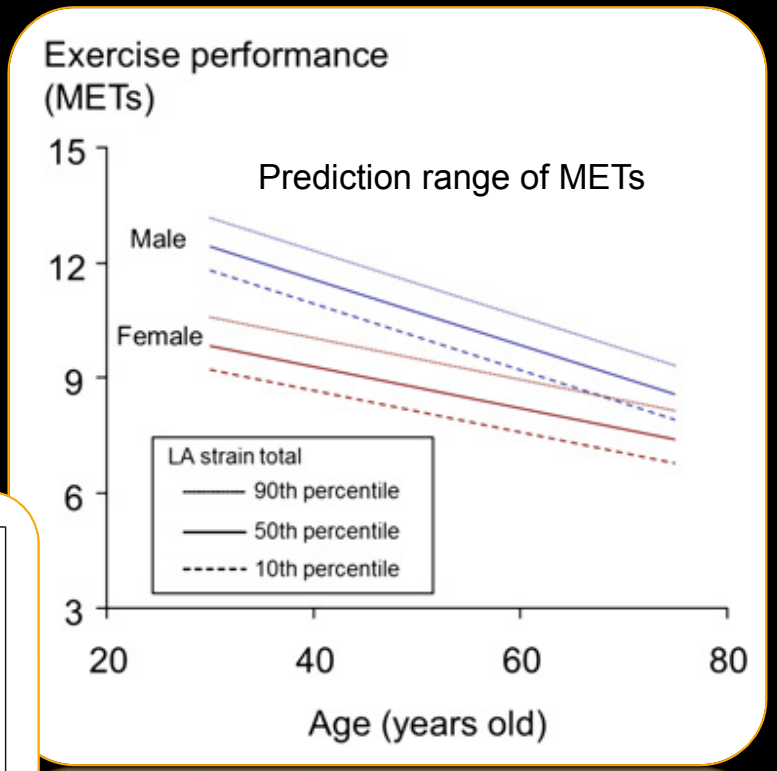

Saraiva et al. J Am Soc Echocardiogr 2010

# Speckle Tracking for Left Atrial Strain

*LA dysfunction Predict Functional Capacity*

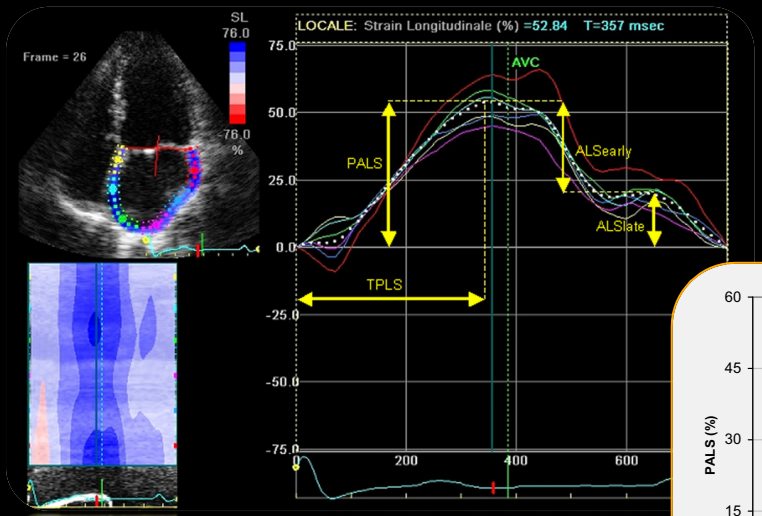


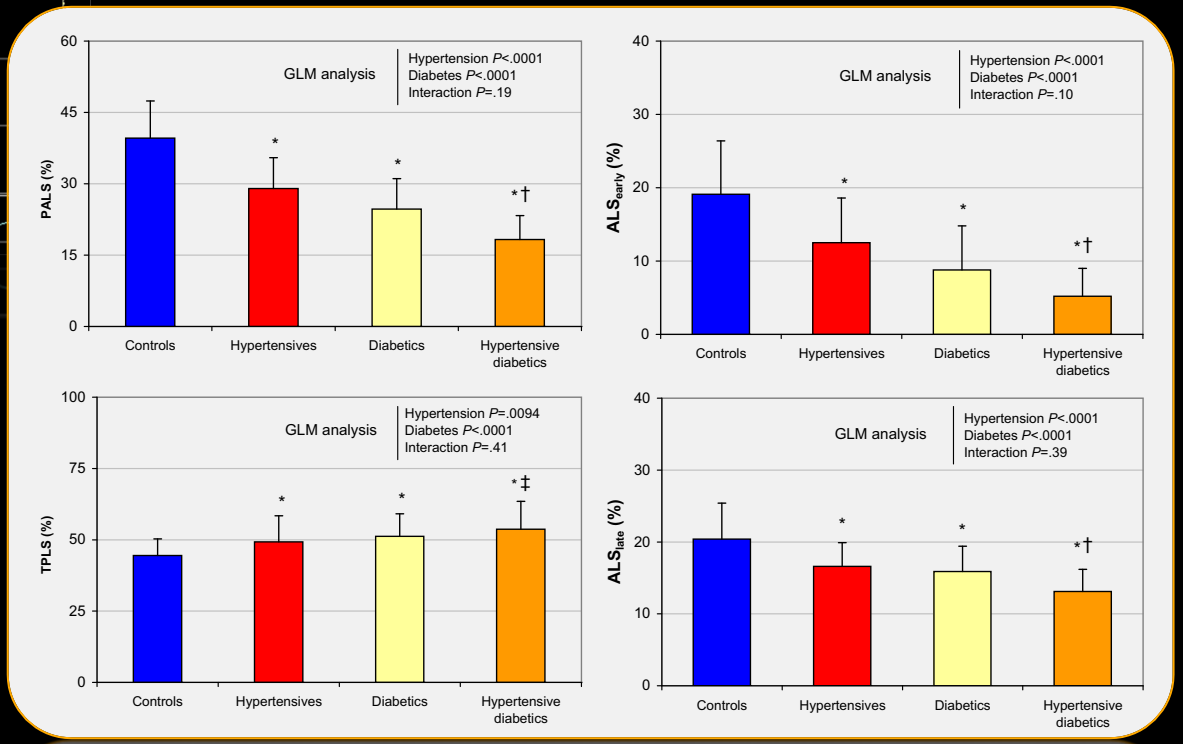




Kusunose, et al. Heart 2012; 98: 1311-17

# Effect of risk factors on Left Atrial Strain

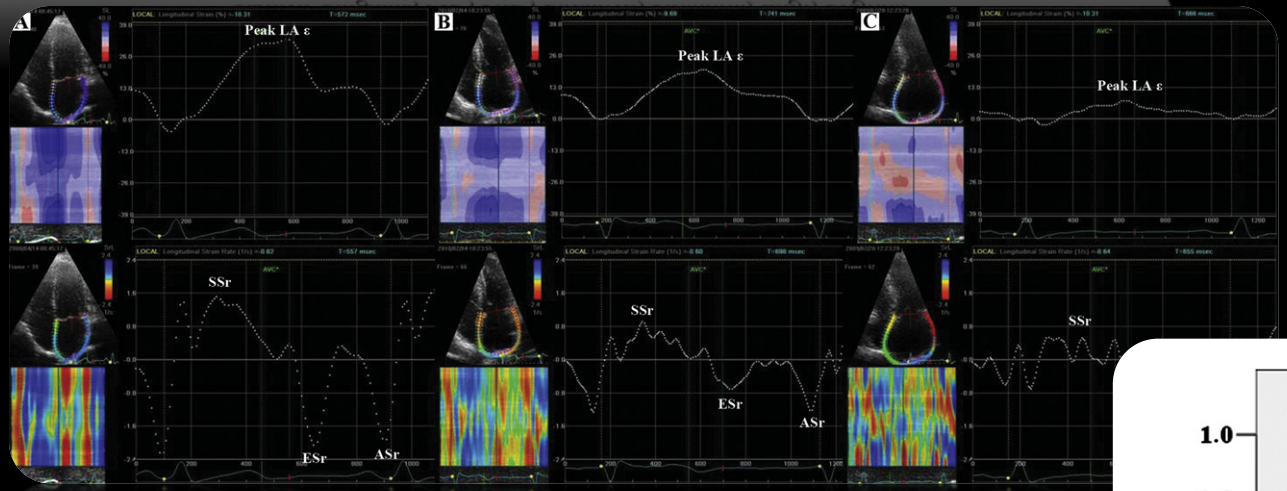


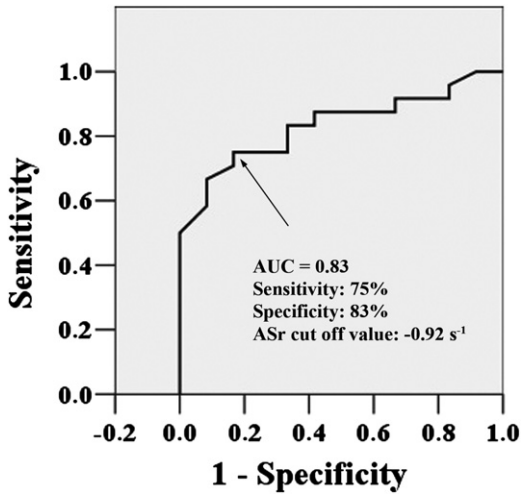

Mondillo et al, J Am Soc Echocardiogr 2011

# Left Atrial Dysfunction as a Correlate of Heart Failure Symptoms in Hypertrophic Cardiomyopathy

Monica Roşca, MD, Bogdan A. Popescu, MD, PhD, Carmen C. Beladan, MD, Andreea Călin, MD, Denisa Muraru, MD, Elena C. Popa, MD, Patrizio Lancellotti, MD, PhD, Roxana Enache, MD, Ioan M. Coman, MD, PhD, Ruxandra Jurcuţ, MD, PhD, Mihai Ghionea, MD, and Carmen Ginghină, MD, PhD, *Bucharest, Romania; Liege, Belgium*




| Variables | Univariate analysis OR | 95% CI | *P* | Multivariable analysis *P* |
|---|---|---|---|---|
| Age | 1.027 | 0.983-1.073 | .23 | - |
| LVϵ | 1.215 | 0.954-1.549 | .11 | .49 |
| LAVi | 1.091 | 1.018-1.170 | .01 | .34 |
| ASr | 3.377* | 1.349-8.616 | .009 | .04 |
| MR degree | 2.277 | 0.969-5.353 | .056 | .10 |
| Presence of LV outflow tract obstruction (Y/N) | 0.476 | 0.118-1.929 | .29 | - |
| Peak LV outflow tract gradient | 1.010 | 0.981-1.041 | .49 | - |



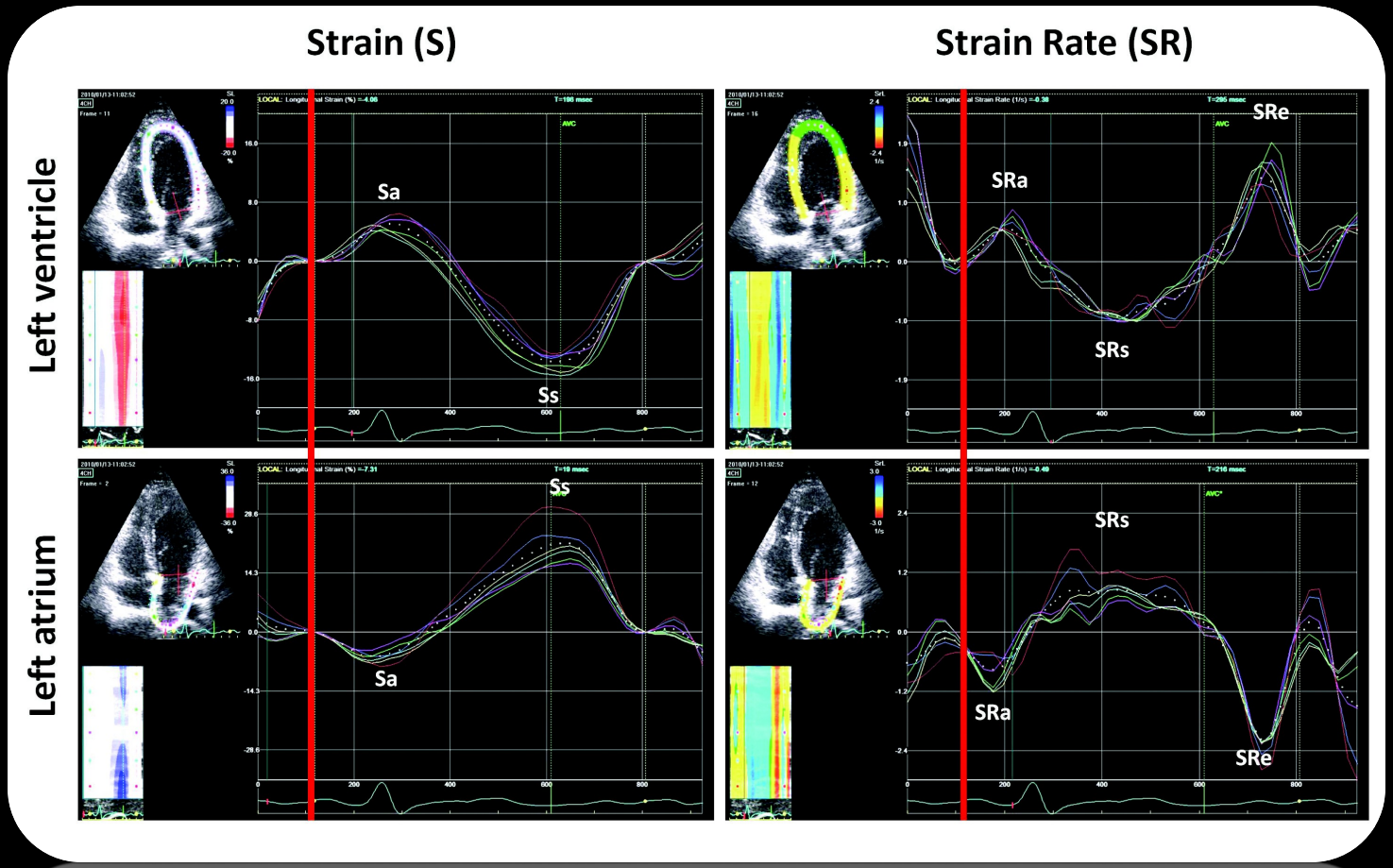

Rosca et al J Am Soc Echocardiogr 2010

# In most studies LA strain mirrors LV strain

| Study | Population | Methodology | Year | Main findings |
|---|---|---|---|---|
| **Cardiomyopathies** | | | | |
| Modesto *et al*.[85] | 95 AL patients<br>30 controls<br>30 DD patients | DTI QRS timed | 2005 | LA $\varepsilon_R$ and $SR_R$ were lower for AL patients with cardiac involvement, compared with a control group, to a group with LA dilatation and diastolic dysfunction and event to a group with AL but with no cardiac involvement.<br>Contrary to LA ejection fraction, LA $\varepsilon_R$ was lower for AL patients with heart failure symptoms. |
| Telagh *et al*.[86] | 20 HCM patients<br>20 controls | DTI QRS timed | 2008 | LA $SR_R$, $SR_{CD}$, and $SR_{CT}$ were lower in patients with HCM than in controls. |
| D'Andrea *et al*.[87] | 40 HTN patients<br>45 elite athletes<br>25 sedentary controls | 2D ST QRS timed | 2008 | Contrary to LA diameter, LA $\varepsilon_R$ was reduced in patients with hypertension and LVH compared with athletes.<br>In patients with LVH LA $\varepsilon_R$ was a predictor of maximum workload during exercise testing. |
| **ASD** | | | | |
| Abd el Rahman *et al*.[88] | 25 ASD patients (median age, 25 y)<br>30 controls | DTI QRS timed | 2005 | 1 wk after surgical ASD closure, LA and RA $SR_{CT}$ were significantly diminished compared with baseline level.<br>This was in contrast to patients submitted to a percutaneous device closure of the ASD. |
| Di Salvo *et al*.[89] | 30 ASD patients (mean age, 9 y; 15 device closure, 15 surgery closure)<br>15 controls | DTI QRS timed | 2005 | 6 mo after surgical ASD closure, LA and RA $\varepsilon_R$ and $SR_R$ were lower compared with age-matched controls.<br>6 mo after percutaneous device ASD closure LA and RA $\varepsilon_R$ and $SR_R$ were similar to age-matched controls. |
| Boyd *et al*.[90] | 23 ASO devices patients (mean age, 44 y)<br>30 controls | DTI QRS timed | 2008 | 6 mo after percutaneous device closure, LA $\varepsilon_R$, $SR_{CD}$, and $SR_{CT}$ were significantly reduced compared with a control group.<br>No difference in LA mechanics between PFO or ASD patients. |
| **Other clinical conditions** | | | | |
| D'Ascenzi *et al*.[91] | 23 soccer athletes<br>26 controls | 2D ST QRS timed | 2011 | No significant difference in LA εR between soccer players and controls, but LA εCT was lower for athletes. |
| Leong *et al*.[92] | 100 TEE patients | 2D ST QRS timed | 2013 | Good correlation between LA $\varepsilon_R$, $SR_R$, $\varepsilon_{CT}$, and $SR_{CT}$ and transesophageal echocardiographic assessed LA appendage emptying velocity and spontaneous echocardiographic contrast.<br>LA mechanics had the highest accuracy to predict LA spontaneous contrast. |
| Karabay *et al*.[93] | 153 ischemic stroke patients | 2D ST QRS timed | 2013 | In ischemic stroke sinus rhythm patients, LA $\varepsilon_R$ and $\varepsilon_{CT}$ were predictors of LAA thrombus. |
| Mondillo *et al*.[94] | 83 HTN patients<br>34 diabetic patients<br>38 HTN + diabetic patients<br>36 controls | 2D ST QRS timed | 2011 | LA $\varepsilon_R$, LA $\varepsilon_{CD}$, LA $\varepsilon_{CT}$, $SR_R$, and $SR_{CD}$ were lower in patients with HTN or diabetes than in controls, and further reduced in patients with diabetes and HTN. All patients had nondilated left atria (LAVI < 28 mL/m$^2$). |
| Motoki *et al*.[26] | 127 patients | 2D ST QRS timed<br>VVI QRS timed | 2012 | Good agreement for LA mechanics assessed with VVI (Siemens) and 2D ST (GE) software technologies, especially for $\varepsilon_{CT}$ and $SR_{CT}$. |

Vieria MJ et al J Am Soc Echocardiogr 2014

# Do left atrial strain and strain rate reflect intrinsic atrial function or are they determined by left ventricular function?




LA deformation strongly reflects LV deformation both in asymptomatic subjects and in patients with LV dysfunction. discriminating intrinsic LA function from LV influence is difficult using deformation analysis

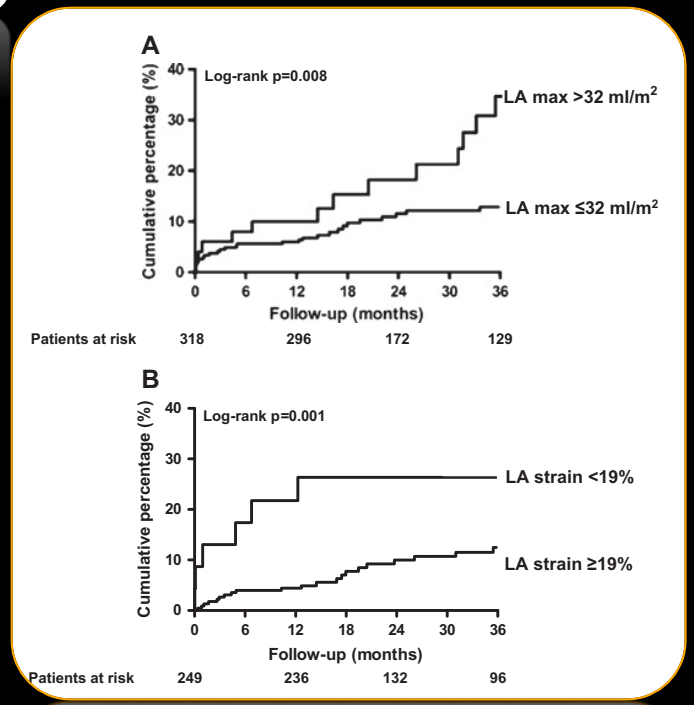
# LA Function and Prognosis

Left atrial strain is related to adverse events in patients after acute myocardial infarction treated with primary percutaneous coronary intervention

M Louisa Antoni, Ellen A ten Brinke, Jael Z Atary, Nina Ajmone Marsan, Eduard R Holman, Martin J Schalij, Jeroen J Bax, Victoria Delgado

Cox univariable predictors for the composite endpoint

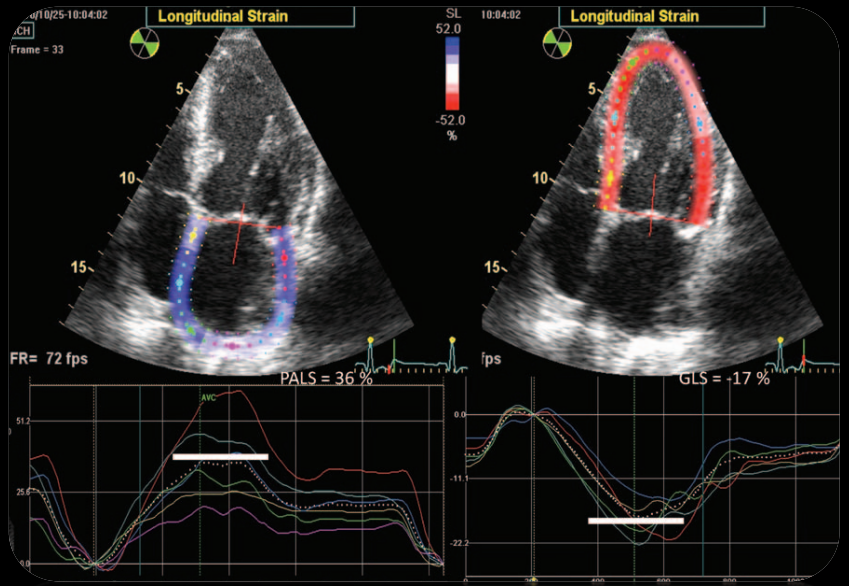
| | HR | 95% CI | p Value |
|---|---|---|---|
| Clinical information | | | |
| Age (years) | 1.04 | 1.01 to 1.07 | 0.006 |
| Killip ≥2 | 3.64 | 1.92 to 6.88 | <0.001 |
| Infarct characteristics | | | |
| Multivessel disease | 2.69 | 1.44 to 5.02 | 0.002 |
| Peak creatine phosphokinase level (per 100 U/l) | 1.02 | 1.01 to 1.03 | <0.001 |
| Peak cardiac troponin T level (μg/l) | 1.07 | 1.04 to 1.09 | <0.001 |
| LV function | | | |
| LV ejection fraction (%) | 0.95 | 0.92 to 0.99 | 0.01 |
| Wall motion score index | 8.9 | 3.1 to 25.8 | <0.001 |
| E/A ratio | 3.1 | 1.4 to 7.0 | 0.005 |
| E/E′ ratio | 1.07 | 1.01 to 1.14 | 0.03 |
| Moderate or severe mitral regurgitation | 3.3 | 1.5 to 7.1 | 0.002 |
| LA function | | | |
| LA max (ml/m$^2$) | 1.05 | 1.02 to 1.08 | 0.004 |
| LA total ejection fraction (%) | 0.96 | 0.93 to 0.98 | 0.001 |
| LA active emptying fraction (%) | 0.96 | 0.94 to 0.99 | 0.005 |
| LA reservoir function (%) | 0.99 | 0.99 to 0.99 | 0.004 |
| LA strain (%) | 0.93 | 0.89 to 0.97 | <0.001 |
| LA strain rate (per second) | 0.42 | 0.23 to 0.79 | 0.006 |

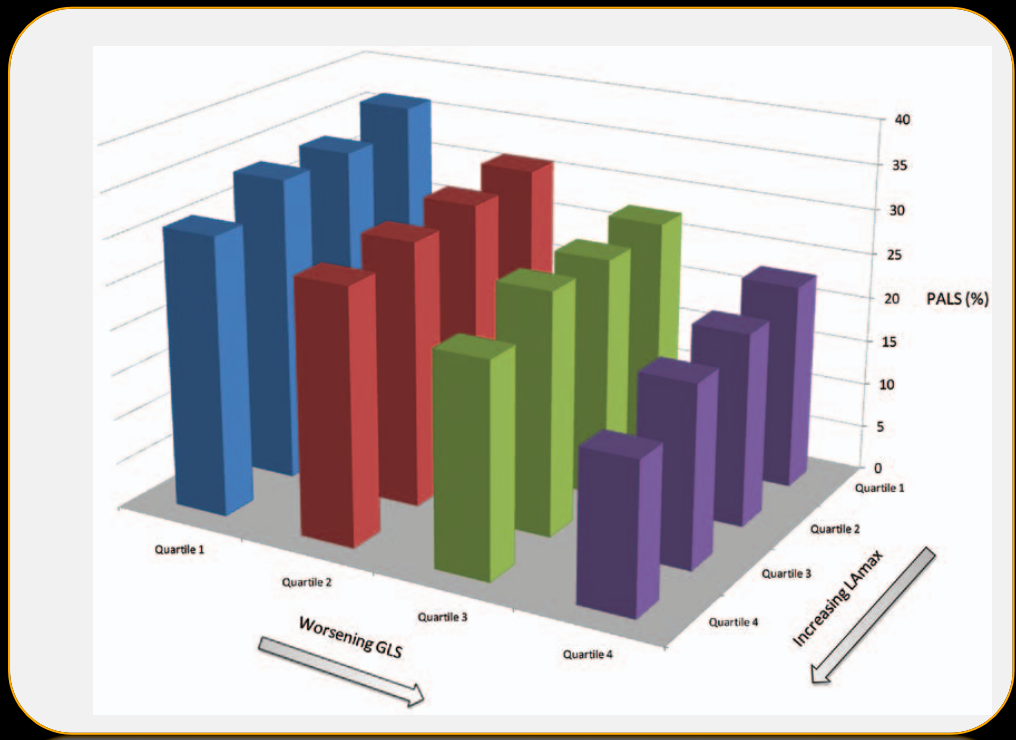



Antoni ML, et al. Heart 2011

# Effect of LV dysfunction on LA function

Prognostic Value of Left Atrial Peak Reservoir Strain in Acute Myocardial Infarction

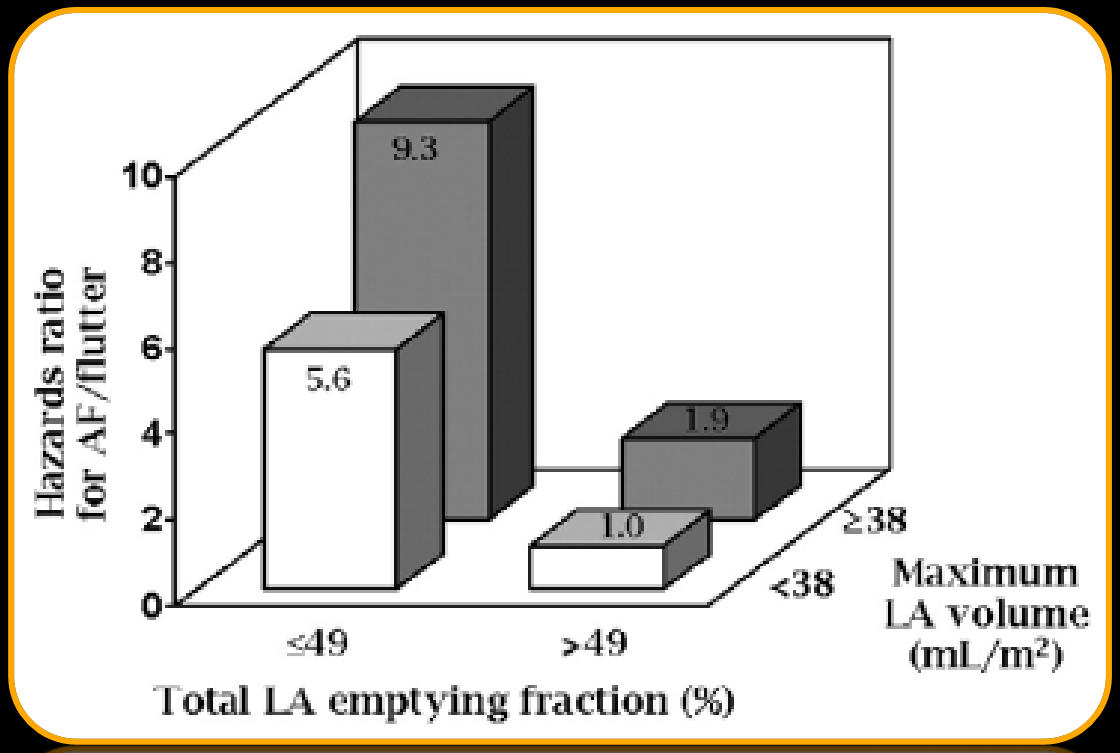



Ersbøll et al *Circ Cardiovasc Imaging*. 2013

# LA Function and Prognosis

***Reduced total LA emptying fraction linked to increased risk for first episode of atrial fibrillation in the elderly population***




Abhayaratna WP et al. Am J Cardiol 2008

# The Pseudorestrictive Pattern of Transmitral Doppler Flow Pattern after Conversion of Atrial Fibrillation to Sinus Rhythm: Is Atrial or Ventricular Dysfunction to Blame?

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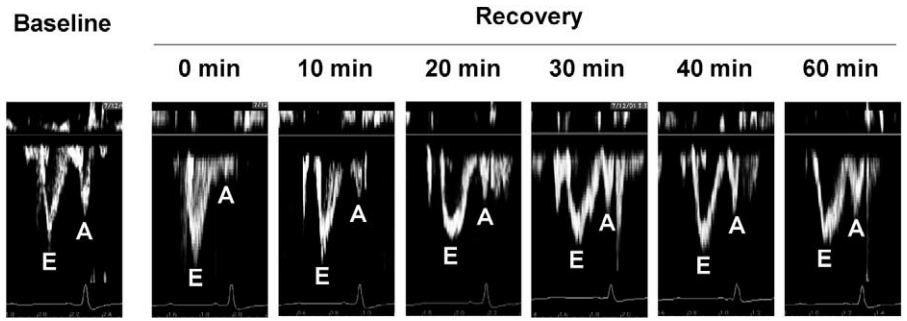
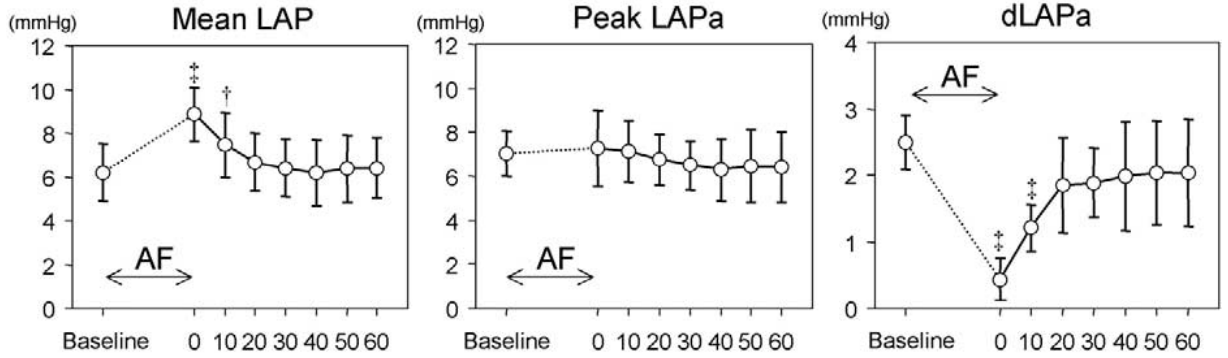
*Cleveland, Ohio*




**Recovery of LA Pressure and Function After 3 Hours of Pacing-Induced AF**




Yamada et al. J Am Soc Echocardiogr 2004

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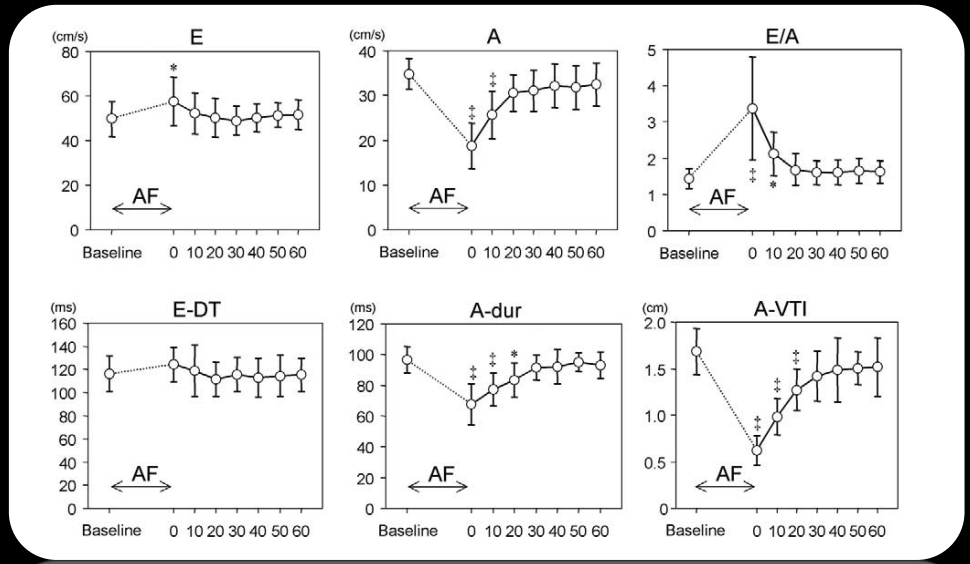
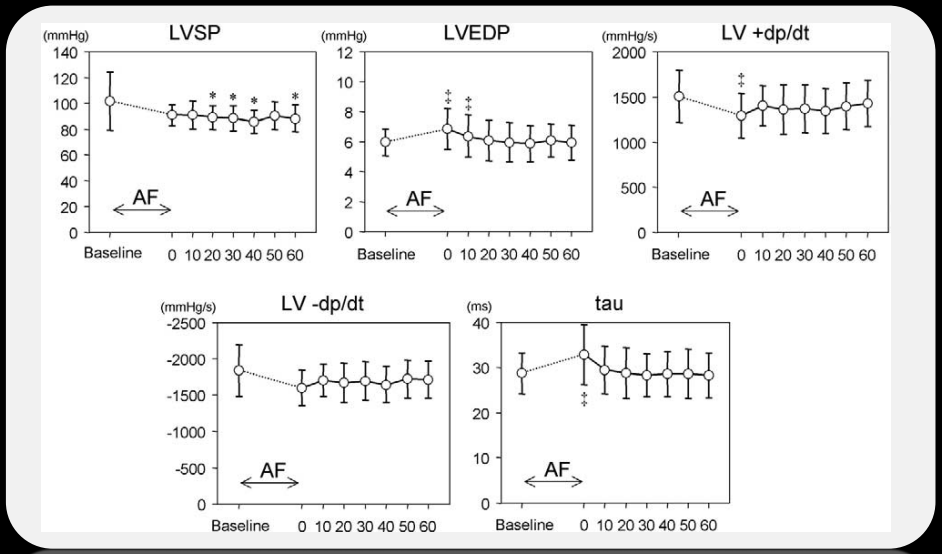
## Recovery of Transmitral Flow After 3 Hours of Pacing-Induced AF



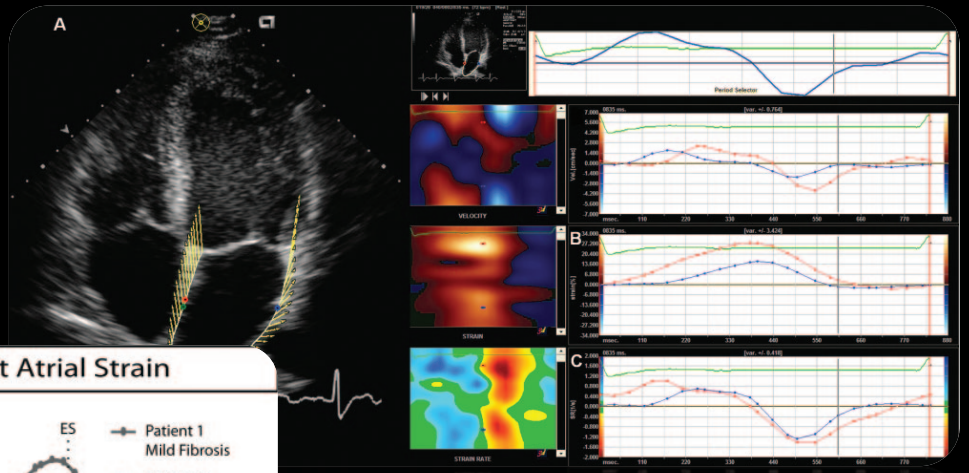

## Recovery of LV Function After 3 Hours of Pacing-Induced AF

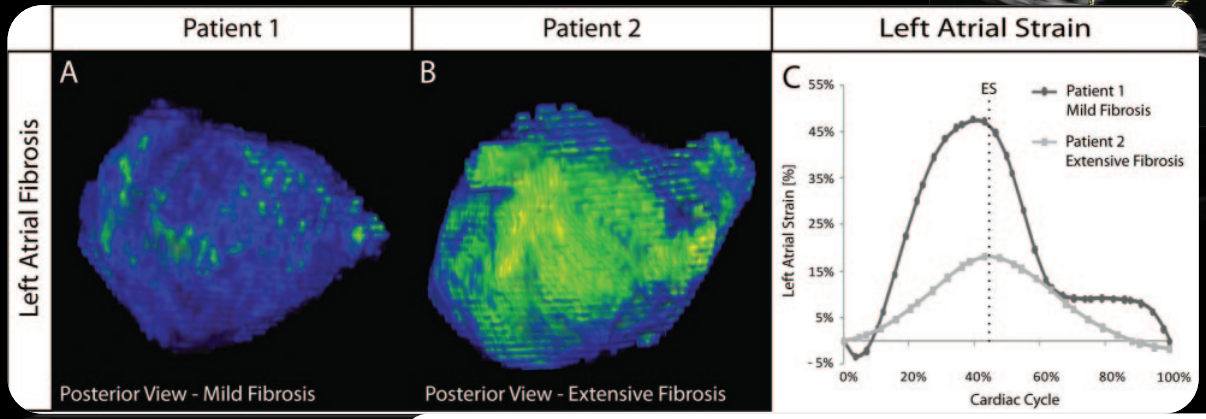



Yamada et al. J Am Soc Echocardiogr 2004

# Left atrial strain in patients with atrial fibrillation

## Relationship to left atrial structural remodeling detected by delayed-enhancement MRI



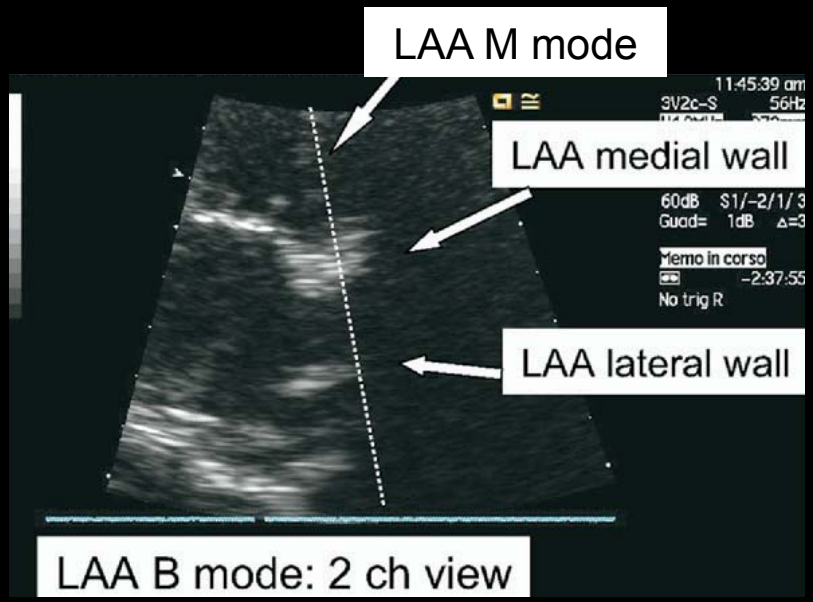

| Predictors of LA Fibrosis | *r* Value | *P* Value |
|---|---|---|
| 1. Midseptal LA strain | −0.1 | 0.5 |
| LA biplane volume index | 0.4 | 0.02 |
| 2. Midlateral LA strain | −0.5 | 0.006 |
| 3. Midseptal LA strain rate | −0.5 | 0.003 |
| 4. Midlateral LA strain rate | −0.4 | 0.01 |

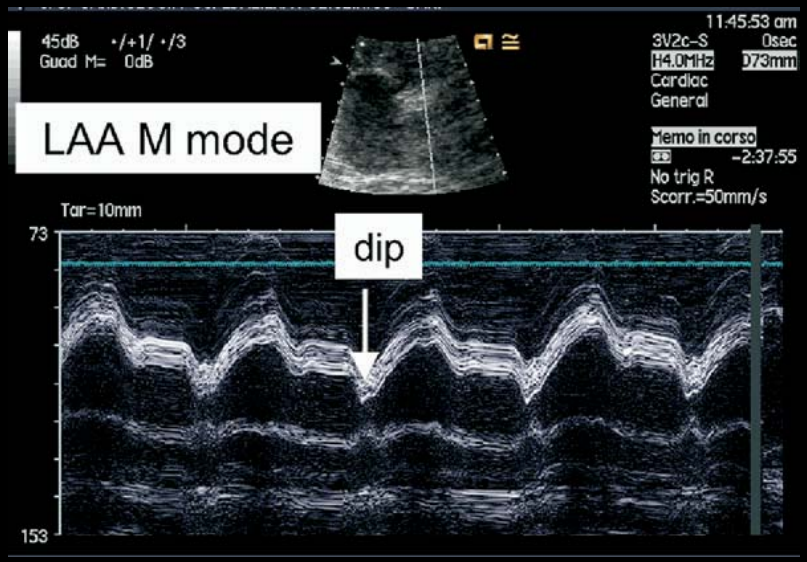
Kuppahally et al Circ Cardiovasc Imaging 2010

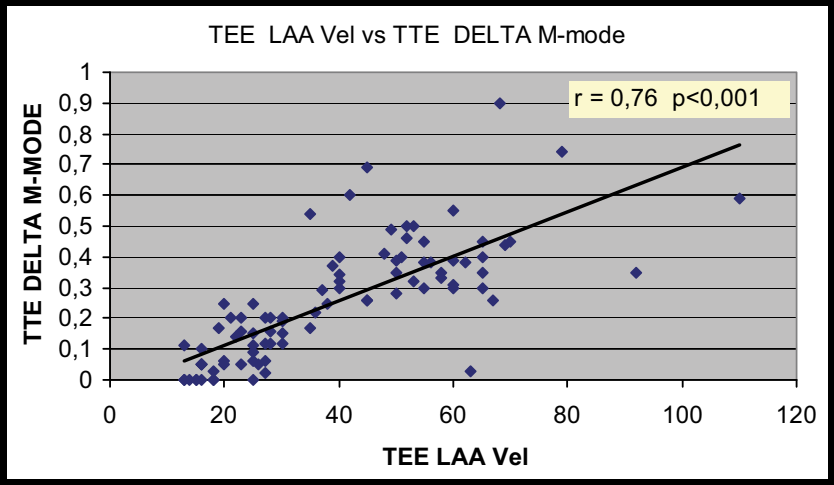
# Atrial Strain evaluation

- *Global atrial strain*
  - stricltly reflect LV longitudinal function
  - impact of the anchoring provided by the pulmonary veins
  - does not assess the differences on LA geometry
  - non inclusion of LA appendage in the analysis
- *Left atrial appendage function*
  - Marker for LA systolic potential

# TTE for LAA function evaluation

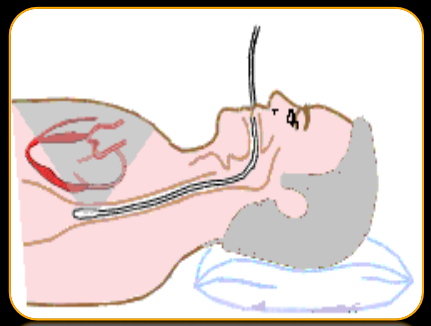


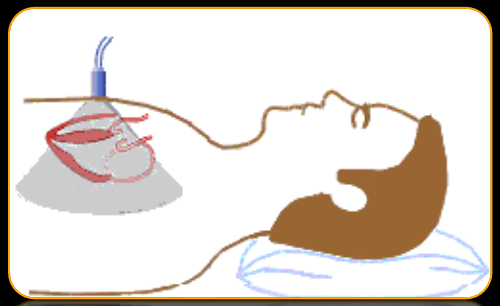



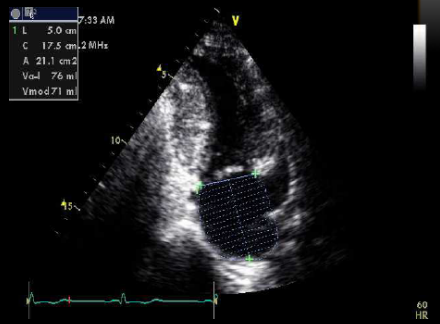



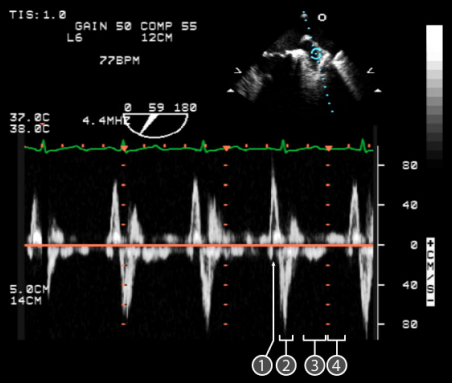

De Luca , Colonna P, et al J Am Soc Echocardiogr. 2007

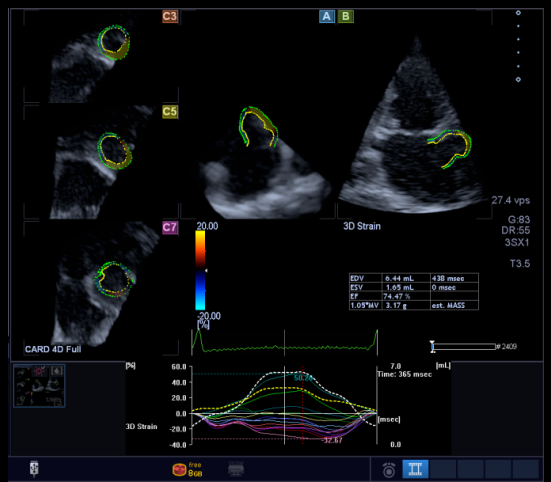
# LAA function - TTE 3D vs TEE pwd

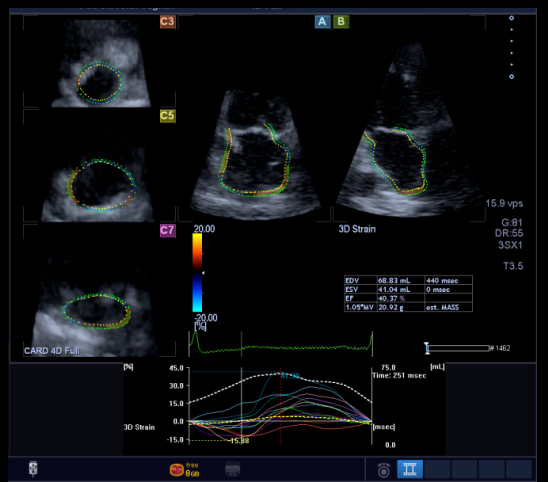




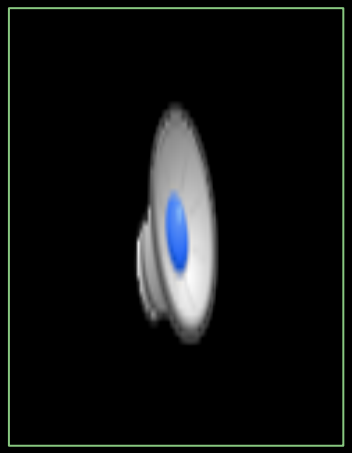




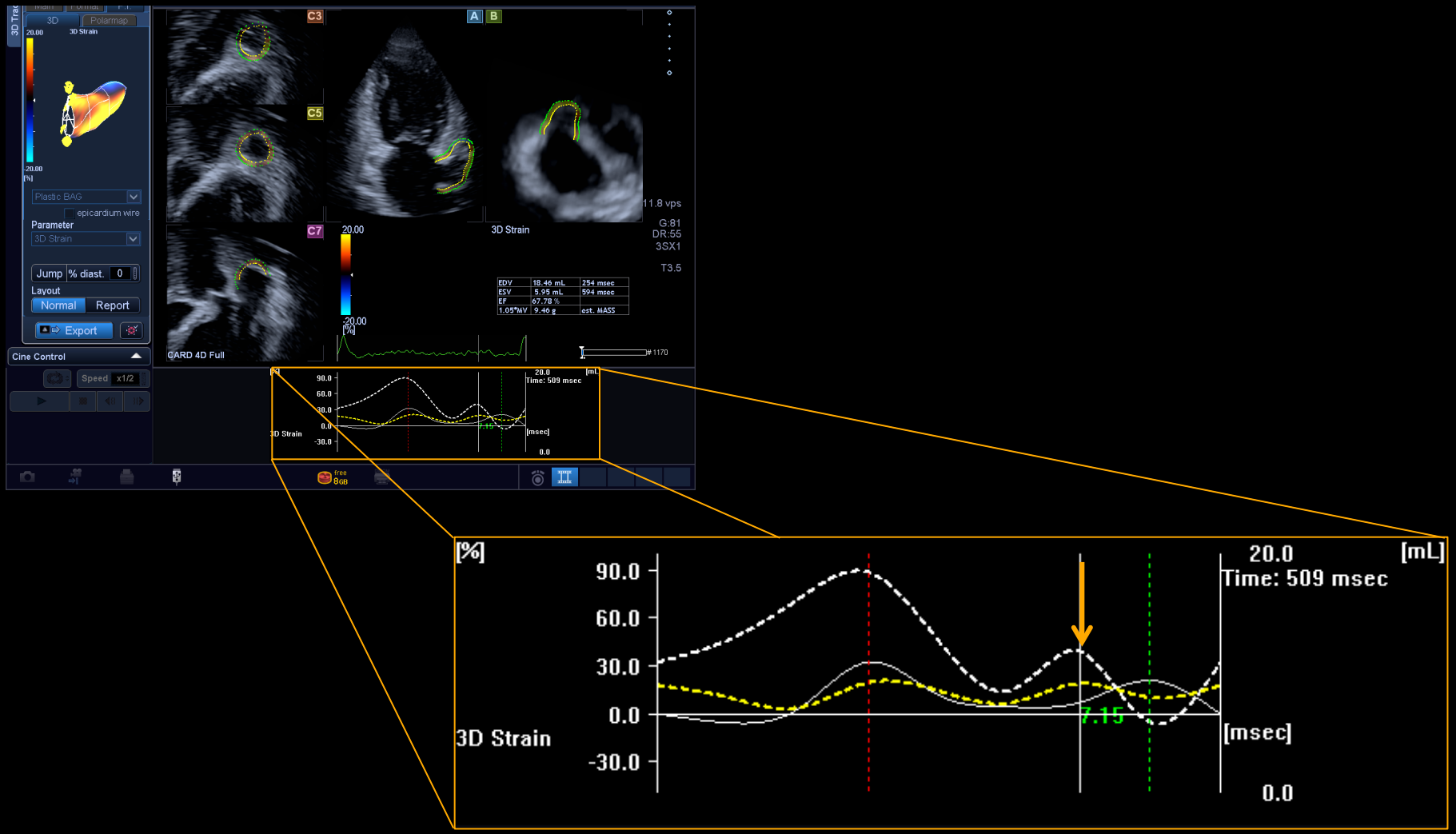



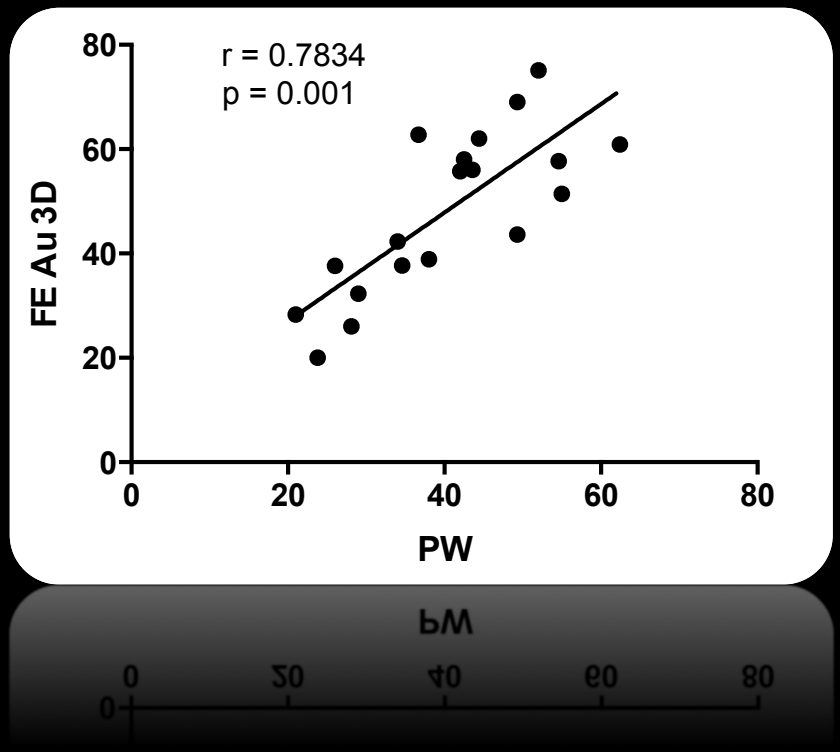
# LAA Function – TT 3D Echocardiography

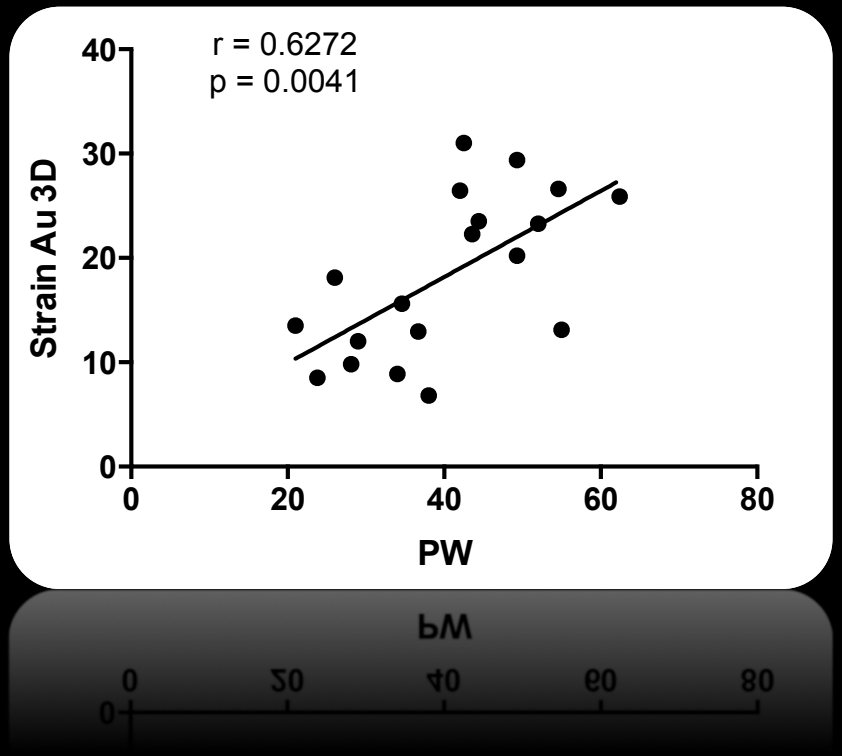


# LAA Function – TT 3D Echocardiography



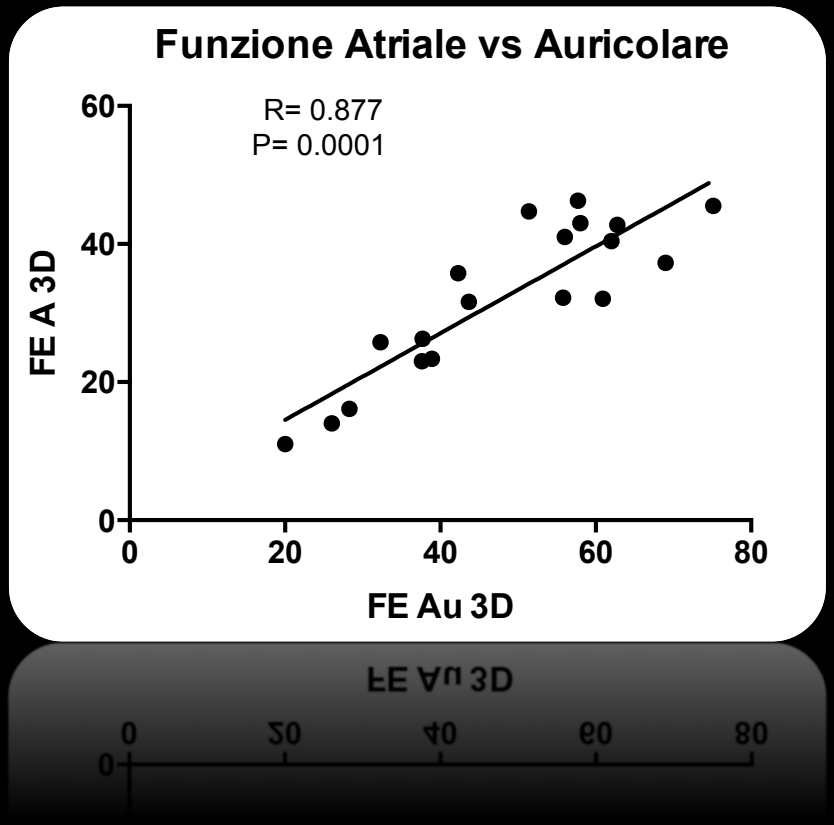
# LAA function - TTE vs PW TEE

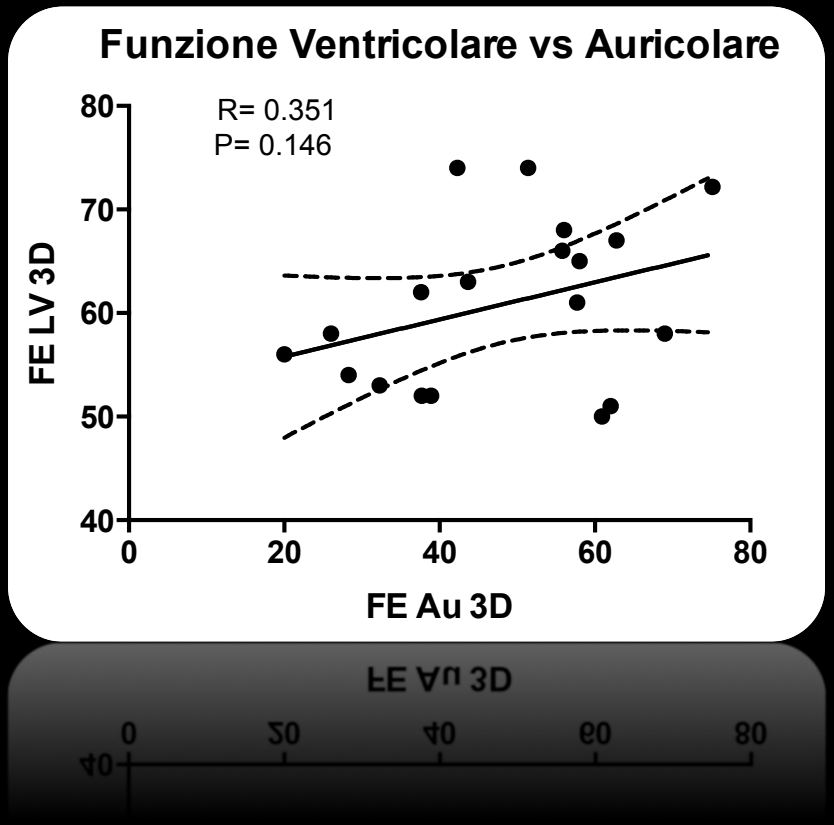



Cadeddu et al data not pblished

# LAA function – LA vs LV




Cadeddu et al data not pblished

# Conclusions

- Many authors have used STE to identify changes in LA longitudinal S and SR in different cardiac diseases.
- Results often reflect known alterations of LV longitudinal S and SR in these conditions
- LA reservoir function is dependent on LA dimensions but also on LV longitudinal deformation, indicating that LA ε is a reflection of LV longitudinal ε and LA dilation and not a measure of LA intrinsic functional properties
- LA pump function better reflects LA intrinsic contractility
- LAA function could be used as a Marker for LA systolic potential