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DEPARTMENT OF NONINVASIVE CARDIOVASCULAR IMAGING AND FUNCTIONAL DIAGNOSTIC

The Impact of Arterial Hypertension on Right Ventricular Deformation

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- Conflicts: None

Why we should measure the RV function ?

- RV function may be impaired from :

- PAH
- Acute/ chronic PE
- CHD
- Valvular heart diseases
- LV dysfunction
- Secondary from coronary heart diseases, cardiomyopaties
- AH

Why we should measure the RV function?

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- RV is not just a conduit of blood flow
  : has its unique function
- Prognostic significance in various clinical settings
- Risk stratification or guide to optimal therapy

RV function and prognosis

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- **RV ejection fraction: an indicator of increased mortality in patients with CHF associated with CAD**

  (Polak et al. J Am Coll Cardiol 1983)

- **RV function predicts exercise capacity and survival in advanced heart failure**

  (Di Salvo et al. J Am Coll Cardiol 1983)

- **RV function is a crucial determinant of short-term prognosis in severe chronic heart failure**

  (Gavazzi et al. J Heart Lung Transplant 1997)

RV function and prognosis

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- **RV ejection fraction: independent predictor of survival in patients with moderate heart failure**

  (De Groote et al. J Am Coll Cardiol 1998)

- **RV function predicts prognosis in patients with chronic pulmonary disease**

  (Burgess et al. J Am Soc Echocardiogr 2002)

- **RV contractile reserve is associated with one year mortality in patients with DCMP**

  (Otasevic et al. Eur J Echocardiography 2005)

European Journal of Echocardiography (2010) **11**, 81–96
doi:10.1093/ejechocard/jep234

REVIEW PAPER

The echocardiographic assessment of the right ventricle: what to do in 2010?

Ruxandra Jurcut[1]*, Sorin Giusca[1,2], André La Gerche[2], Simona Vasile[1], Carmen Ginghina[1], and Jens-Uwe Voigt[2]

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For many years, the echocardiographic quantitative assessment of right ventricular (RV) function has been difficult owing to the complex RV anatomy. Identifying an accurate and reliable echocardiographic parameter for the functional assessment of the RV still remains a challenge. The review presents a summary of the most studied and presently used parameters of RV function, with their reported normal values, as well as advantages and limitations of use. Combinations of these parameters are used in daily clinical practice, each one offering only partial information about the status of the RV. Myocardial velocity and strain rate imaging have promising results in the assessment of RV function. There is hope that novel myocardial deformation parameters and three-dimensional echocardiography-derived parameters may add value to the examination of the RV, but validation studies are still needed.

Keywords Right ventricle • Echocardiography • Tissue Doppler • Strain rate imaging • 3D echocardiography

Doppler Echocardiography: Tissue Doppler Imaging

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- Allows quantitative assessment of RV systolic and diastolic function by measurement of myocardial velocities

- Peak systolic velocity (PSV)
  : PSV < 11.5 cm/s identifies the presence of RV dysfunction
  : Sensitivity of 90%, specificity of 85%
  : Less affected by HR, loading condition, and degree of TR

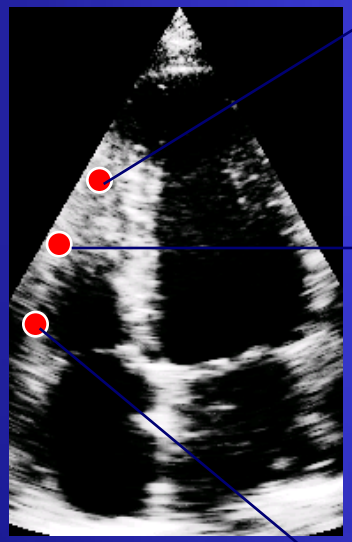
- Tricuspid lateral annular velocities
  : Reduced in patients with inferior MI and RV involvement
  : Associated with the severity of RV dysfunction in patients with heart failure

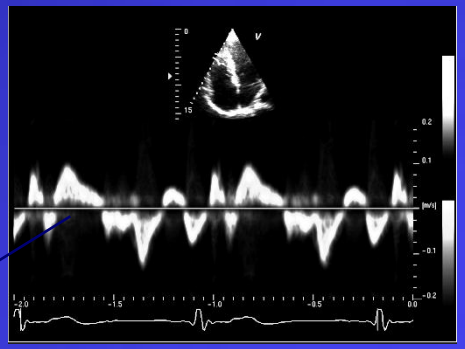
Normal RV Regional Function

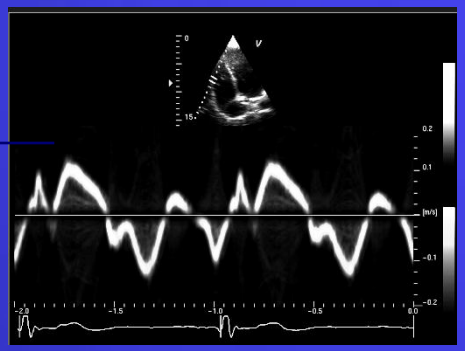
RV longitudinal motion

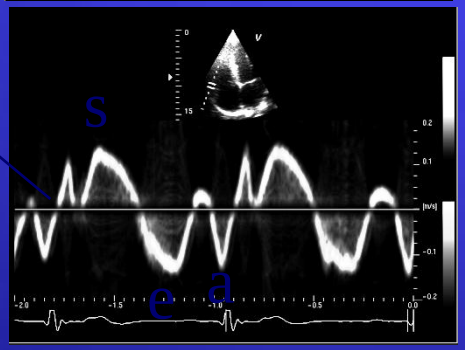
Pulsed Doppler

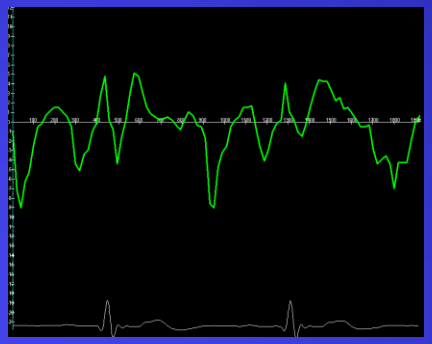
Colour Doppler

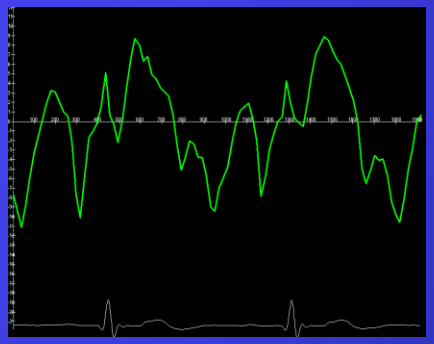


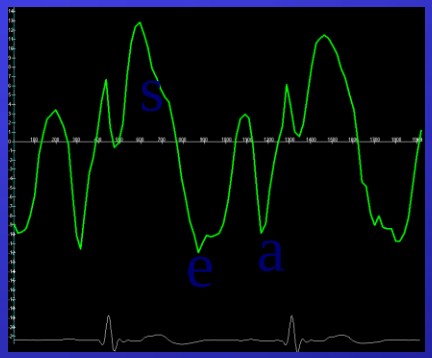


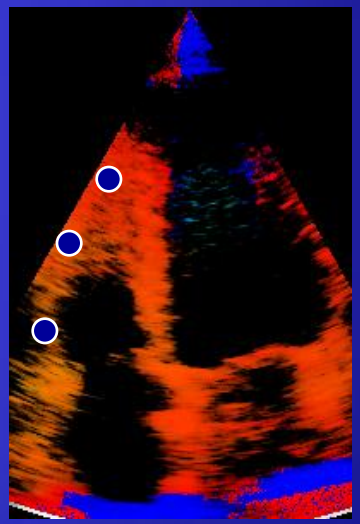










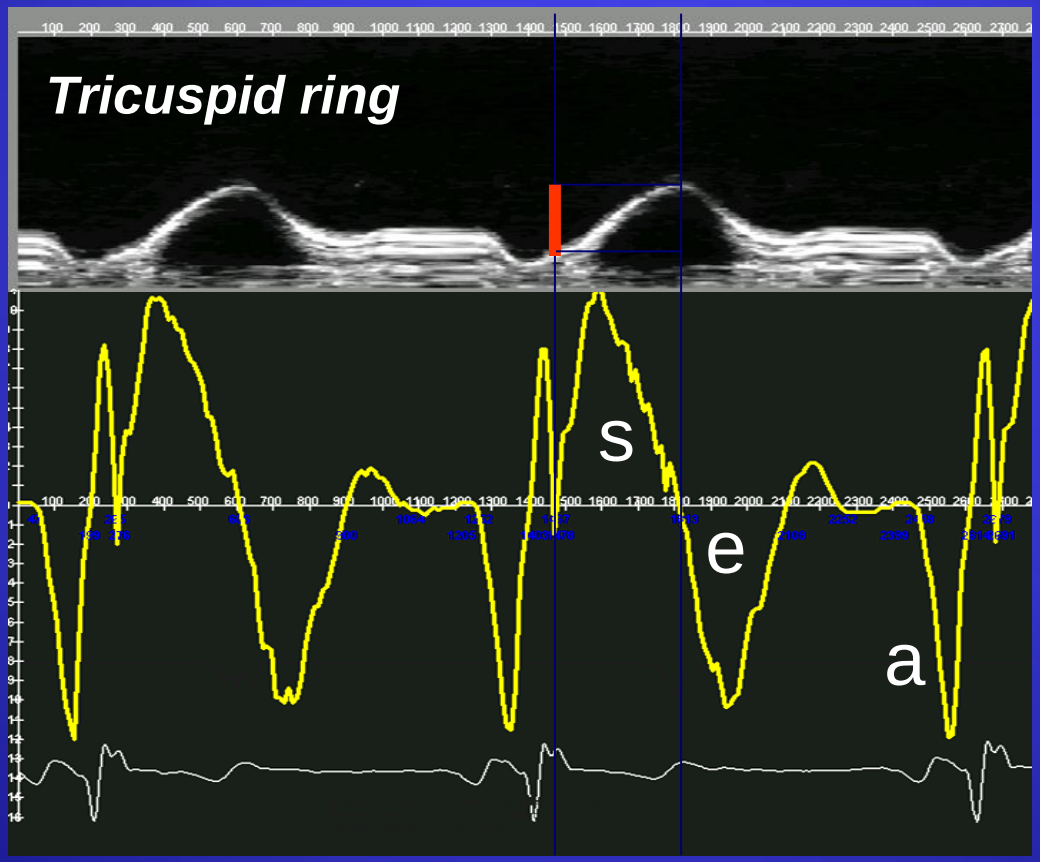


(4CH view)
RV free wall

Normal RV Regional Function

RV longitudinal motion

Systolic ring excursion vs ring velocity



Mmode annular motion

DMI annular velocity

Doppler Echocardiography: Strain Rate Imaging

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- **RV longitudinal strain in apical view**
  - : Feasible in clinical setting
  - : Baso-apical gradient with higher velocities at the base
  - : RV velocities are consistently higher as compared to LV
- **Strain and strain rate values**
  - : More inhomogeneously distributed in the RV
  - : Reverse baso-apical gradient, reaching the highest values in the apical segments and outflow tract
- **Acute increase in RV afterload**
  - : Increase in RV myocardial strain rate
  - : Decrease in peak systolic strain, indicating a decrease in SV

Normal RV Longitudinal Deformation

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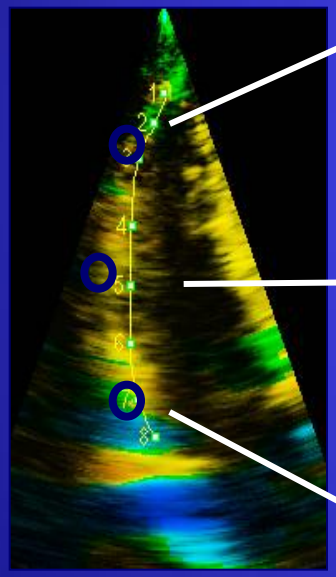
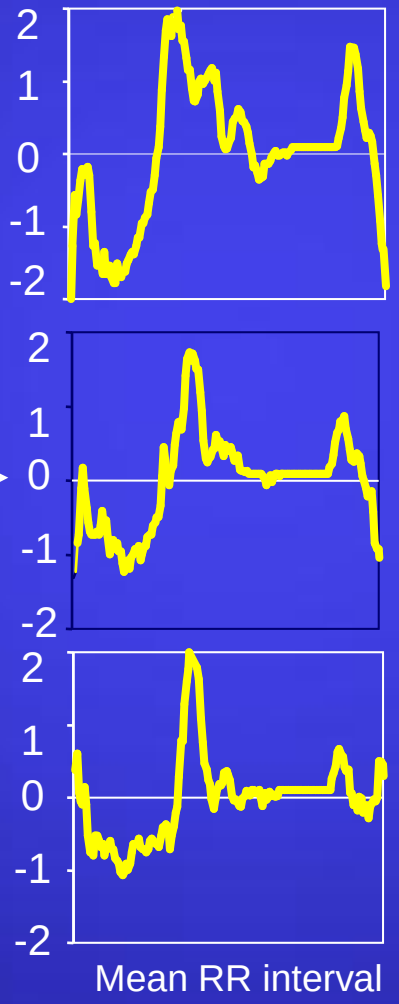
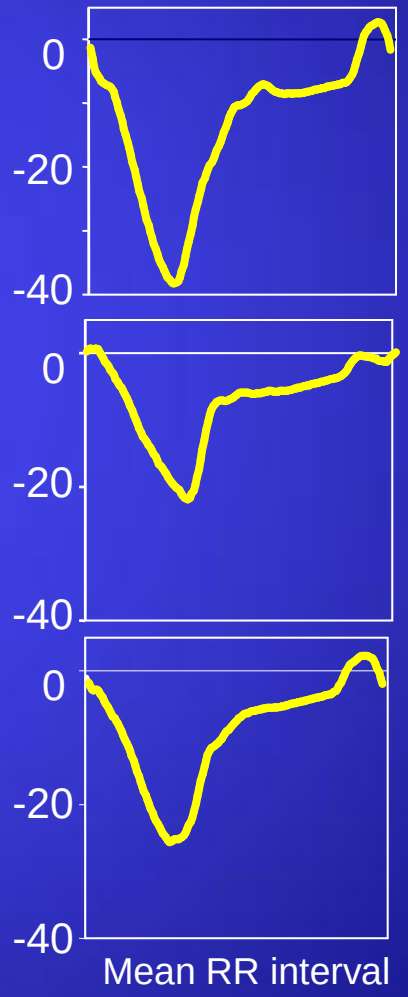


RV lateral wall

Strain rate



Strain



apical

medial

basal

Speckle tracking

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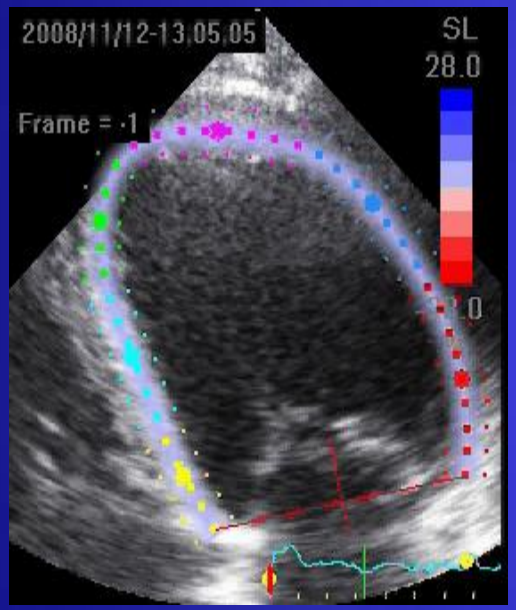
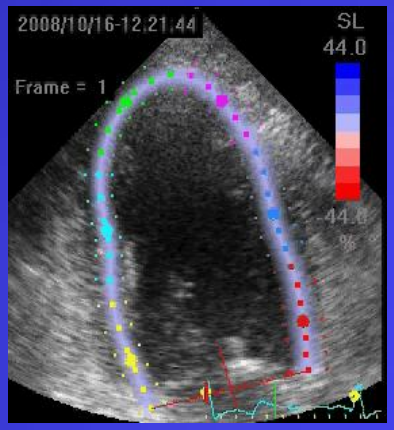
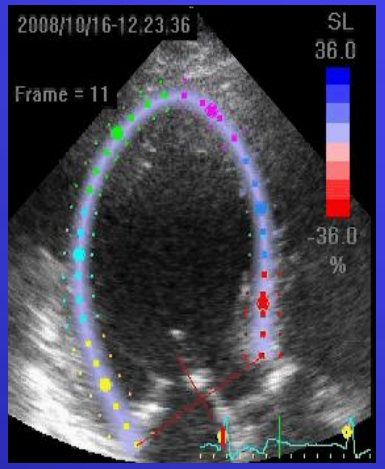
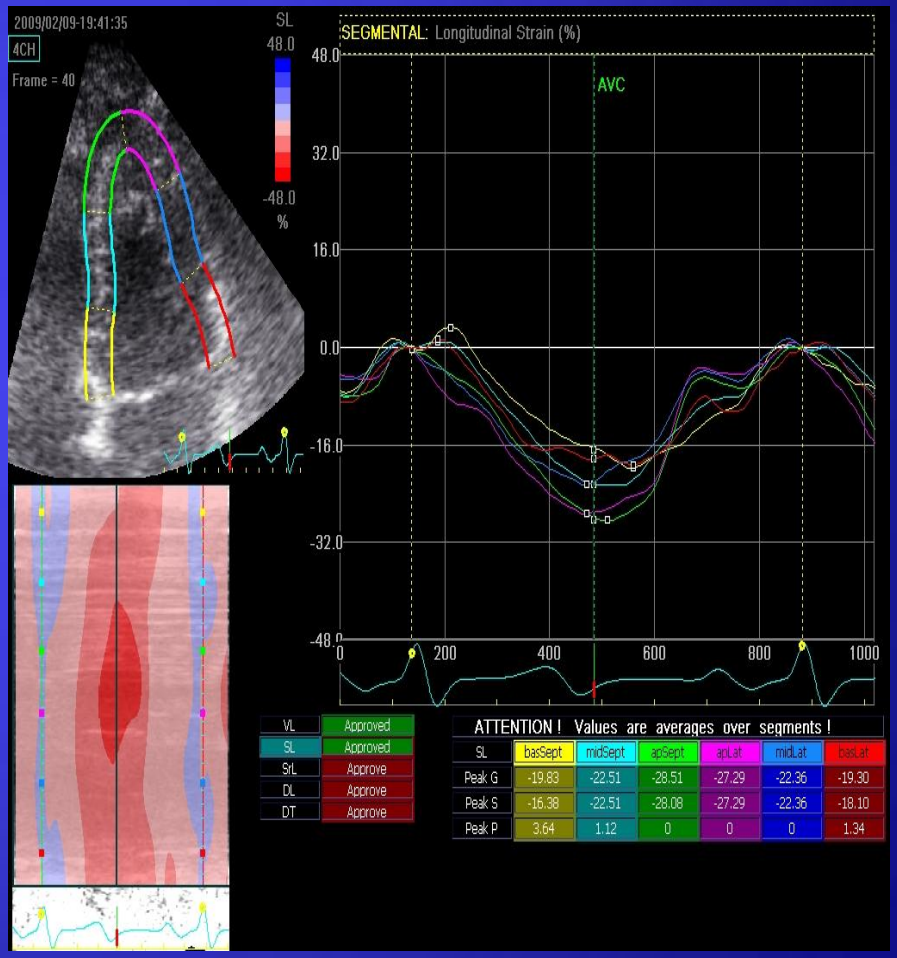








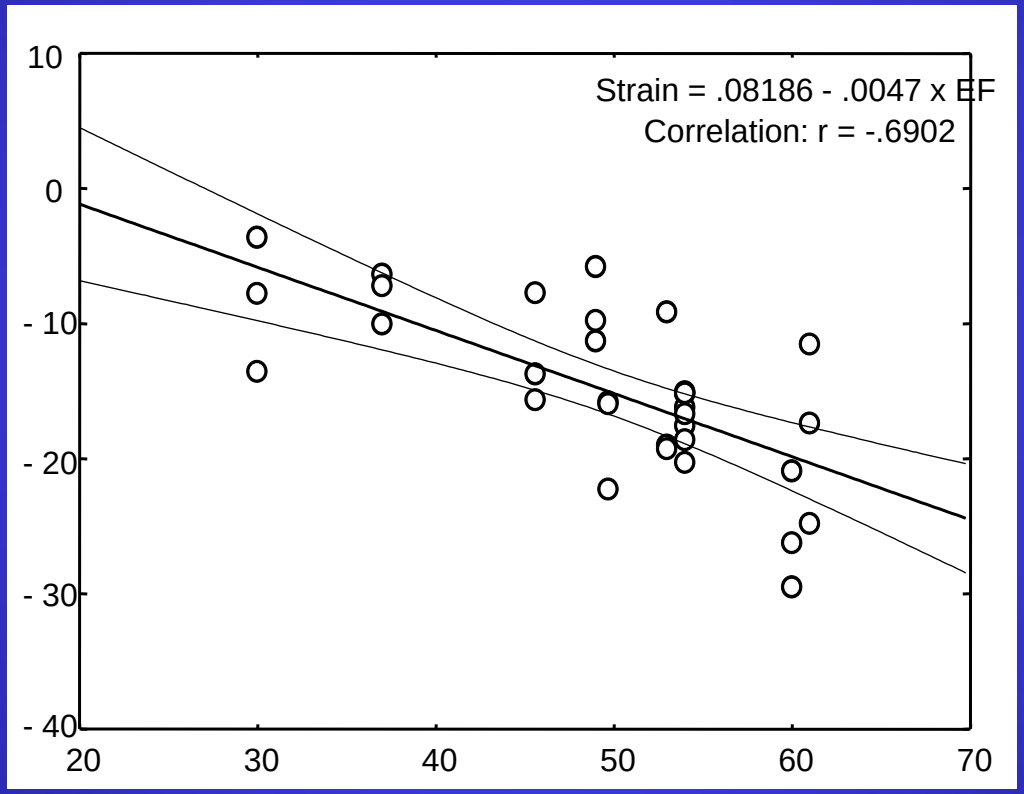
Comparison of Strain values in Different studies

Mean Strain (%)	Augustine et al.(BSE 2009)	Stefani L et al. Cardovasc US 2009	Tong C et al. (2008)	Pirat B at al. Cardiol (2006)	Teske et al. JASE (2008)	Luc Mertens Nature Reviews 2010
RV basal Free wall	-27.817± 5.77 N 109	-28.69± 4.62	-33.802± 7.03	-44.8± 10.2	-22.8± 10.2	-19. ±6
RV Mid Free wall	-27.179± 5.6	-25.21± 4.97	-32.69± 5.9	-26.9± 5.3	-24.4± 7.7	-27. ±6
RV Apical Free wall	-21.568± 7.94		-24.86± 8.15	-28.1± 8.15	-27.6± 6.7	-36+2

Basal to apical reduction in strain

Apiacal to basal reduction in strain

RV Global Function vs EF

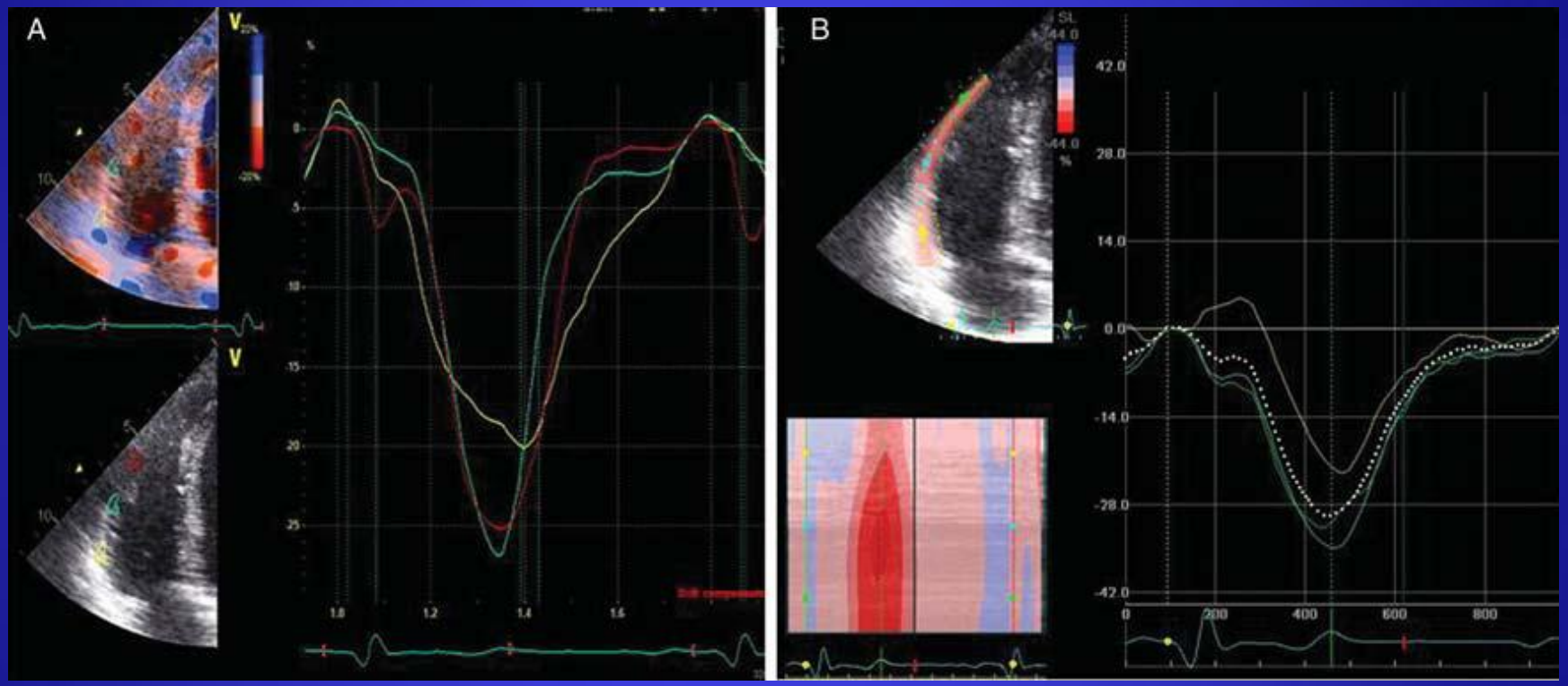


Longitudinal RV systolic strain - %

RV ejection fraction -% (MRI)

F. Rademakers JACC, 2000

DTI vs. STE

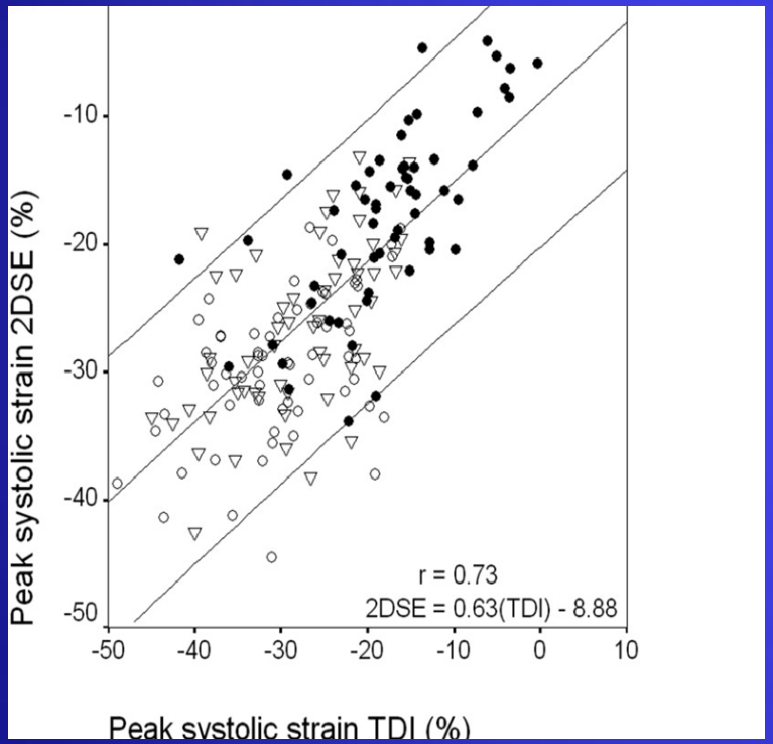


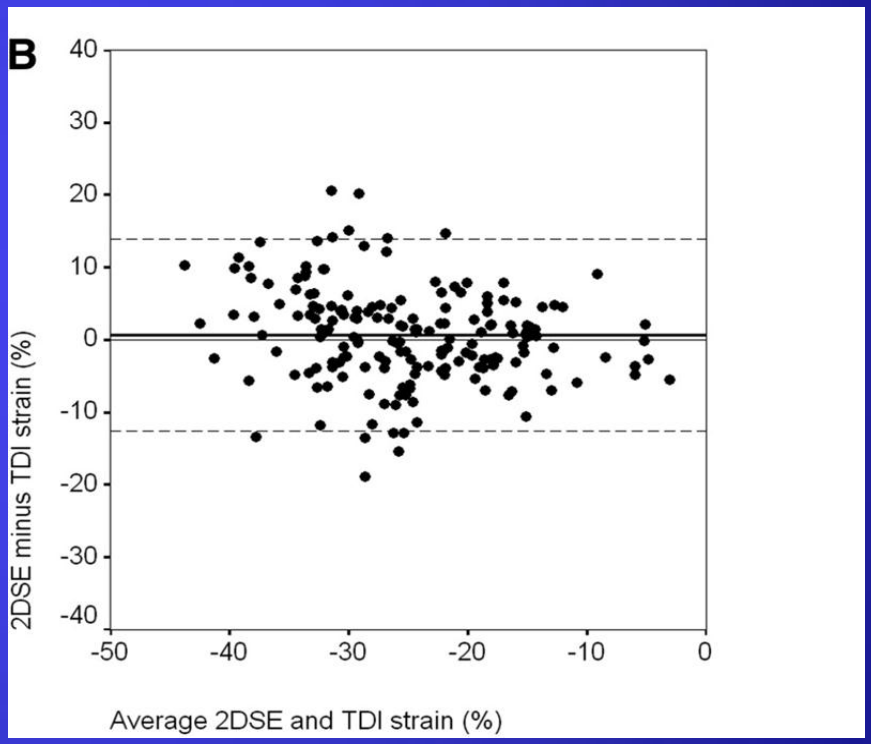
A. TDI – derived strain

B. STE derived strain

Jurcut R et al. *Eur.J.of Echo , 2, 2010*

Comparison between 2D strain and TDI

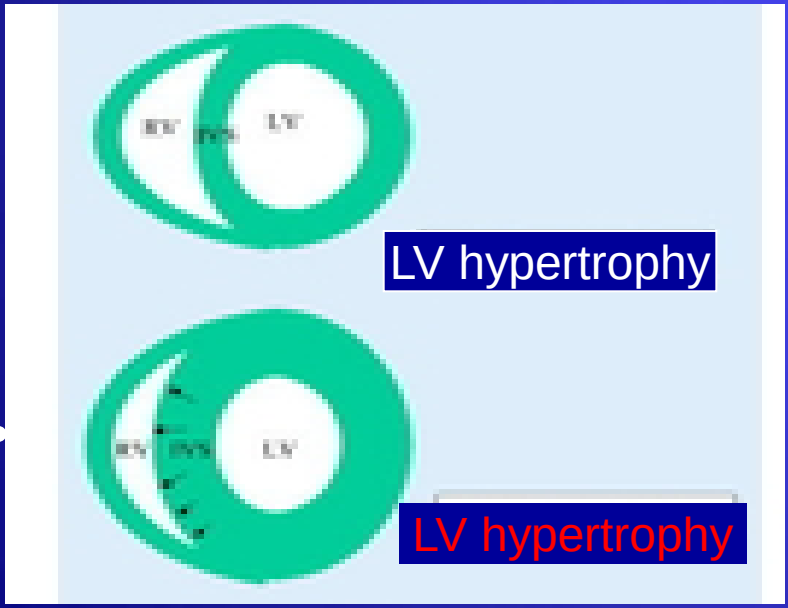




Teske . JASE 2008

RV function and AH

- RV performance in hypertensive's in not well evidenced
- Bernheim's syndrome *(Selzer,1955, Russek 1950)*



↑ *peripheral venous pressure*
↑*RA pressure*

RIGHT HEART FAILURE

RV function and AH

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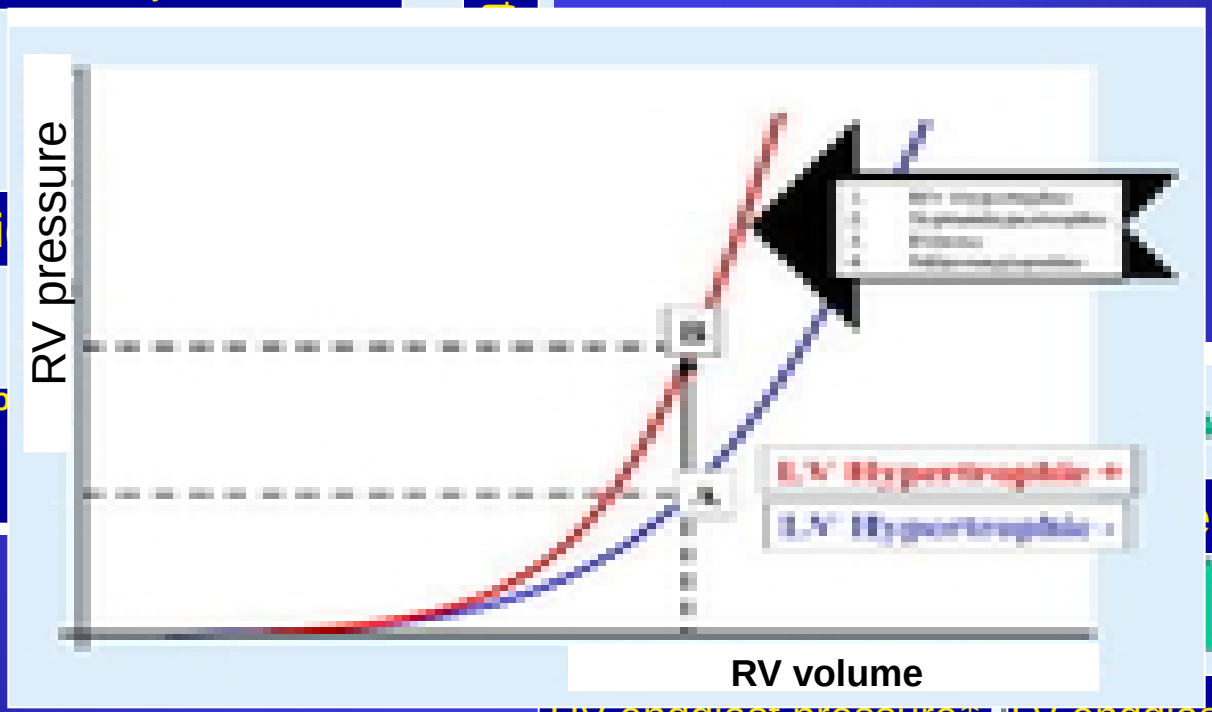
LV hypertrophy ,LV pressure
LV diastolic dysfunction

RV-LV interrelationship

Ri

Pulmo
Enhanced



ssure ↑

RV enddiast pressure↑

LV enddiast. pressure ↑

RV hypertrophy
RV diastolic dysfunction

LV hypertrophy
LV diastolic dysfunction

W. Motz. Internist,2004

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RV function and AH

- RV EF % in hypertensive's with LVH is higher than without LVH

(Olivari, Circulation,1978)

- Hypertensive pts have higher RV pressure than normal's and RV performance is lower RV EF %

(J. Ferlinz, Circulation,1980)

- Invasive studies showed the pathology of pulmonary circulation in pts with AH

(*R. Fagard, JACC,1998)*

- *MRI study of RV remodelling in systemic hypertension*

(Pedrinelli, Heart, July 2011)

RV function and AH

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- **Echocardiographyc studies** *(Myslinski, 1998, Akkos1999) about RV function and diastolic parameter*
- AH is associated to RV longitudinal diastolic dysfunction – pulsed TDI imaging

  (S. Cicala, EJEcho, 2002)
- TDI provide quantitative analysis of RV alteration in hypertensive's

  (Tumuklu, AJE, 2007)
- Abnormal RV mechanic of IVS in hypertensive’s

  (R. Pedrinelli , EJ Echo , 2010)

SCIENTIFIC PROGRAMME ONLINE
EUROECHO 2010
8-11 DECEMBER
COPENHAGEN - DENMARK

The impact of arterial hypertension on right ventricular deformation

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[2]Catholic University of Leuven - Leuven - Belgium

- First STE study with hypertensive patients

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Purpose :

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- HT has long been known to be a major risk factor for heart failure .
- The Framingham study provides some of the best evidence with regard to the association between BP and HF. Around 90% of those developing HF had aprior history of HT. This is three times the risk seen in normotensives.
- HT is the most important modifiable factor in congestive cardiac failure. However, almost 40% of episodes are associated with diastolic dysfunction.
- Diastolic dysfunction ranges from a failure of end diastolic volume to rise appropriately with exercise to that of overt diastolic HF

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Aim:

The aim of our study was to determine the effect of arterial hypertension and hypertensive cardiac remodelling on right ventricular (RV) function, using vector velocity echocardiography to determine strain and strain rate.

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Methods:

- **40 patients** with arterial hypertension and left ventricular hypertrophy (LVH group) with **20 healthy control subjects**.
  None of the hypertensive patients had symptomatic heart failure.

- Apical four-chamber images were acquired (frame rate 74 ± 6 frames/s) with Aloka alfa- 10 and analyzed offline on Syngo US Workplace 2007, Siemens AG . in order to extract the strain (rate) curves.

- From these, the maximal systolic strain (PSS) and peak strain rate (PSR) on right and left ventricle were derived, using vector velocity imaging (VVI) software. Tricuspid annular plane systolic excursion (TAPSE) and as well as mid-apical and basal peak ejection strain (S) and strain rate (SR) of the RV free wall were measured

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2DSTE

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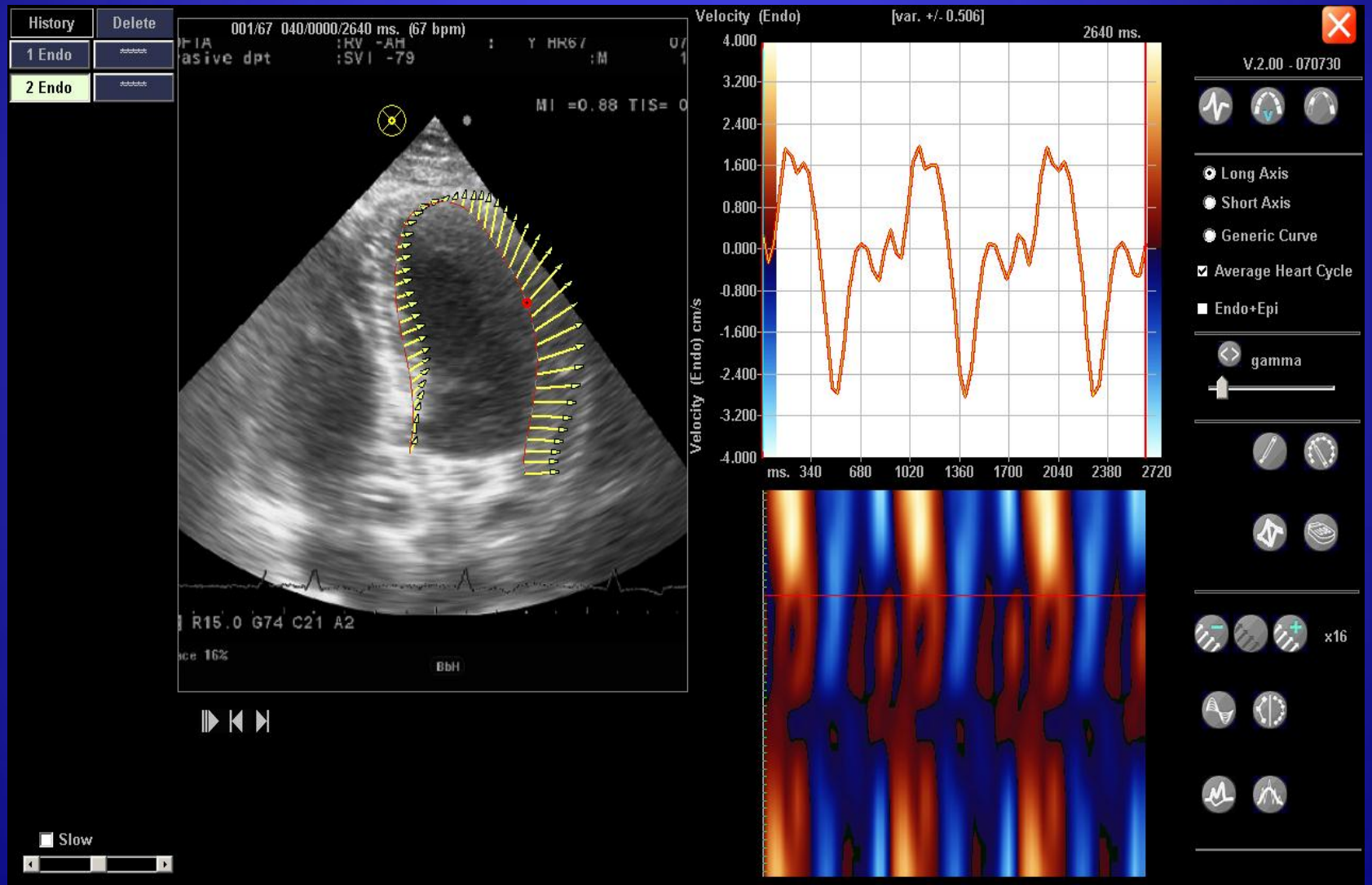

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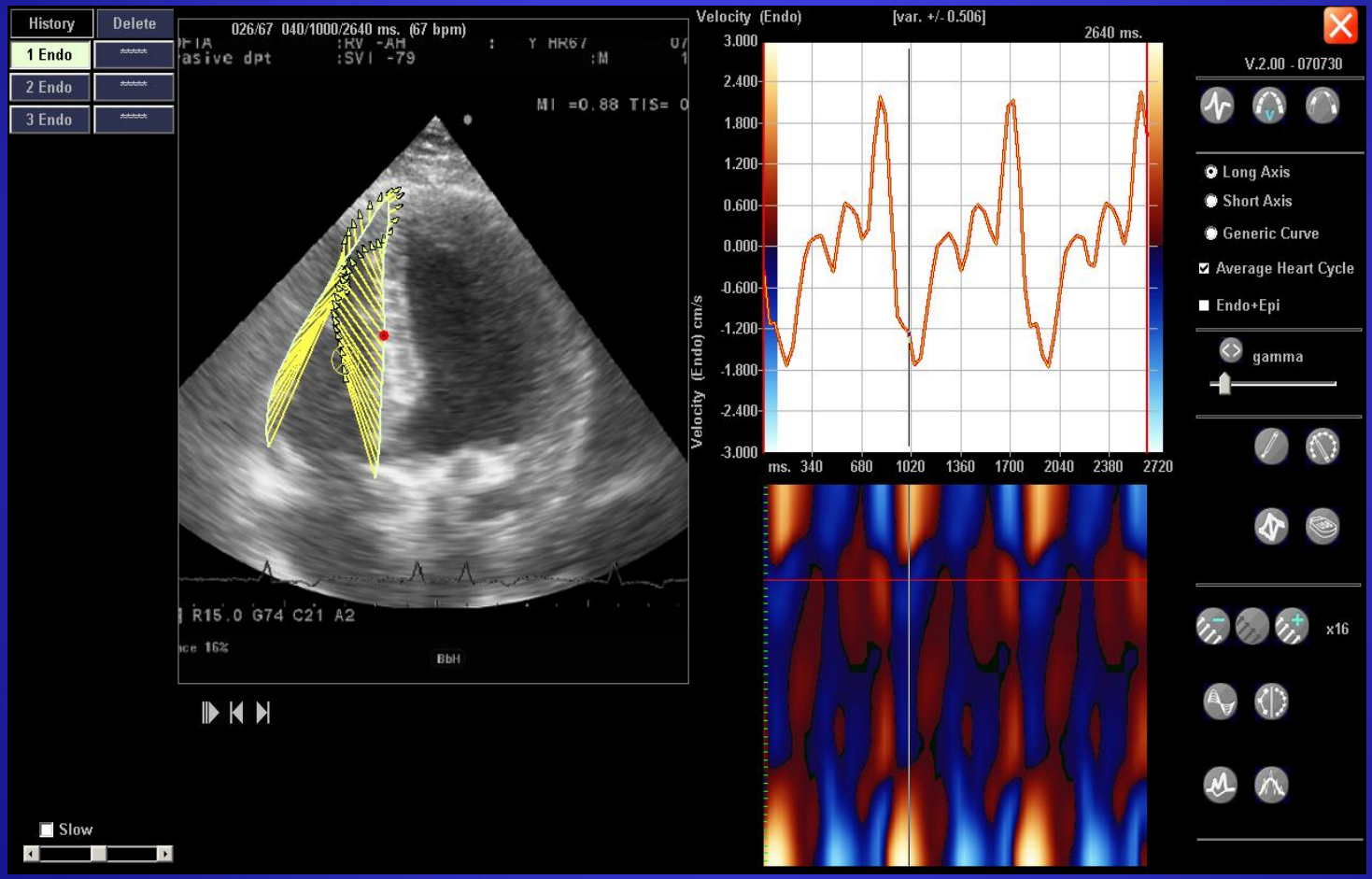
2DSTE



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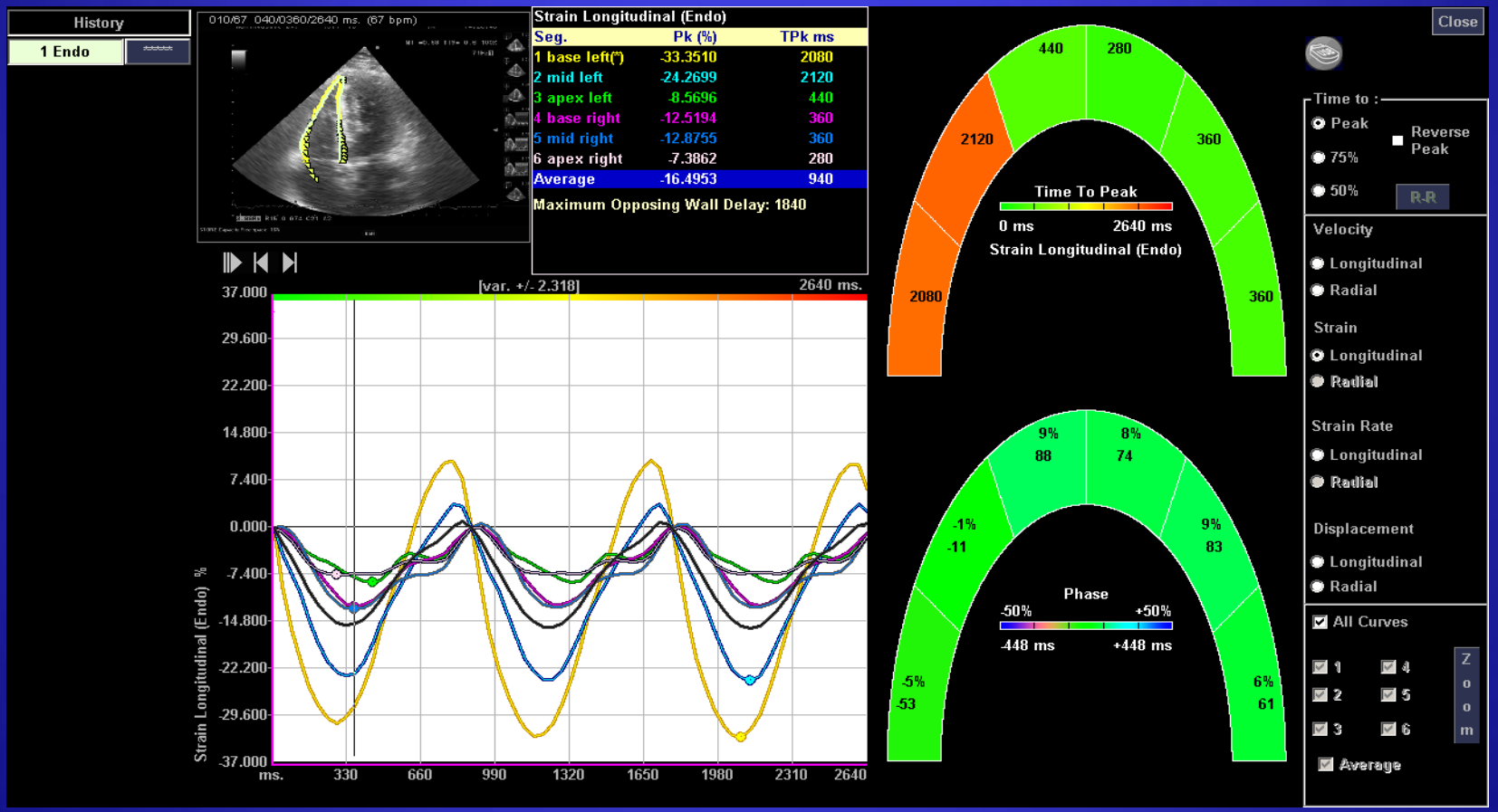
2DSTE - VVI



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2DSTE- VVI

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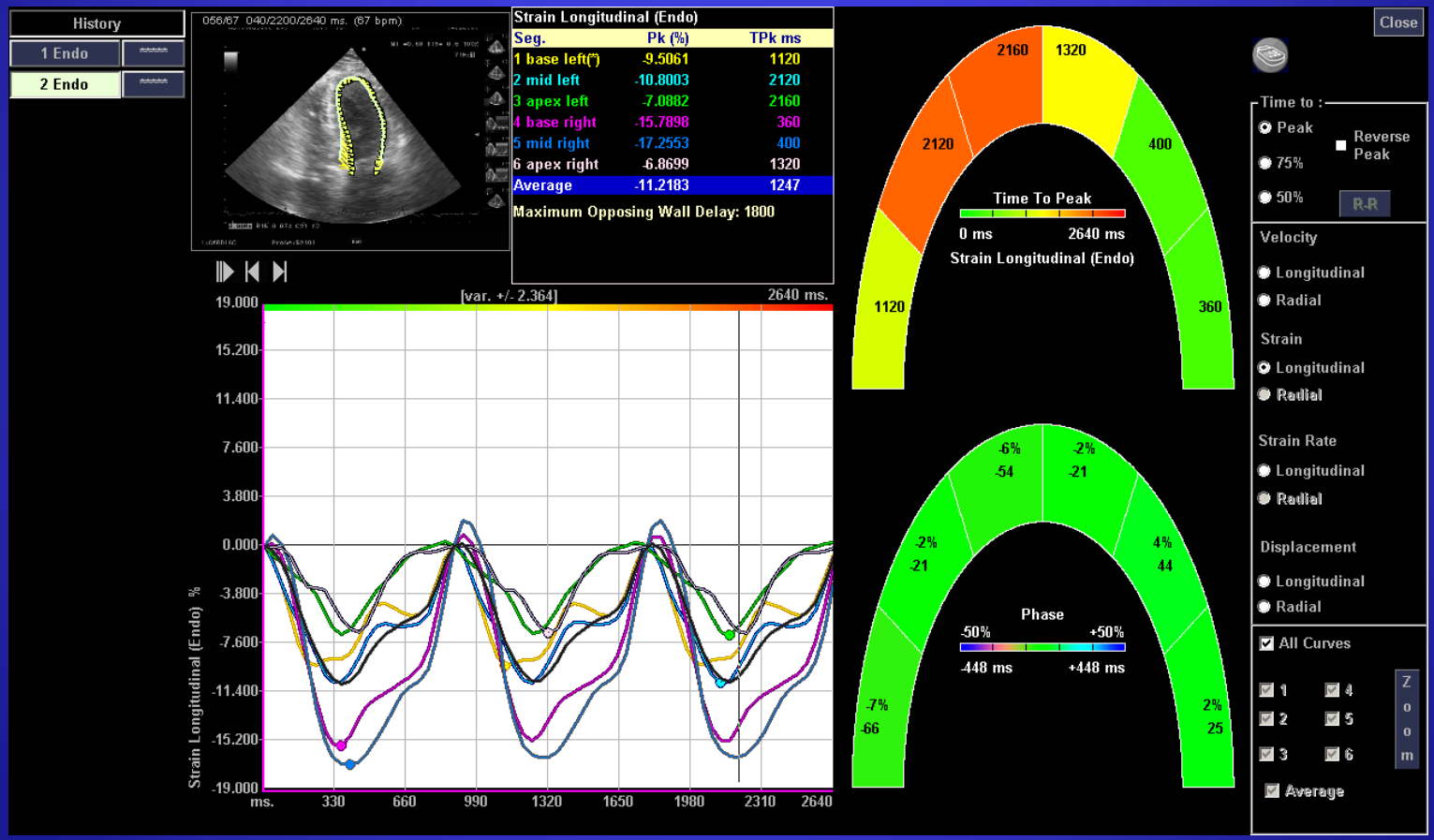

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Results:

Demographic and baseline data of study population

	AH - groups	Normals
Age	68.9±13	31±5
Height (cm)	173.14±9.45	174± 4
Weight (kg)	82.74±13 .8*	67±11
Gender	30M/10F	12M/8F
BSA(m2)	1.99± 0.21	1.8±0.11
HR (bpm)	67.5±12.4	78.8±3.4
SBP (mmHg)	156.8±13,7*	115±12
DBP (mmHg)	87±12*	67±9

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Results:

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Echocardiographic data of the study population

	AH - groups	Normals
LVEF (%)	62±6.3	66±10,1
LVEDD (mm)	48.7±8.7	45±4,4
LVEDD/BSA (mm/m2)	24.47±4.7	25±3,7
LVEDV (ml	109.6±31.10*	81.11±25*
LVEDV/BSA (ml/m2)	54.77±14.8*	45.06±12.3*
LVESV (ml)	48.71±13.60*	38.37±13*
LVESV/BSA (ml/m2)	24.48±6.7	21.31±6.8
LVSV (ml)	60.56±10	61.46±16
LVSV/BSA (ml/m2)	30.43±5.5	34.14±8,2
mass (g)	264.30±.765*	173±11.3
mass index(g/m2)	132.3±30.9*	92.02±5.6
E/ A	0. 75 ± 0. 41*	1. 87 ± 0.48
TAPSE (mm)	21 ± 2,9 mm	23 ± 2,2 mm

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Results :

Global strain / rate	**Normals (1)**	**AH - group (2)**	**p-value (2) vs(1)**
$PeakSS_{LV}$	- 19.69±1.82	16.4 ± 3.14	**p=0.56**
$PeakSS_{RV}$	-15, 5 ± 2, 3	-10.03 ±4, 5 *	**p<0.01**
$PeakSR_{RV}$	1.75	0.45 *	**p<0.01**

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Results:

Regional right ventricular myocardial function

	Peak Systolic Strain – RV		
	Basal level	Middle level	Apical level
Normals	-14.03 ± 3.78	-17.23± 2.23	. - 12.3 ±2.56
AH group	- 12, 31 ±3, 87	- 11, 24 ± 3.2*	- 7, 87±2.34*

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Conclusion:

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- **The present study demonstrates that measures of RV deformation are reduced in patients with LVH secondary to hypertension.**
- **Thus, this data suggests that LVH may cause early sub-clinical RV dysfunction even in the absence of overt diastolic heart failure.**

Take home message :

- **RV function is an important parameter in cardiac disease**
- **2DE is a relatively feasible method to assess RV dysfunction in clinical practice**
- **Several new echocardiographic techniques such as TDI, SRI, RT3DE may give us further information in assessing RV function**

" Don`t forget to check your ~~Facebook account~~ right ventricle before leaving, you might get a new ~~friend~~ Prognosis request ! "

Mark Elliot Zuckerberg

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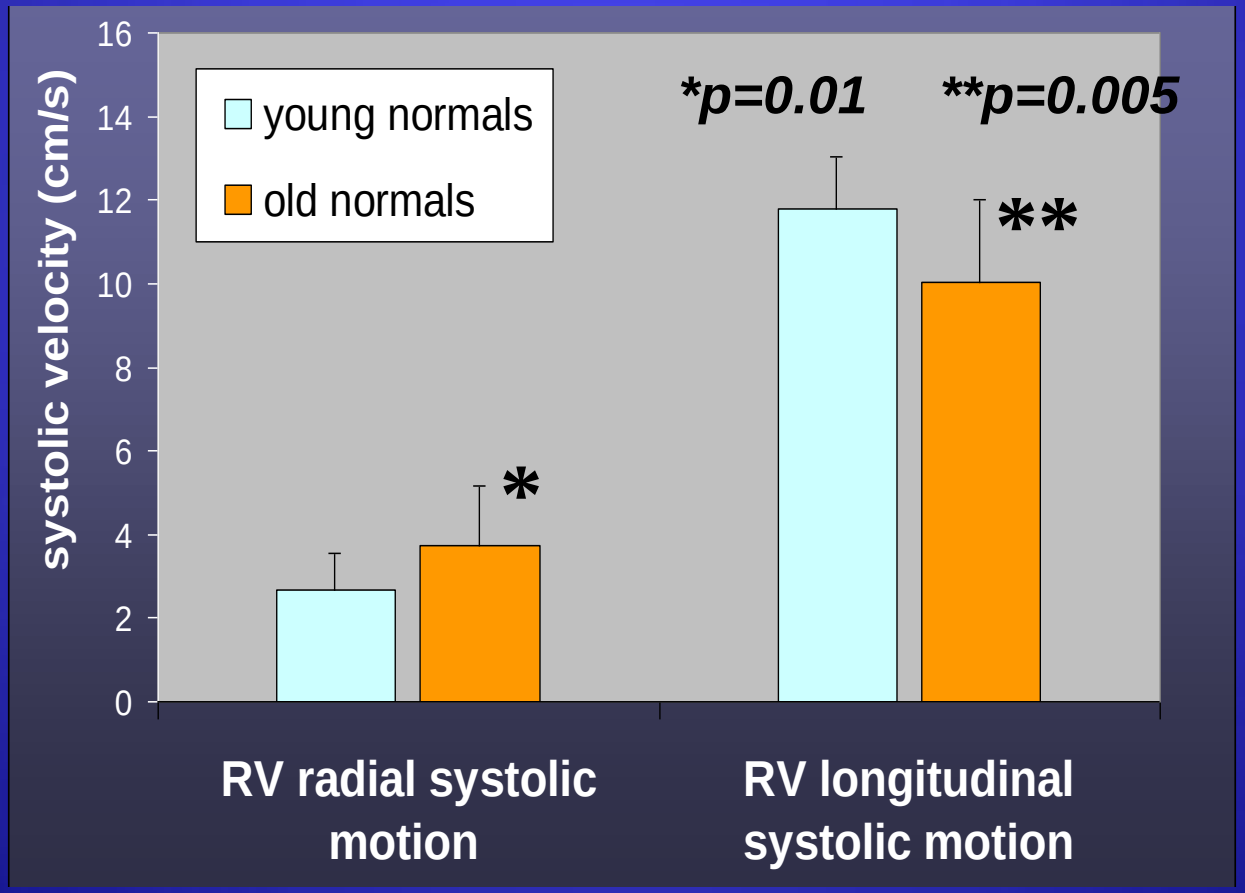
Thank you for your attention!

RV Systolic Function

LONGITUDINAL vs RADIAL FUNCTION

Longitudinal vs radial RV systolic velocities in young (16-40 y, n=19) and old normals (41-76 y, n=13)



Normal RV Regional Function

RV DIASTOLIC FUNCTION

Early diastolic (e) velocities in young (16-40y) and old normals (41-76y)