Left Ventricular Mechanical Dyssynchrony

Ventricular Mechanical Dyssynchrony

- In Physiological conditions Cardiac Performance is co-determined by temporal and spatial mechanical dyssynchrony (Brutsaert JACC 1987)
- "It is conceivable that dyssynchrony represents a newly appreciated pathophysiological process that directly depresses Ventricular function" (Auricchio Circulation 2004)
- Mechanical Dyssynchrony is common in CHF, LBBB, LV Aneurysm and during Ischemia
- Influence of Mechanical Dyssynchrony on Cardiac Performance is not well documented

Characteristics LV Aneurysm

- LV post-infarction aneurysm is characterized by akinetic and/or dyskinetic LV wall motions.

- Non-uniformity of contraction and relaxation reduces mechanical efficiency of ventricular filling and ejection and contributes to diastolic and systolic dysfunction.

- LV aneurysm is associated with reduced EF due to LV dilatation to maintain stroke volume and with impaired LV relaxation.

LV Restoration Surgery

Endo-ventricular patch plasty aneurysmectomy (Dor Procedure) aims for LV reduction and geometric remodeling to reduce akinesia, dyskinesia and LV load to improve cardiac performance

Study Objectives/Methods

- Intra-operative Evaluation of LV Contractile State and LV Mechanical Dyssynchrony in Patients undergoing LV Restoration
- Contractile State was derived from LV Pressure-Volume Loops as determined by the conductance catheter technique (CD Leycom)
- Mechanical Dyssynchrony was determined by short-axis volume slices from the conductance catheter

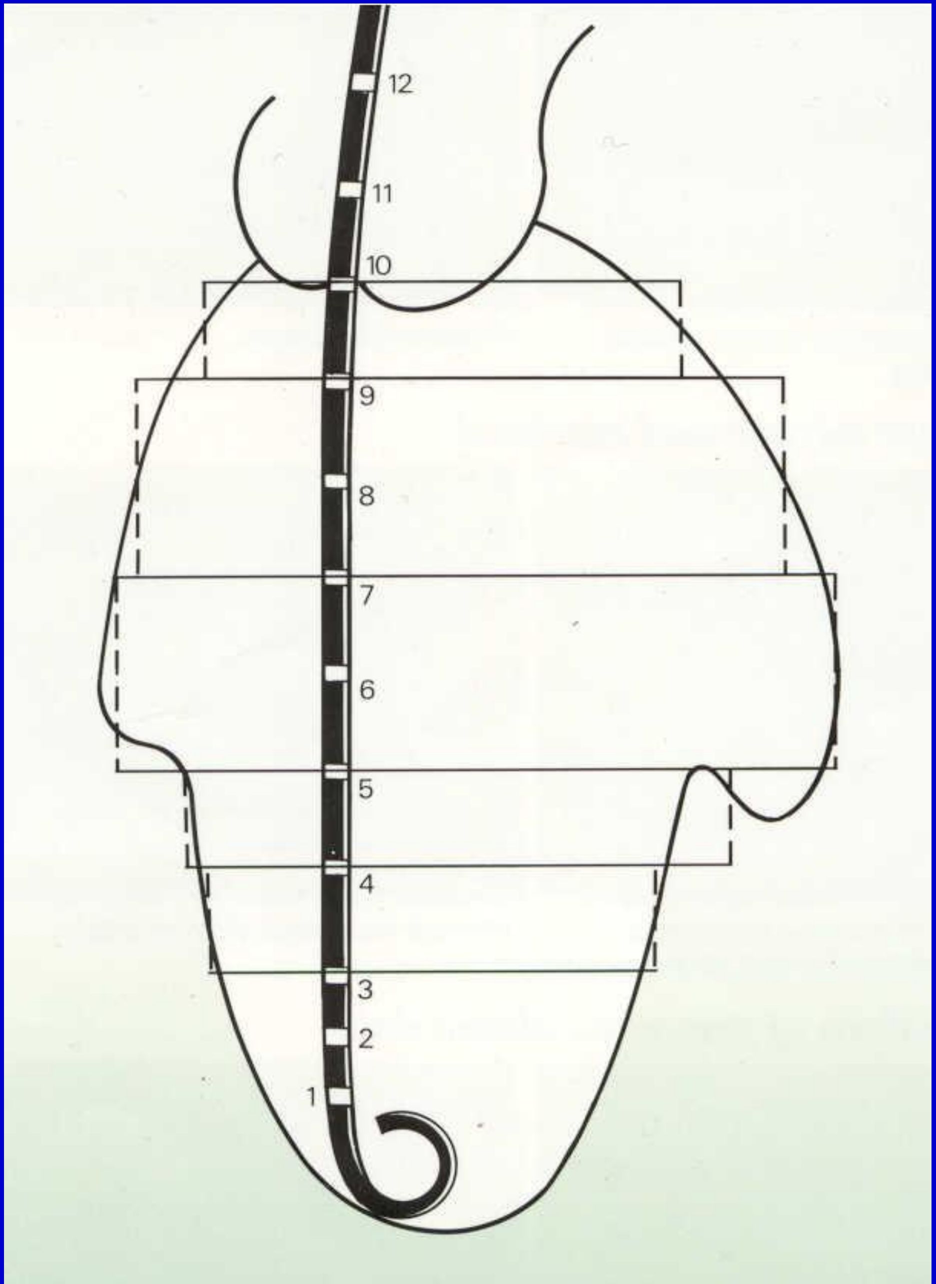
Conductance Volume Catheter Principle

An electro-magnetic field is applied between distal and proximal electrodes

Up to 7 electrode pairs measure the conductance of intraventricular blood segments perpendicular to the long heart axis

Segmental conductance changes reflects time-varying segmental volume

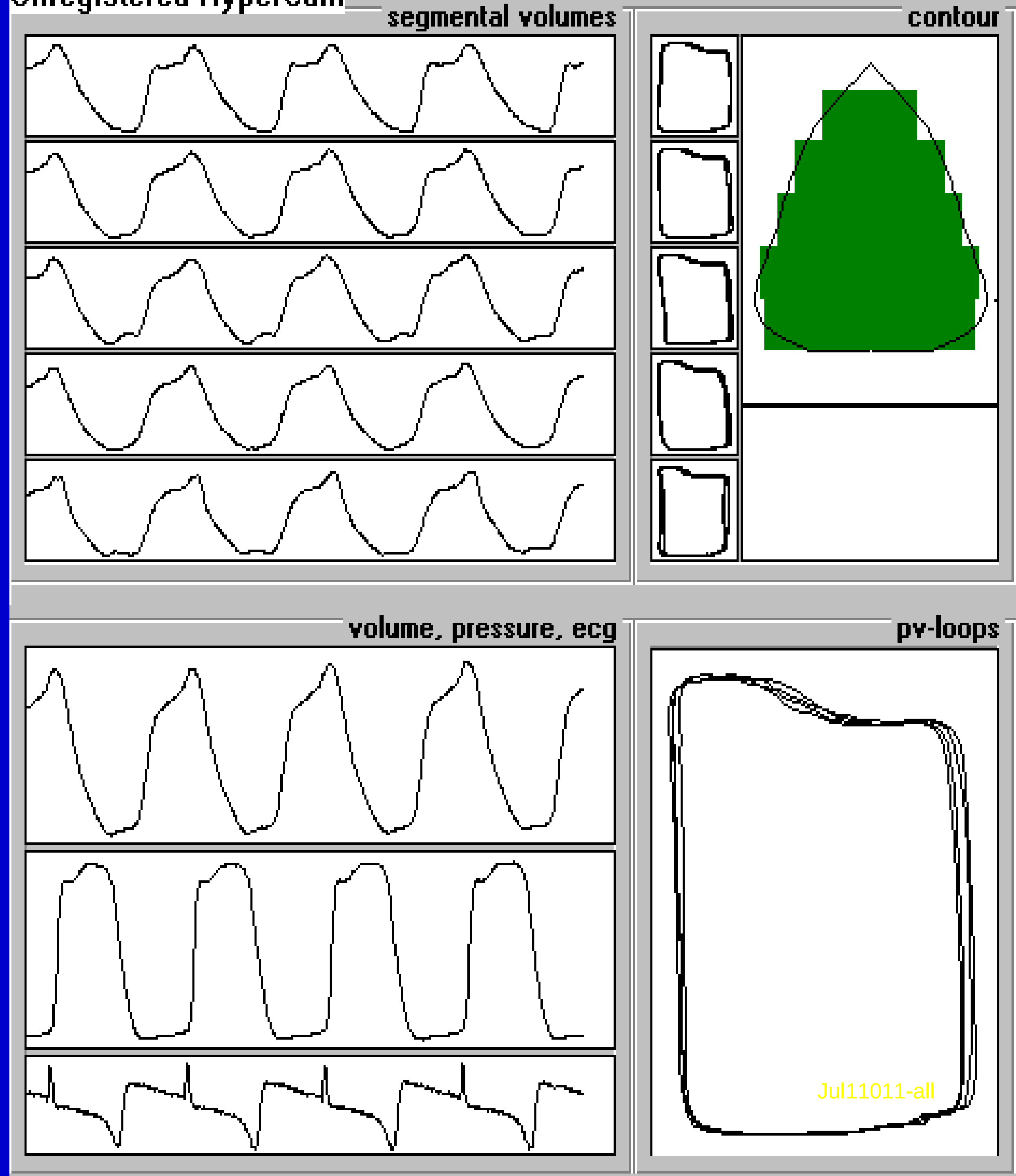
Total volume is calculated as the sum of segmental volumes



5 segmental volume signals from apex (top) to base

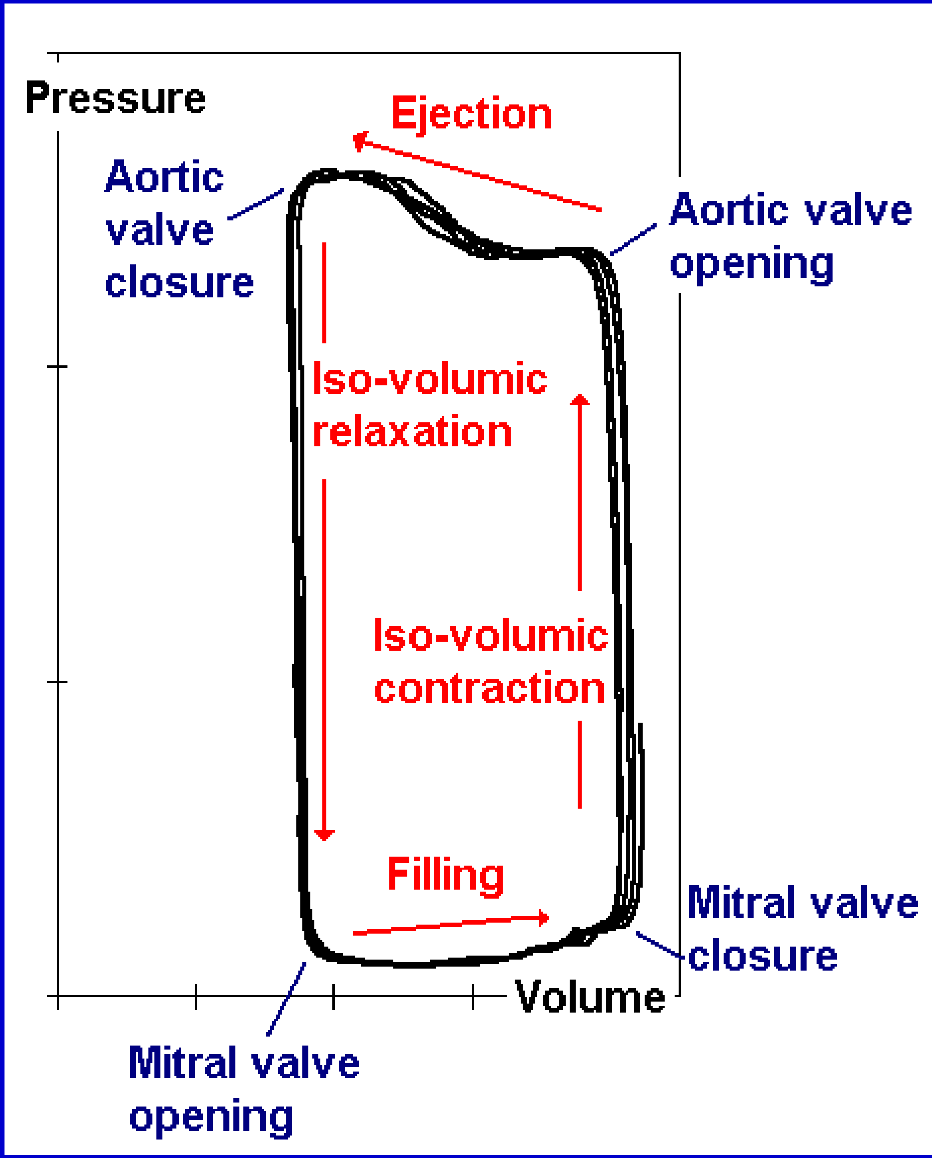
Segmental volume combined with left ventricular (LV) pressure give segmental P-V loops

Total volume signal combined with the LV pressure signal give the typical P-V loops (click at screen)



Ventricular Pressure-Volume Loops

- show the performance of the Heart in its role as a pump
- three load independent indices of contractile state can be derived from P-V loops
- Systolic and Diastolic disorders can be analyzed real-time

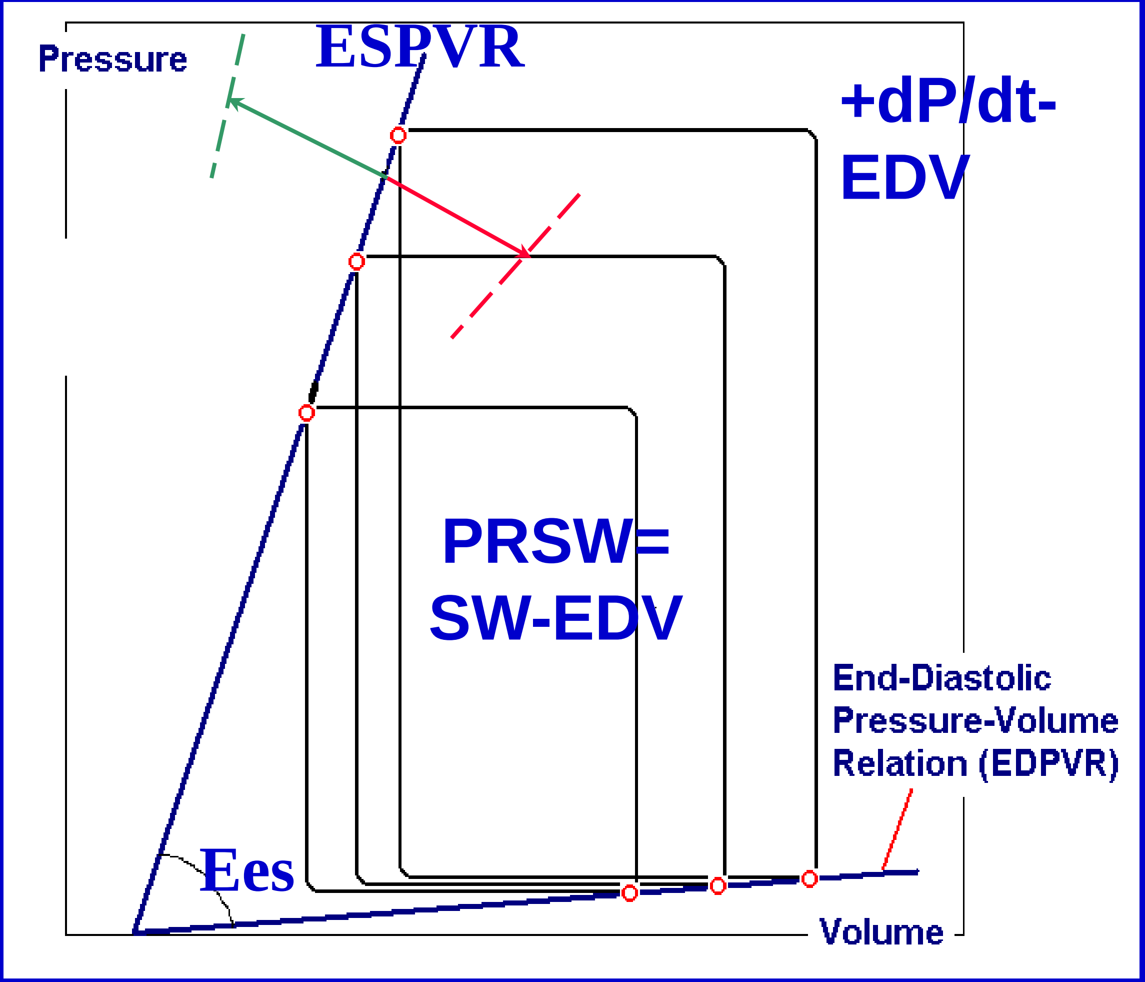


P-V Loops and Load Independent Contractile State Indices

1) ESPVR= end-systolic pressure volume relationship, its slope =Ees

2) +dP/dt-EDV, the Starling contractile state

3) PRSW= preload recruitable stroke work

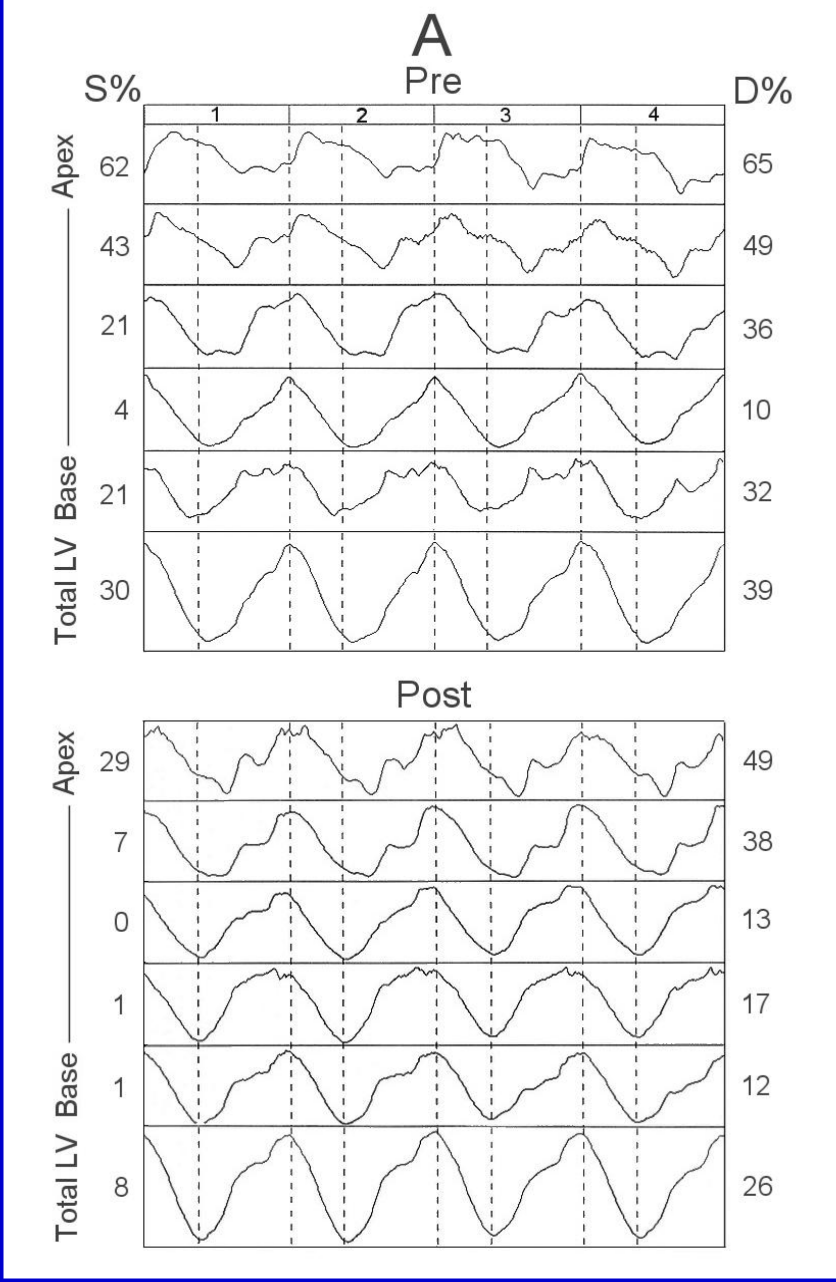


Mechanical Dyssynchrony Assessment

Calculated from segmental volume changes compared to total LV volume changes

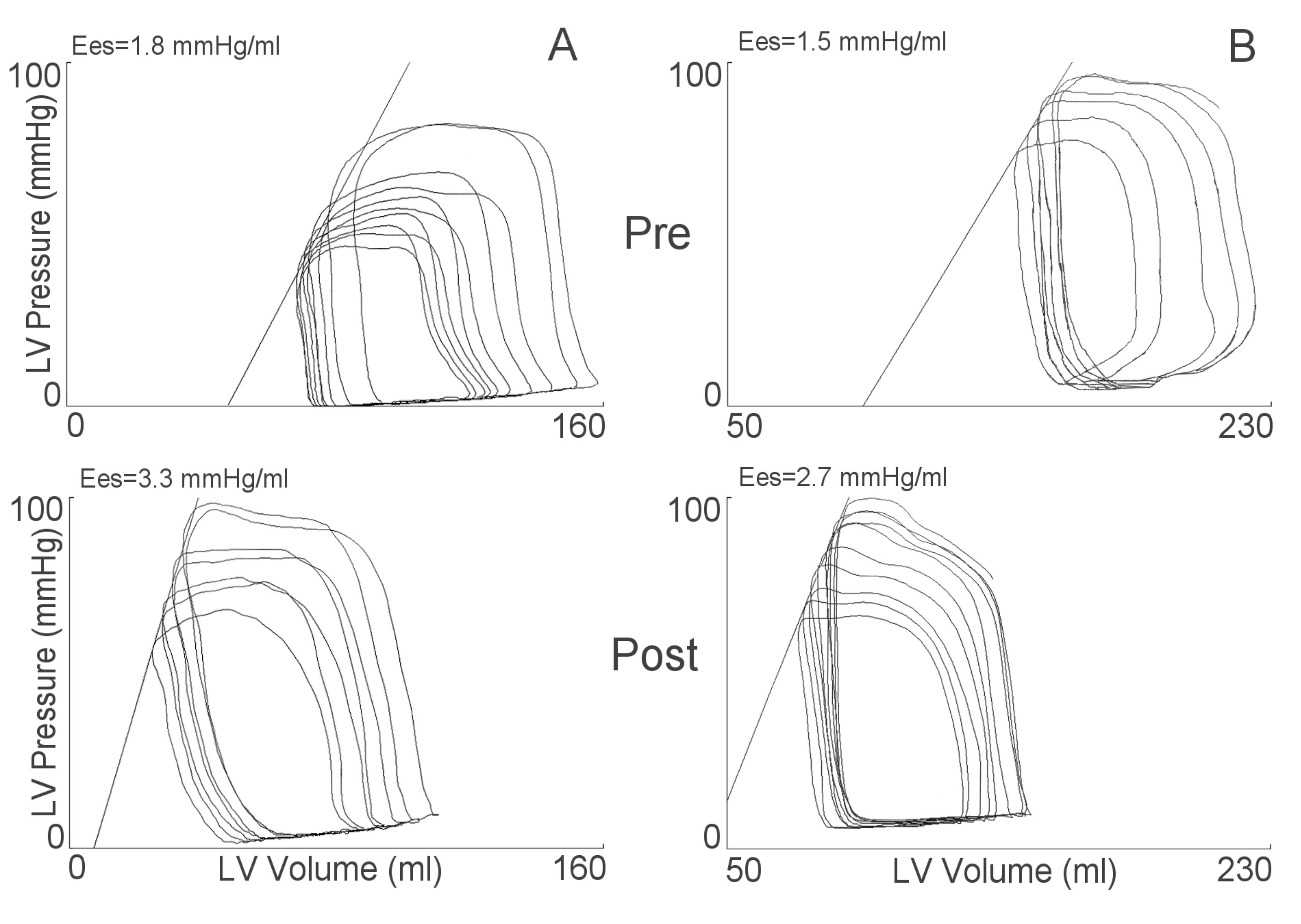
A segment is dyssynchronous when it is out of phase with total volume change

Expressed in % of time of total heart cycle or of systolic or diastolic phase

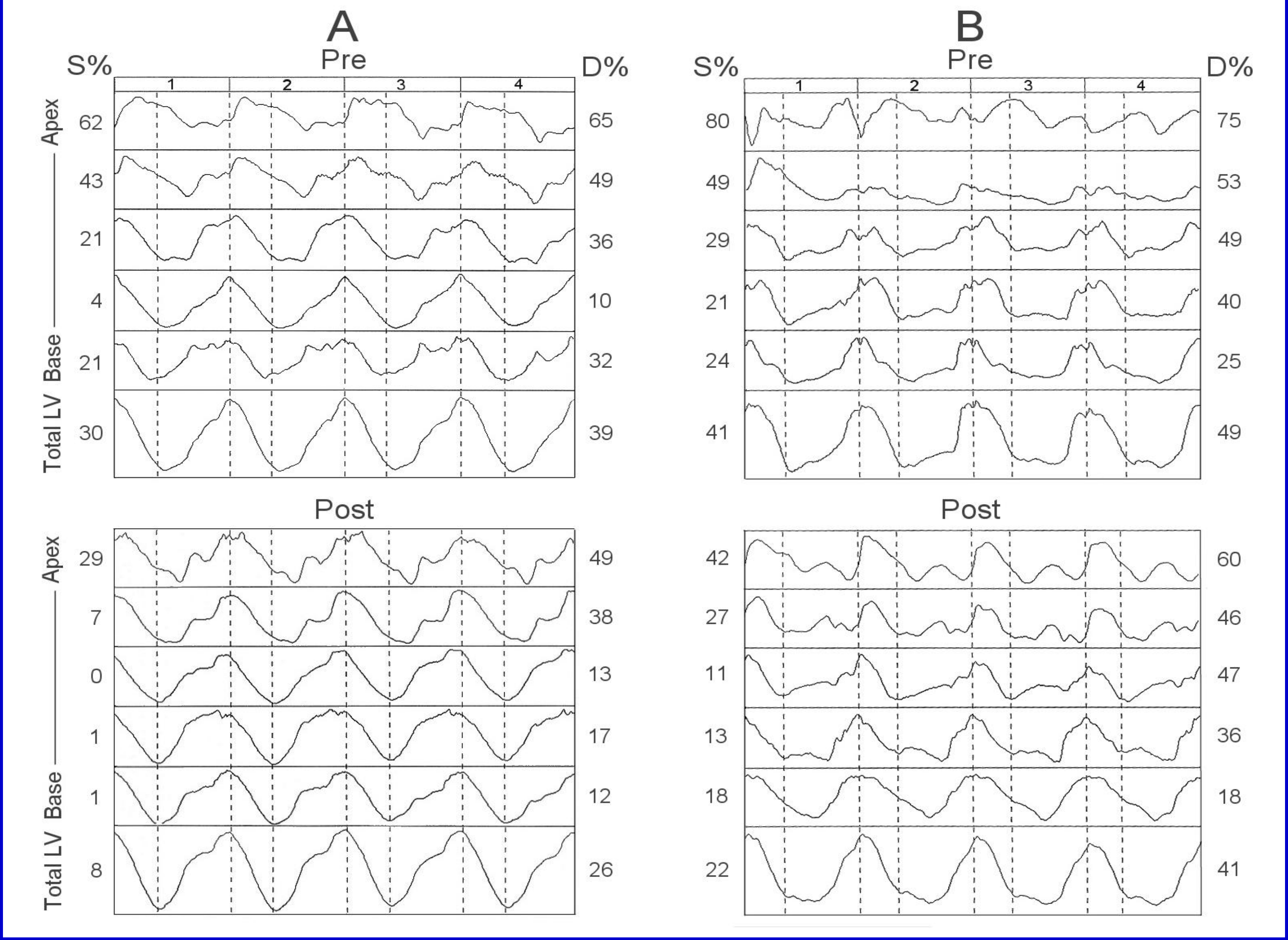


Patients Characteristics

- 9 patients with LV post-infarction aneurysm
- Age 59-71 yrs
- NYHA class II-III
- Cardiac Index 1.6-2.5 L/min
- Ejection Fraction 12-35%
- CABG performed in 8pts



Schreuder et al JTCS 2005



Schreuder et al JTCS 2005

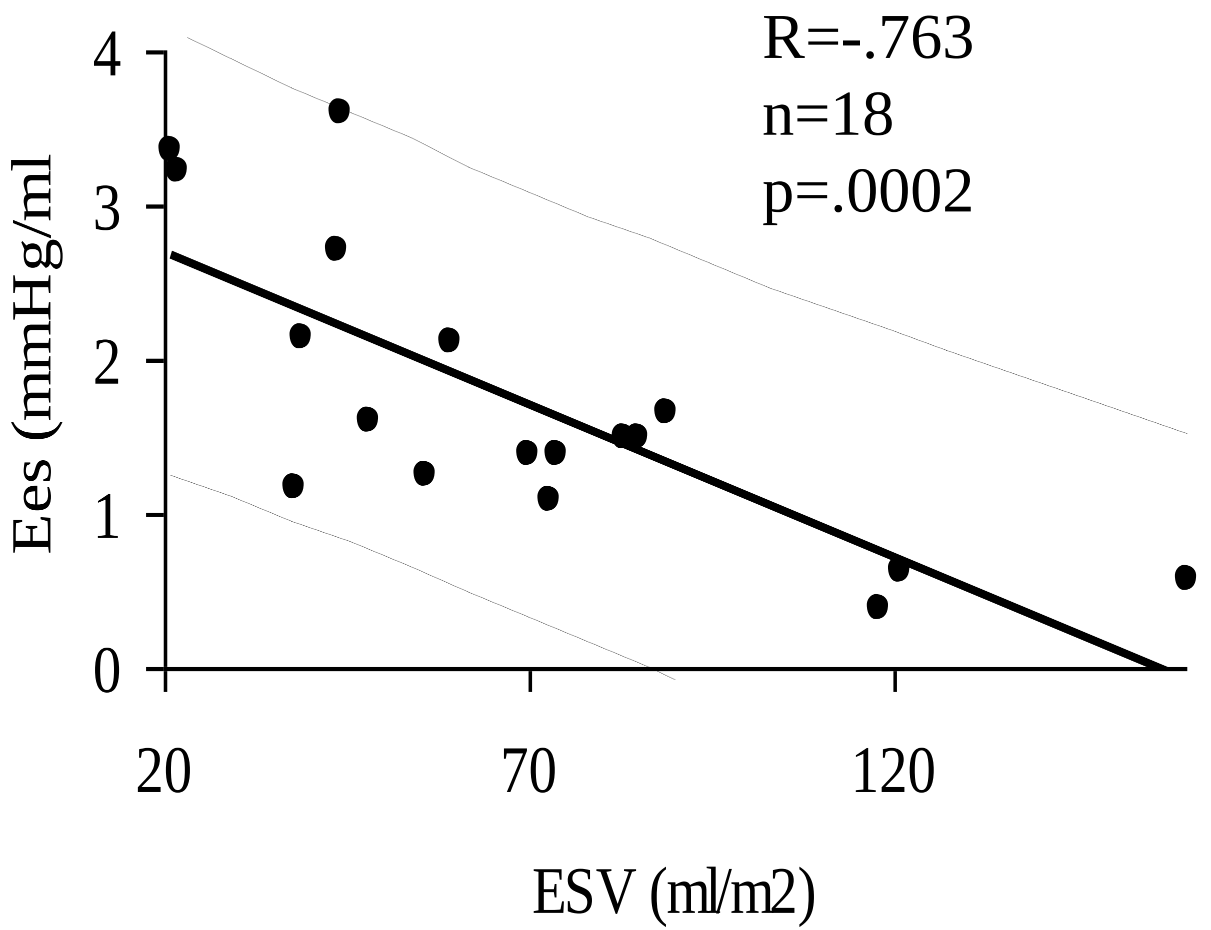
Hemodynamic Data

	Before	LV Restor	After	
HR	76±16		99±21	P<.01
SV	46 ±12		48±12	
EDV	123±35		78±18	P<.001
EDP	9.4±3		13.8±3	P<.03
+dP/dt	787±276		1116±171	P<.03
-dP/dt	601±145		803±72	P<.006
Tau	59±7		41±9	P<.001
PRSW	42±22		72±22	P<.01
Ees	1.2±.6		2.2±1	P<.001

Dyssynchrony Data

	Before		LV Res		After
	Systole	Diastole		Systole	Diastole
Apex1	62±15	64±14		44±10*	49±7*
Apex2	44±10	47±16		25±10*	37±7*
Mid Seg	27±7	36±10		14±10**	22±10**
Base2	15±7	20±9		14±5	22±5
Base1	21±11	24±7		17±6	25±13
Total	34±3	38±7		23±6**	31±5**

*=P<.05, **=P<.01



R=-.763
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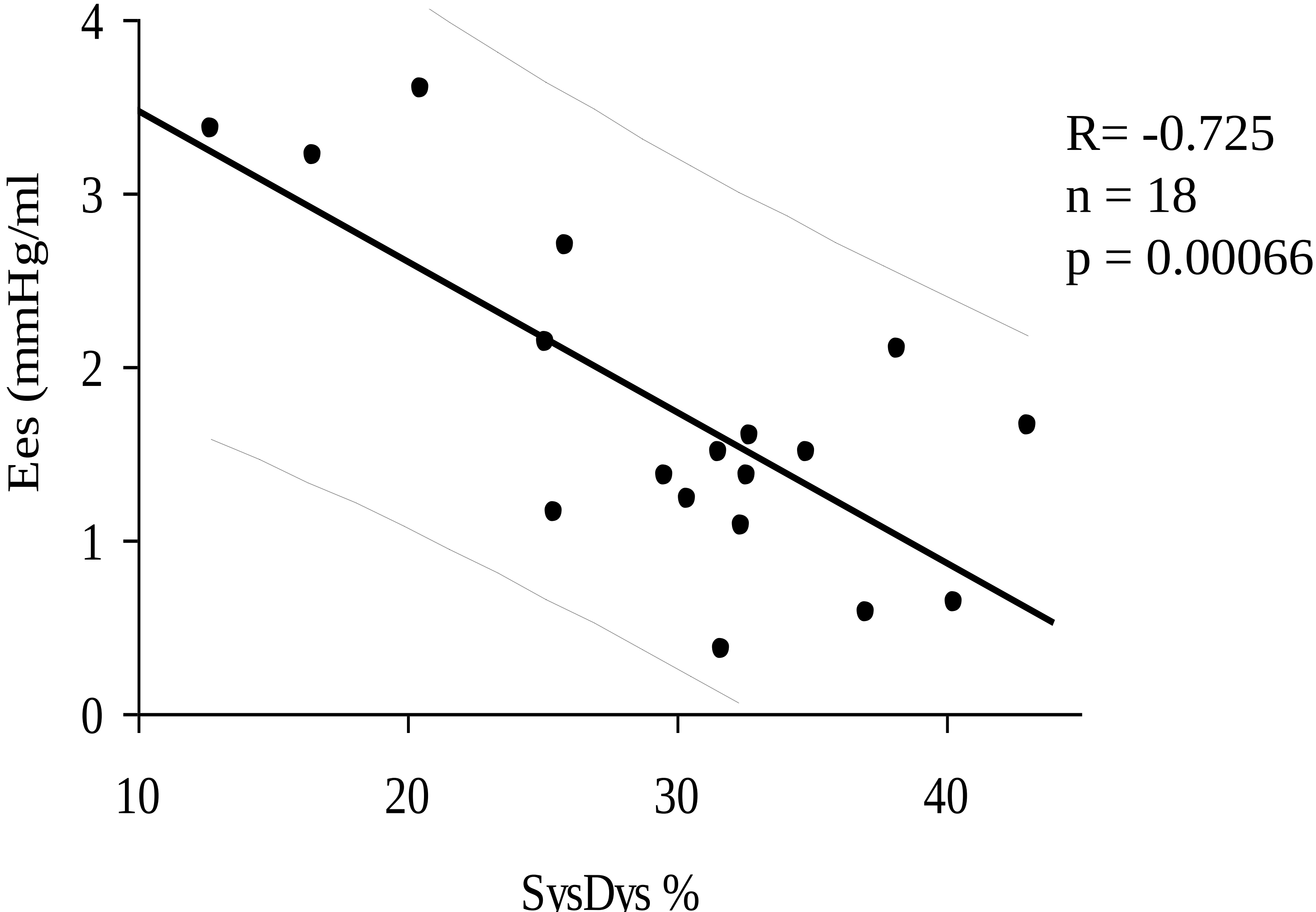
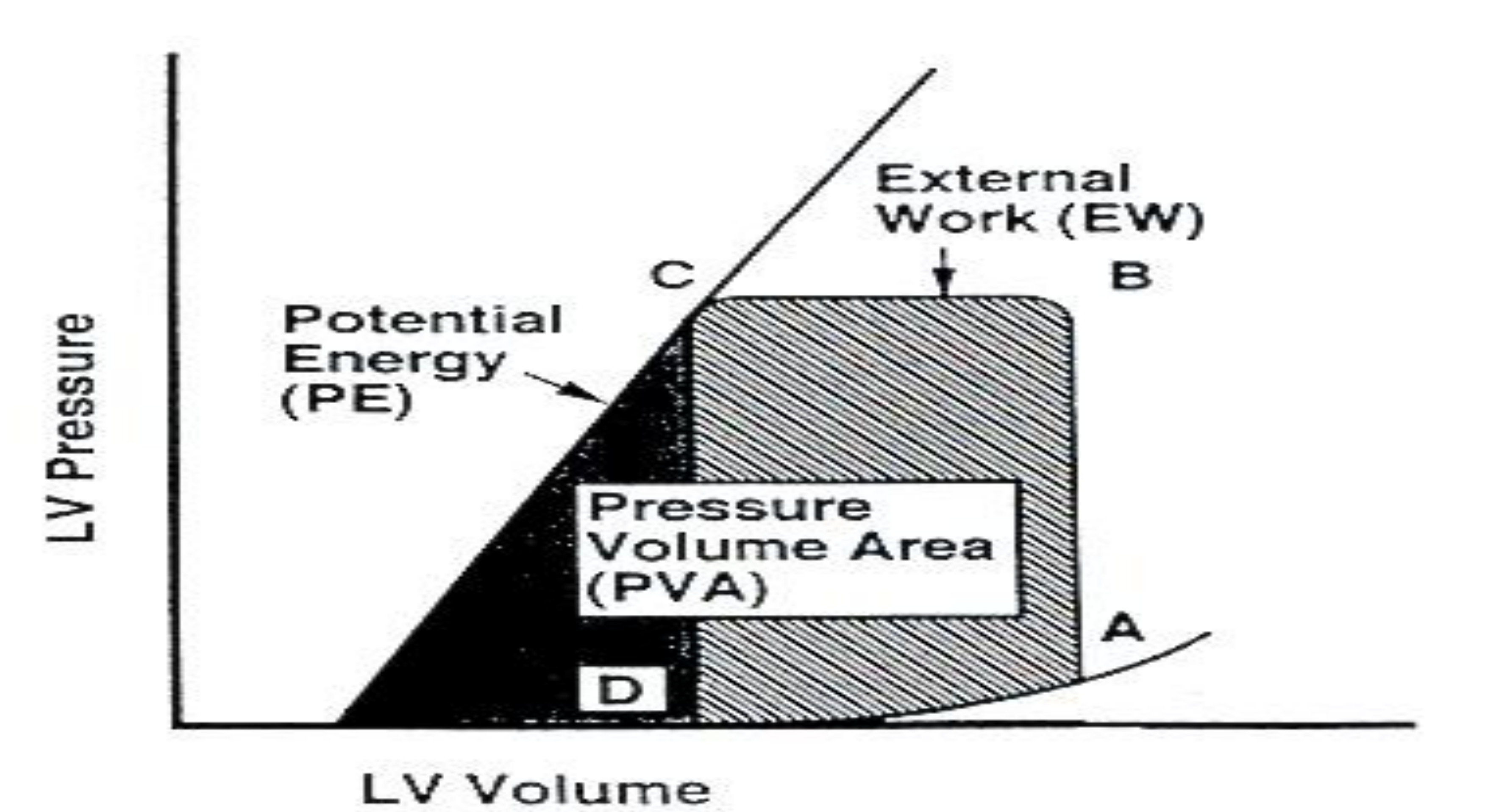
p=.0002
Ees (mmHg/ml
4
3
2
1
0
20
70
120
ESV (ml/m2)



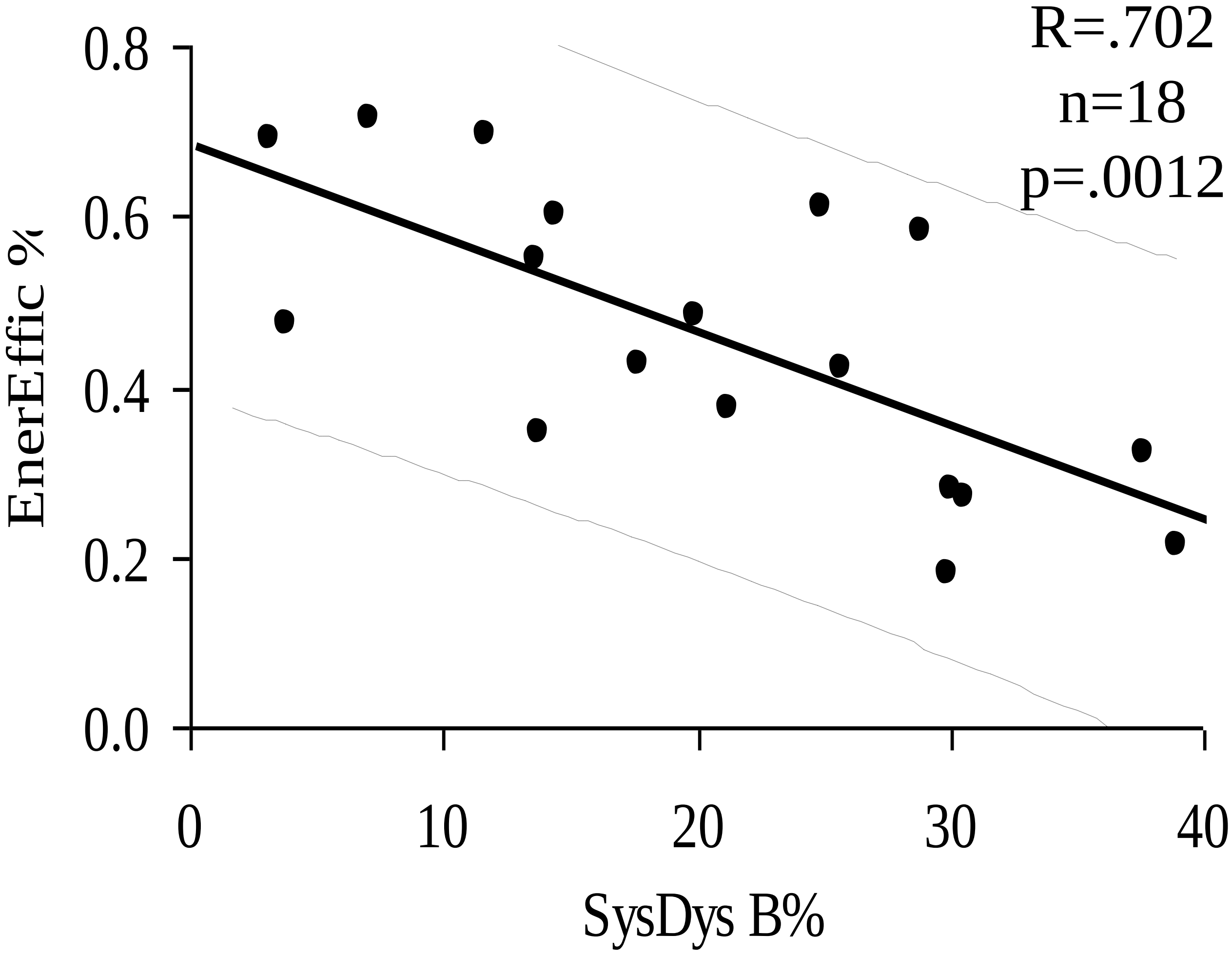
Schreuder et al JTCS 2005

Pressure- Volume Area concept

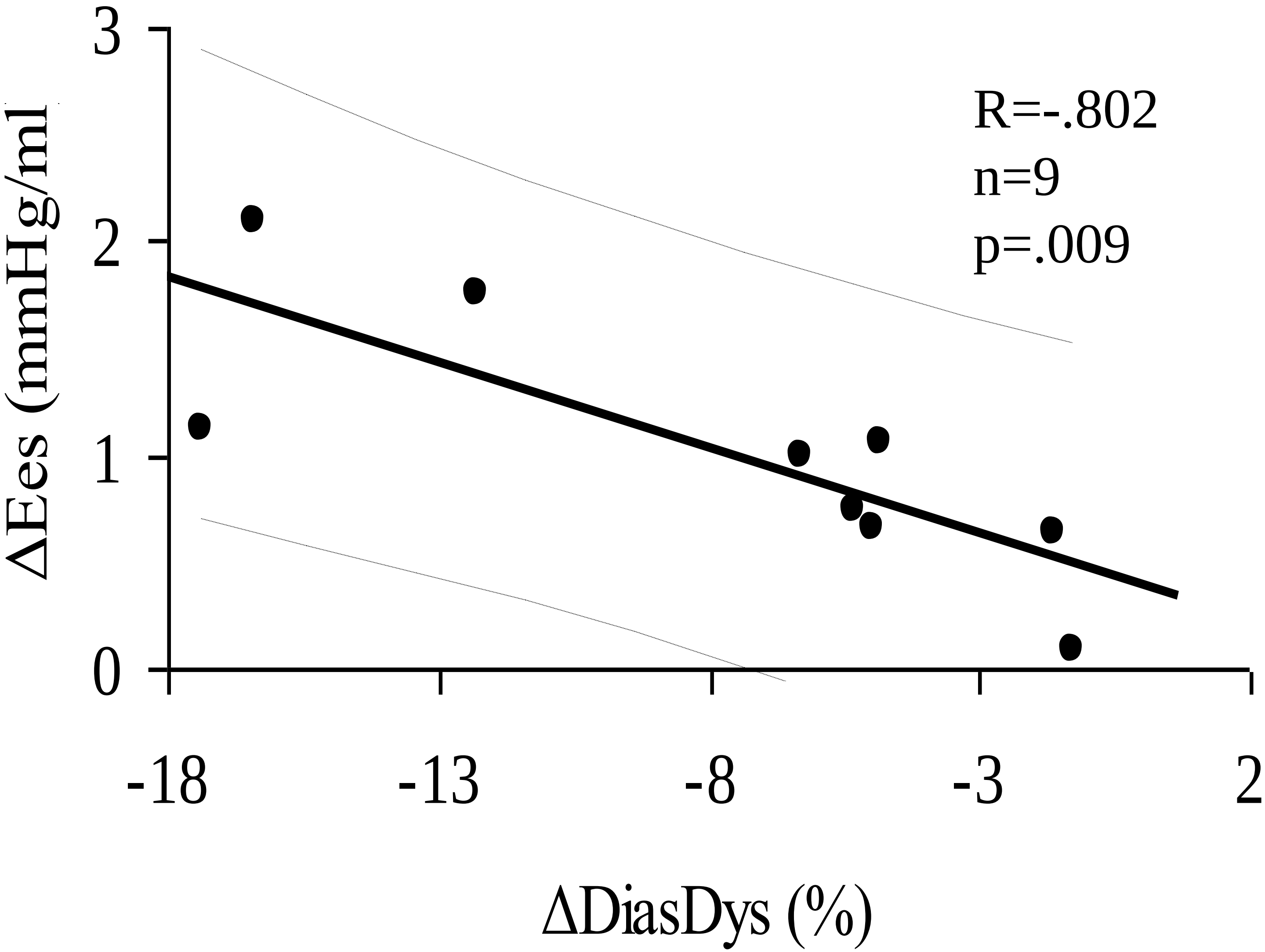


Energy Efficiency % = SW/PVA

Suga et al,1982



Schreuder et al JTCS 2005



Schreuder et al, JTCS 05

Summary LV Restoration

- LV Restoration Surgery improved immediately diastolic relaxation and Contractile State
- The decrease in LV mechanical dyssynchrony and increase in Contractile State markedly correlated
- LV mechanical dyssynchrony and Energy Efficiency inversely correlated
- LV volume reduction, reducing wall stress, and the grade of geometric remodeling determine the improvement in cardiac function

Ventricular Mechanical Dyssynchrony

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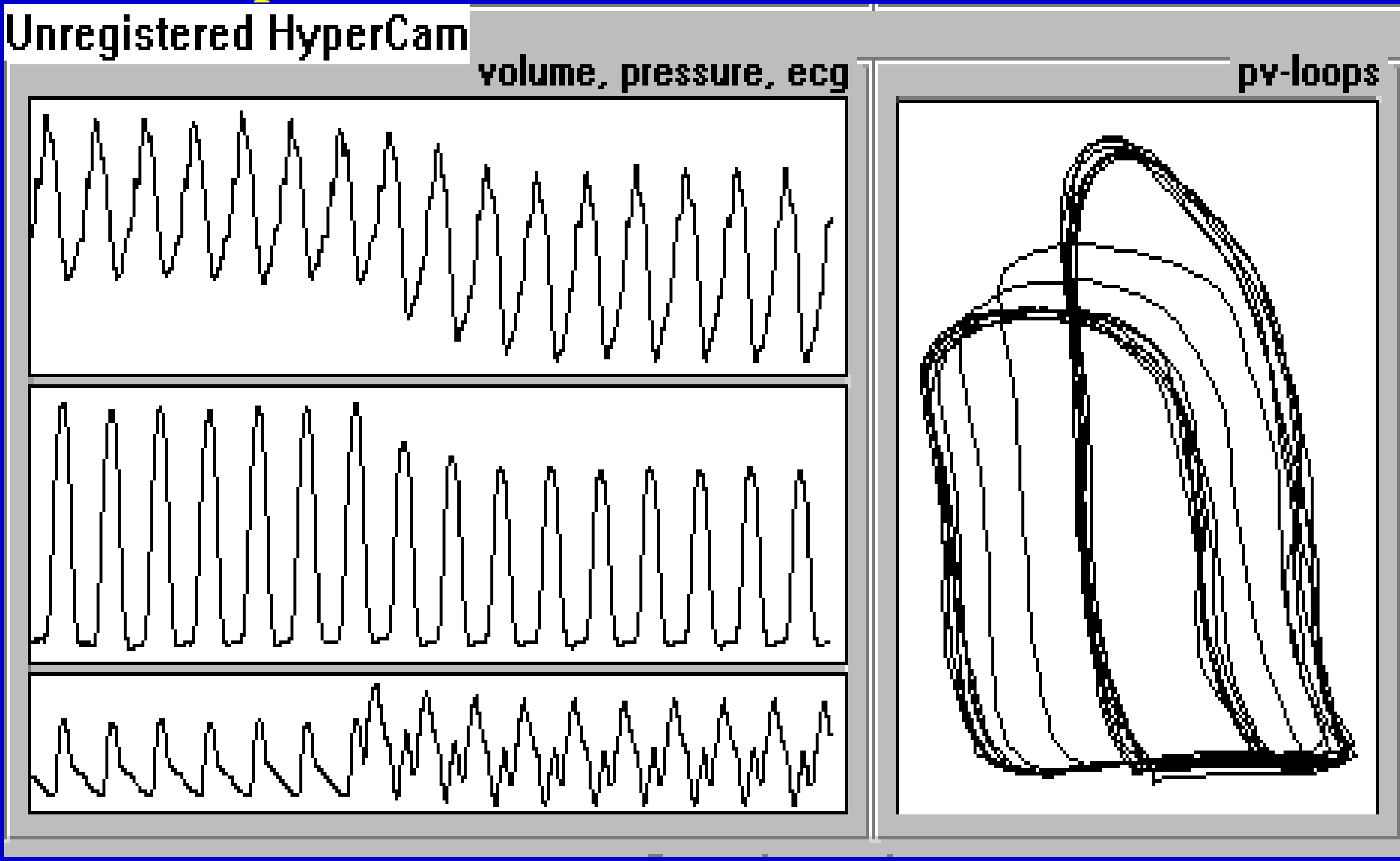
  Leclercq Circulation2004
- *"It is conceivable that Dyssynchrony represents a newly appreciated pathophysiological process that directly depresses ventricular function and ultimately leads to ventricular dilatation and CHF"*
  Auricchio Circulation 2004
- *"It will be useful if additional methods can be developed that identify dyssynchrony"*
  Willerson Circulation 2004

P-V loops in Clinical IABP Research

LV Volume

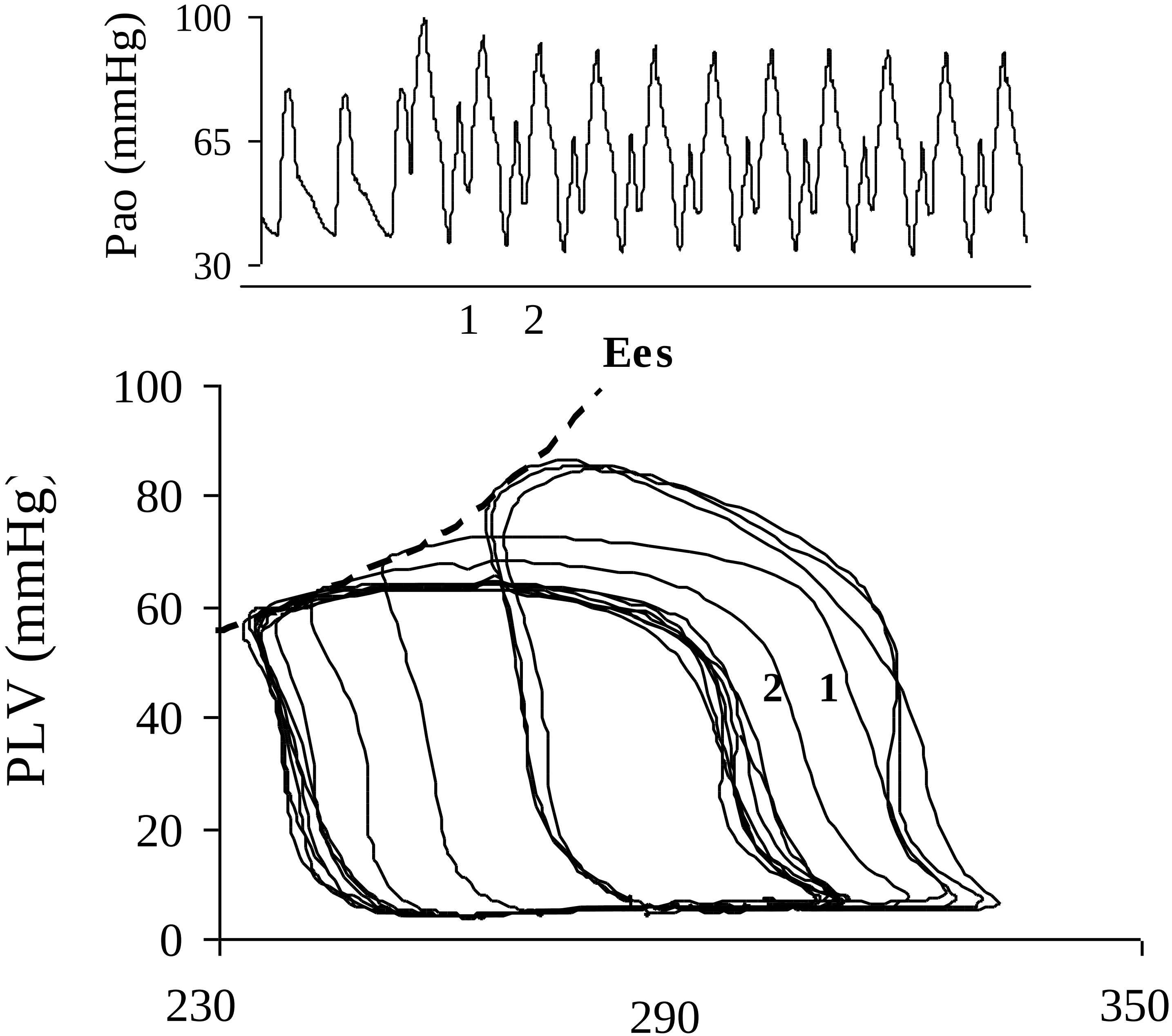
LV Pressure

Aortic Pressure

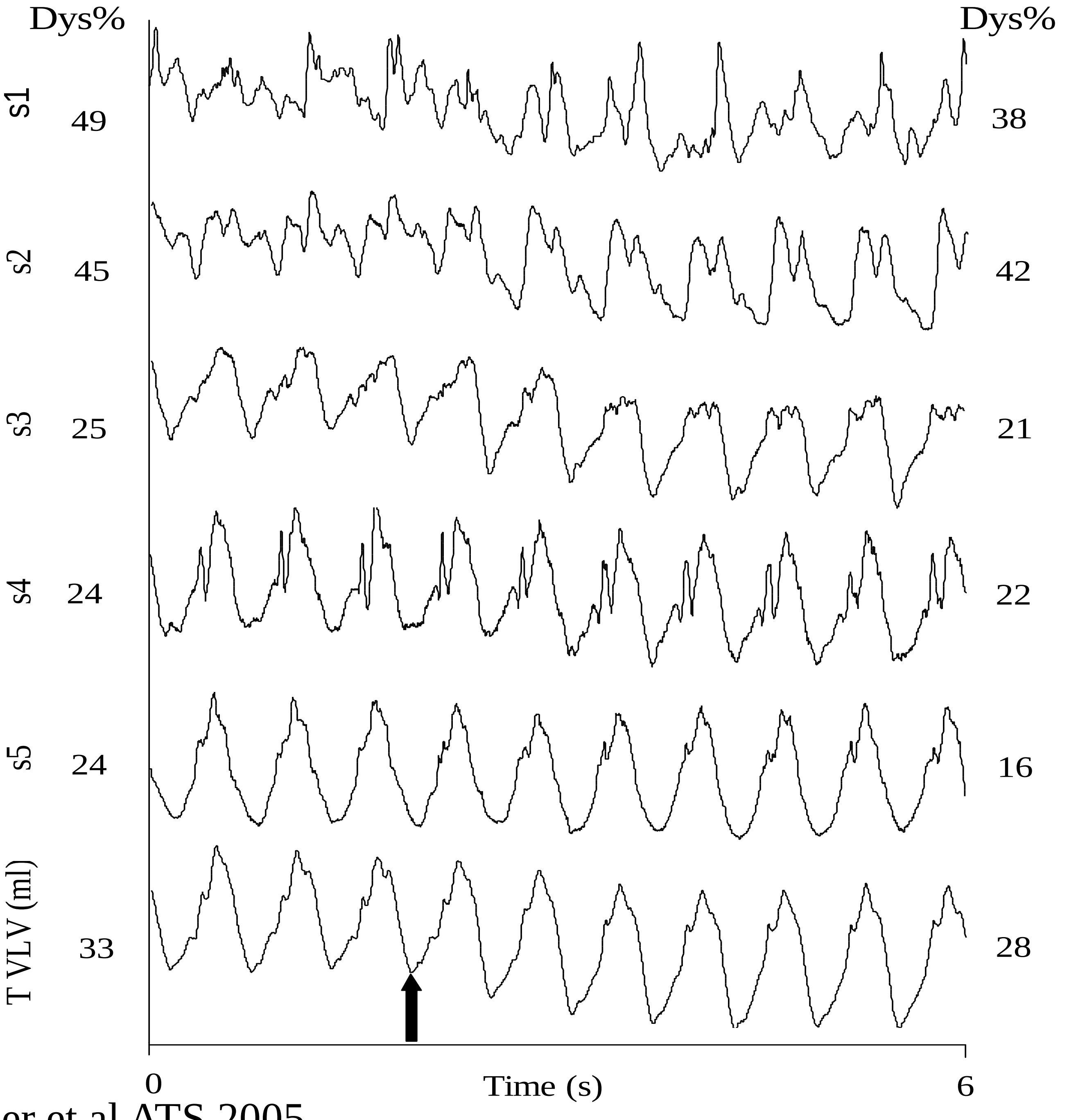


Start IABP at 1:1

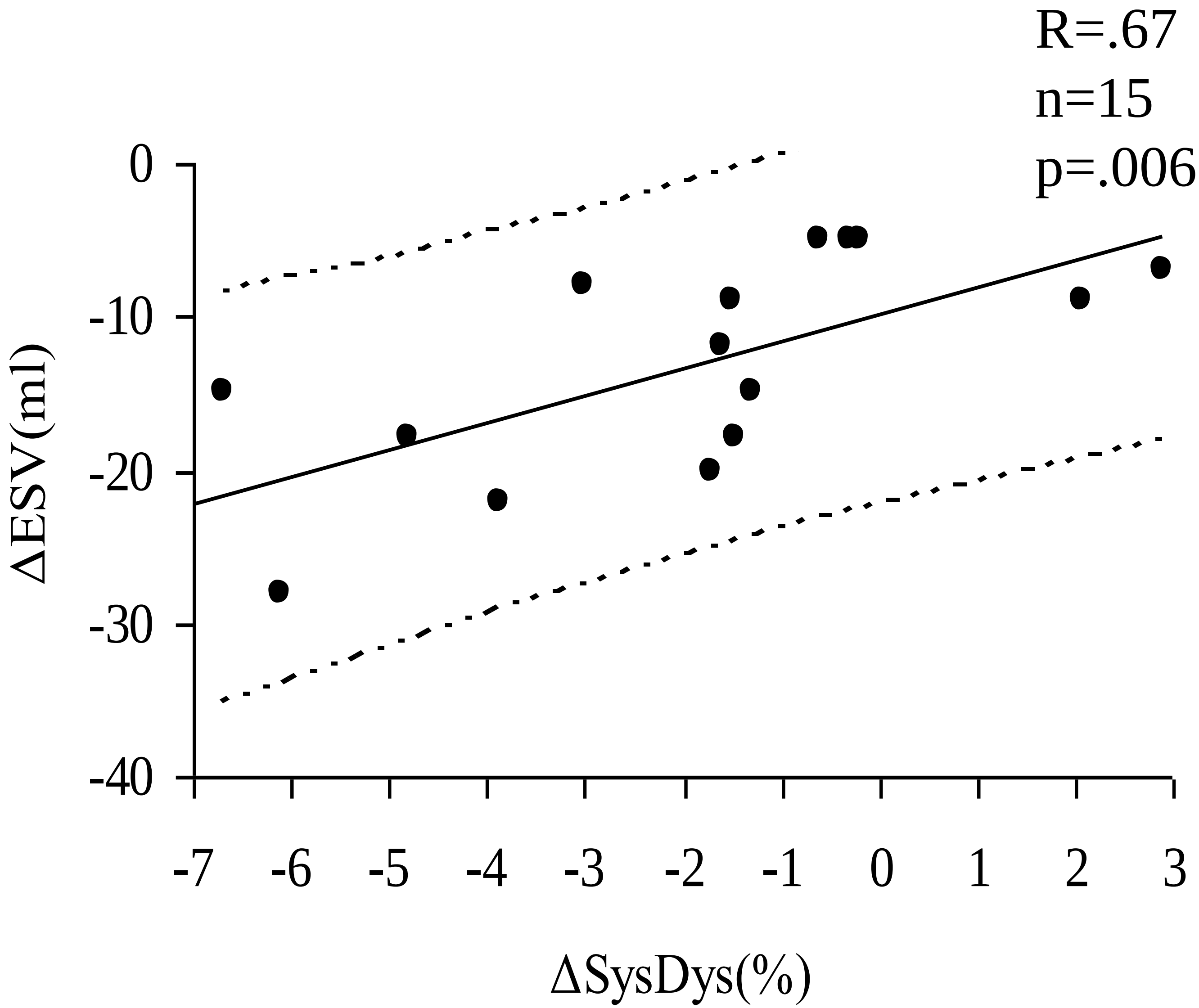
Acute Effects of IABP in a NYHA classIII patient, EF 23%, CABG



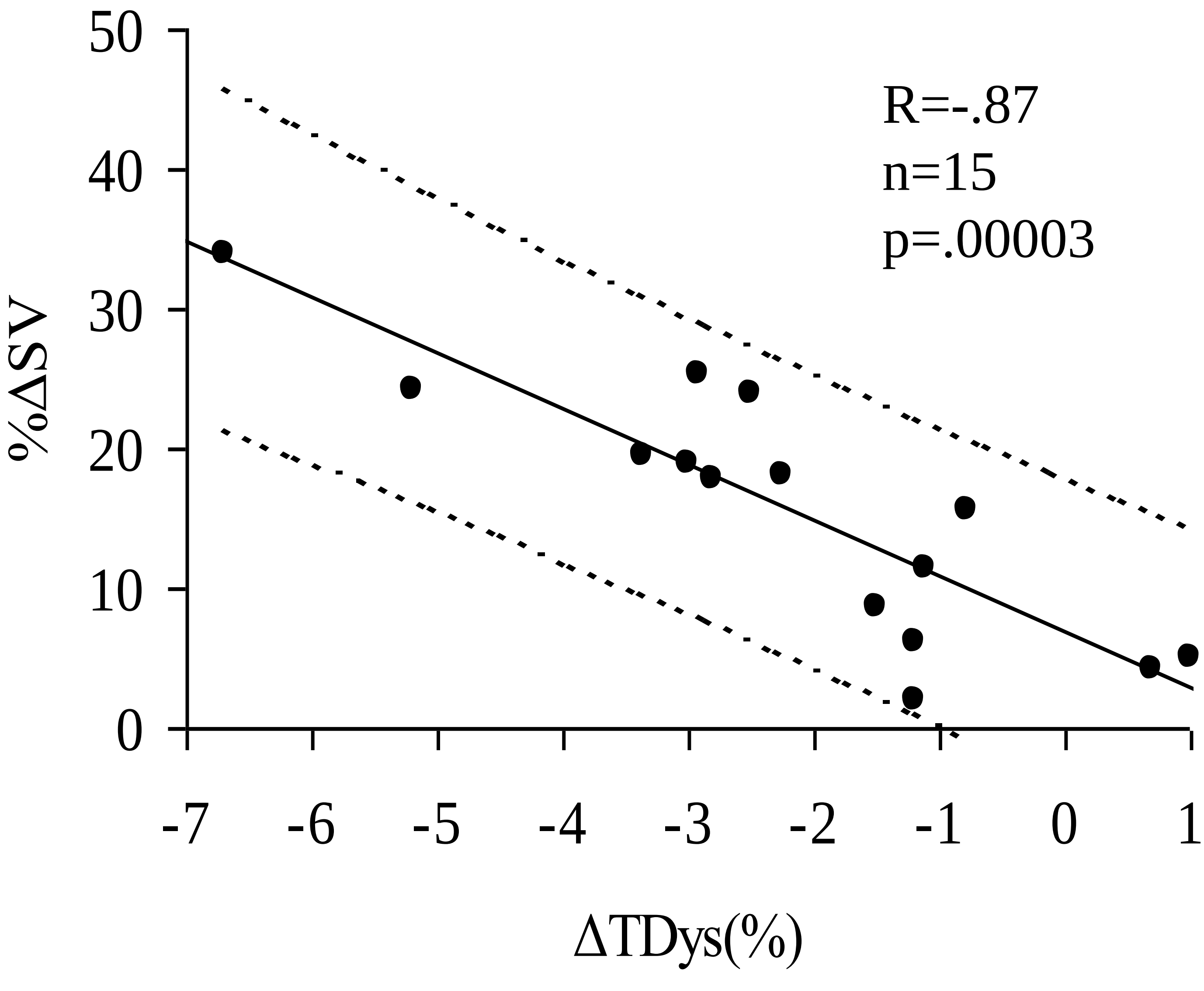
Schreuder et al ATS 2005



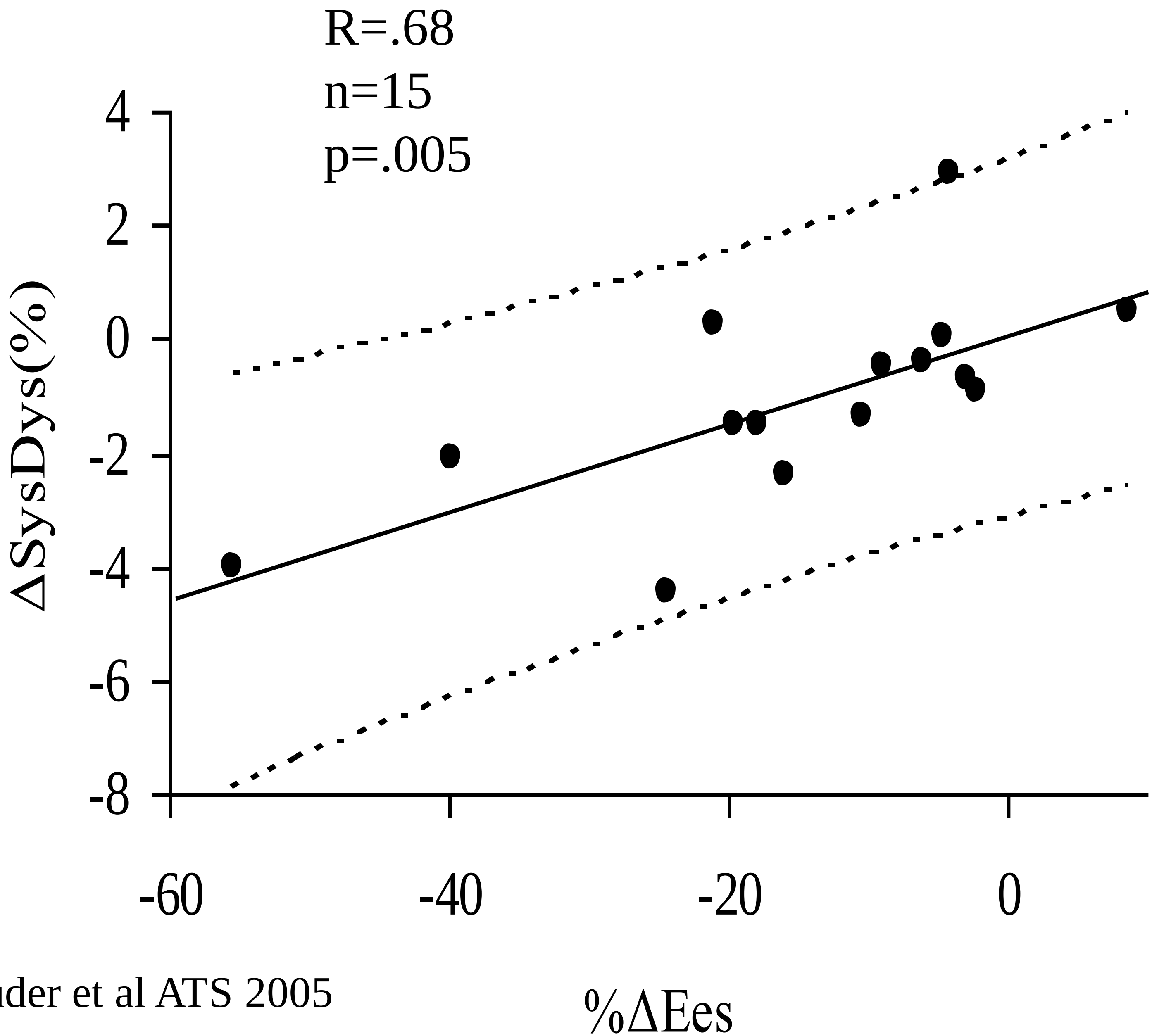
Schreuder et al ATS 2005



Schreuder et al ATS 2005



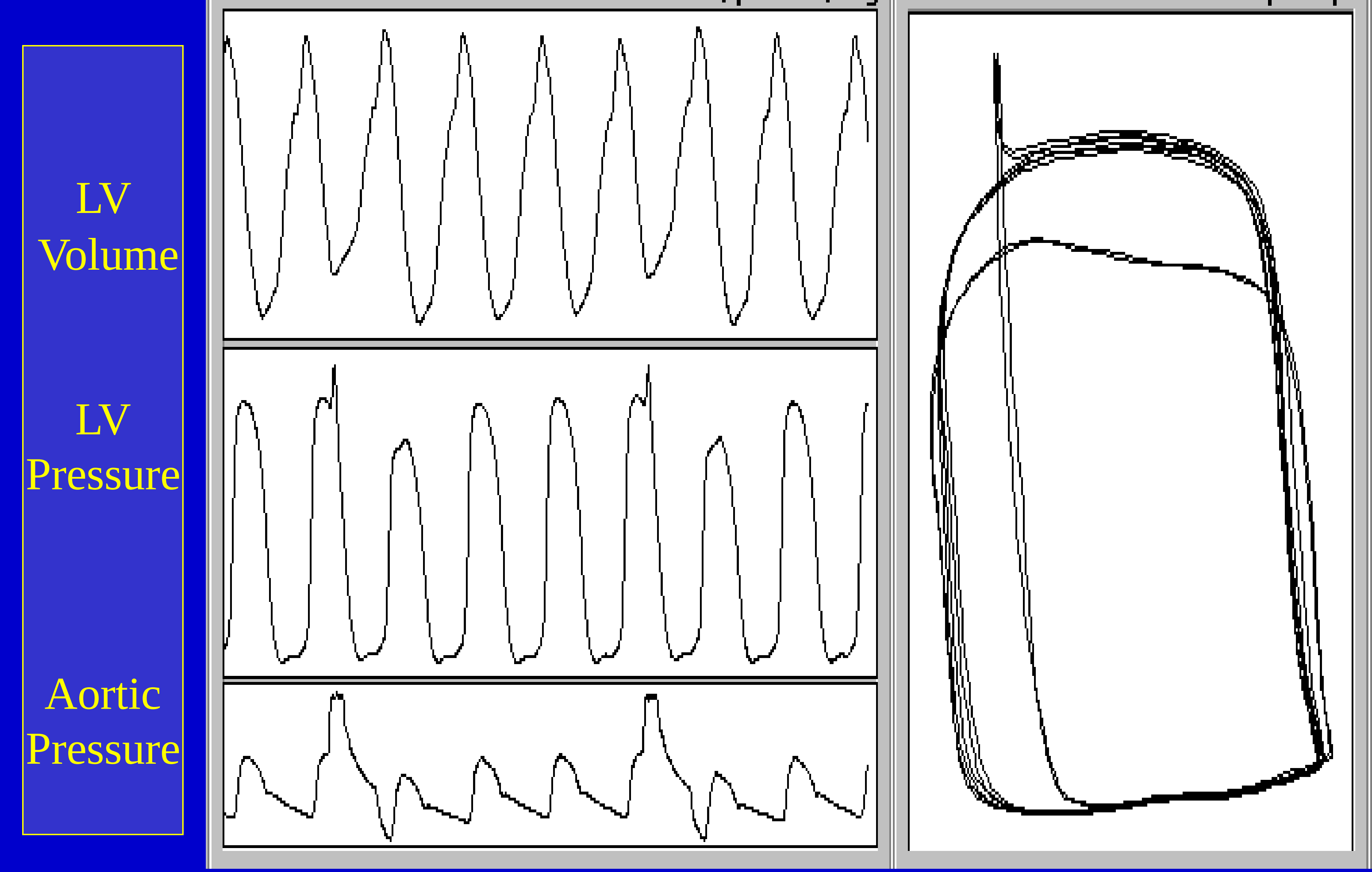
Schreuder et al ATS 2005



Schreuder et al ATS 2005

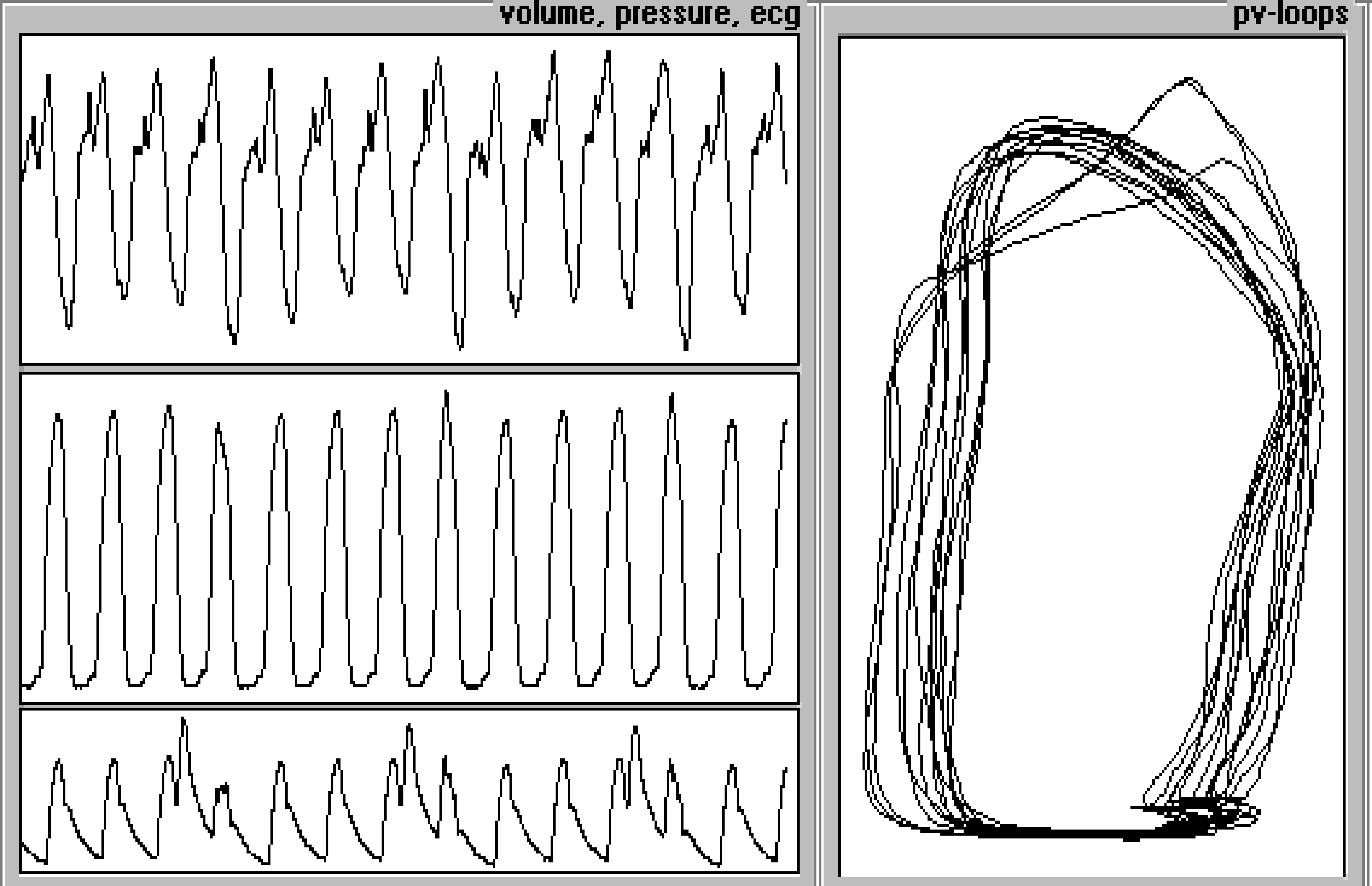
LV Mechanical Dyssynchrony

IABP	Off	On	
Apex S Dys	56.4±12	50±13	P<.001
Mid D Dys	35.1±10	31.3±10	P<.04
Base D Dys	27±8	24±8	P<.05
Tot S Dys	32.3±5	29.7±5.4	P<.01
Tot D Dys	38.6±5.5	36.4±4.8	P<.05



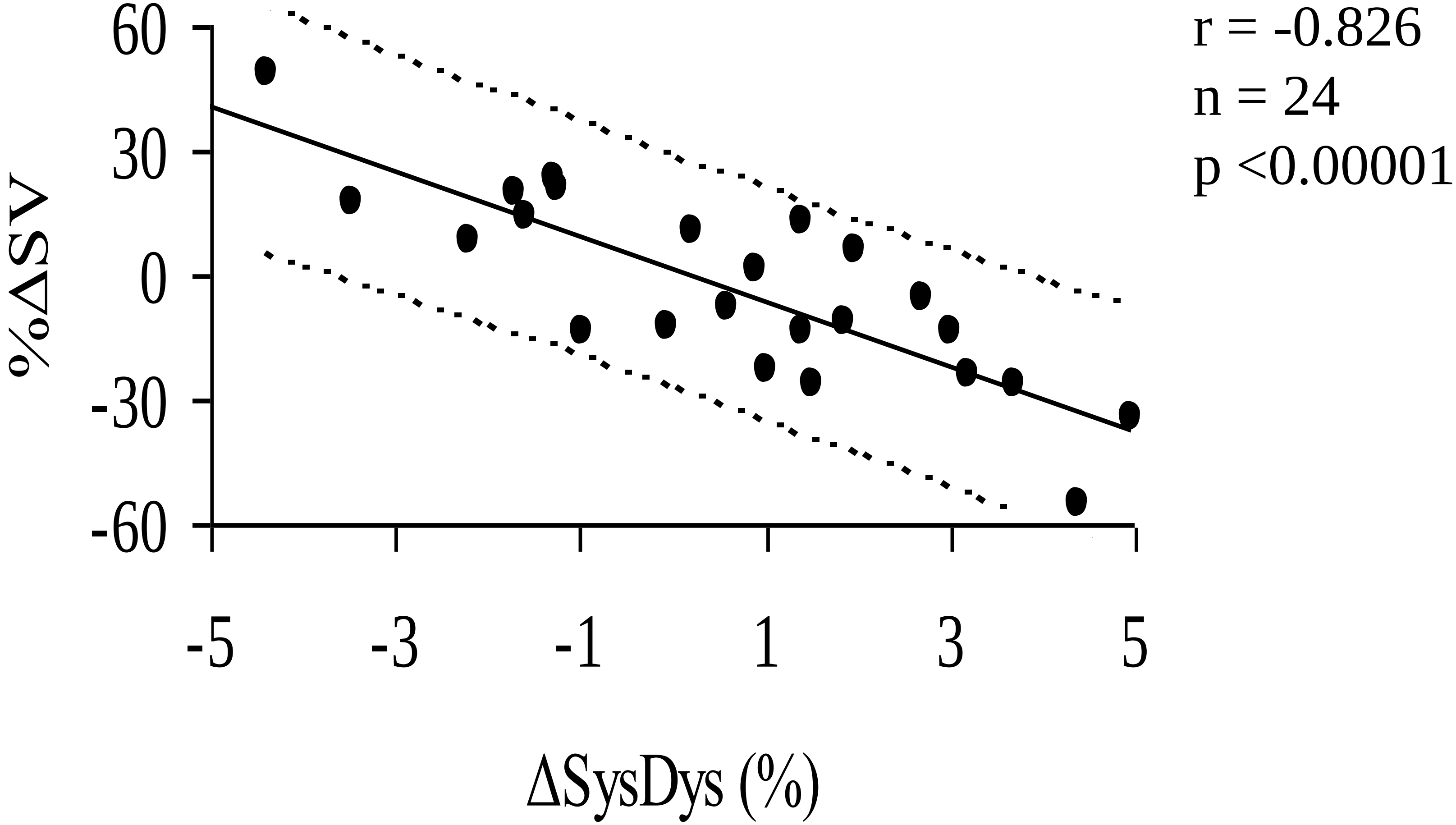
Effects of very early IABP inflation at 1:4 in NYHA class II patient, EF 35%, undergoing LV aneurysmectomy

sep29018



Too late IAB deflation at a 1:4 ratio in a NYHA class III patient, EF20%, undergoing LV aneurysmctomy+CABG

Relation between change in Stroke Volume (SV) and change in Systolic Dyssynchrony (Sys Dys) due to intra-beat changes in left ventricular afterload in heart failure patients.



Schreuder et al ATS 2005

Summary III

- SV changes due to intra-beat changes in afterload induced by early/late IAB inflation/deflation were best predicted by changes in SysDys

- LV performance during IABP is causally related to changes in LV afterload and its timing in the contraction and relaxation phase, to contractile state, to preload and to concomitant changes in LV mechanical dyssynchrony.

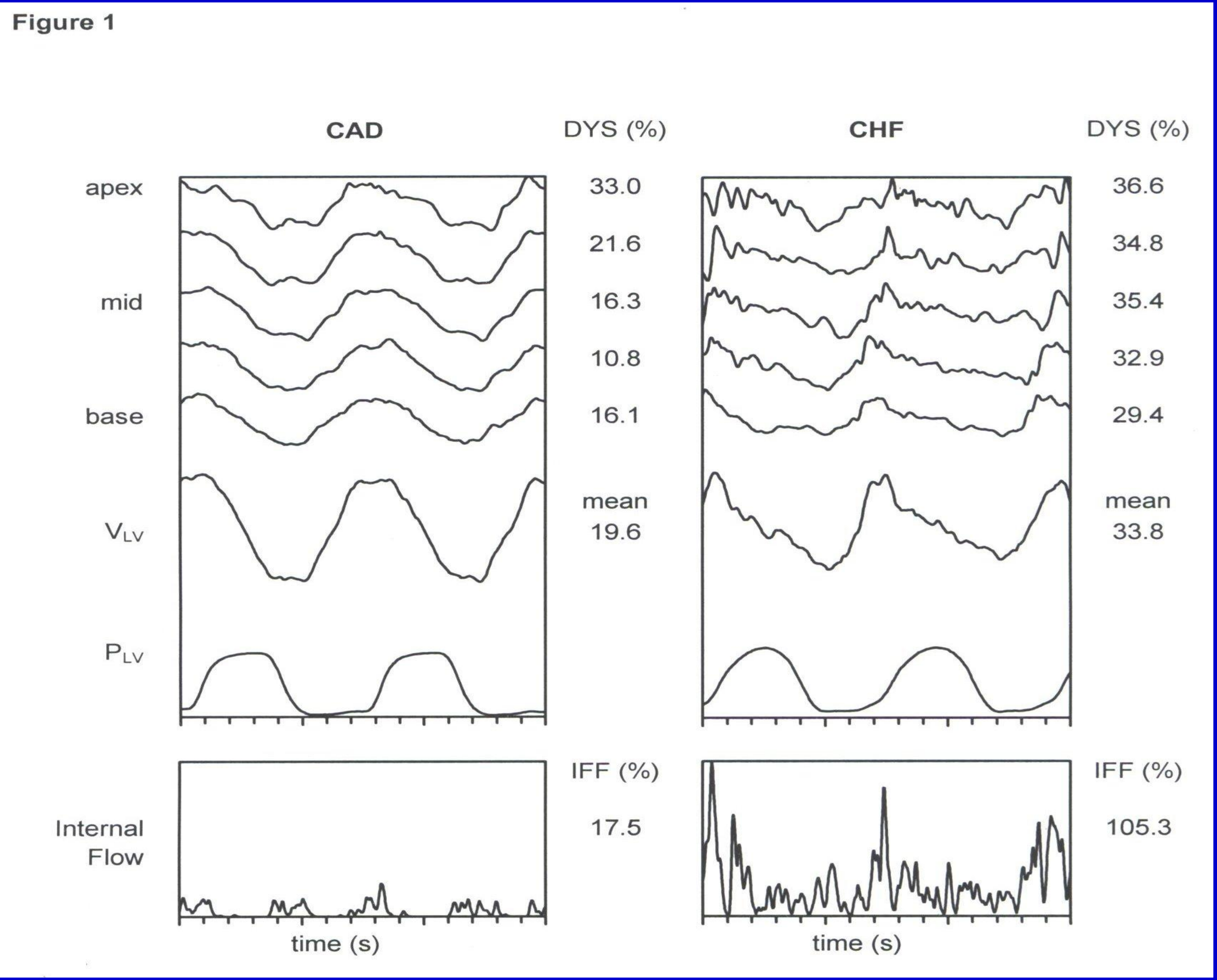
- Brutsaert's hypothesis that LV Dyssynchrony may act as a modulator of cardiac performance together with heart rate, contractile state, preload and afterload may therefore be applicable in heart failure patients.

Ventricular Mechanical Dyssynchrony

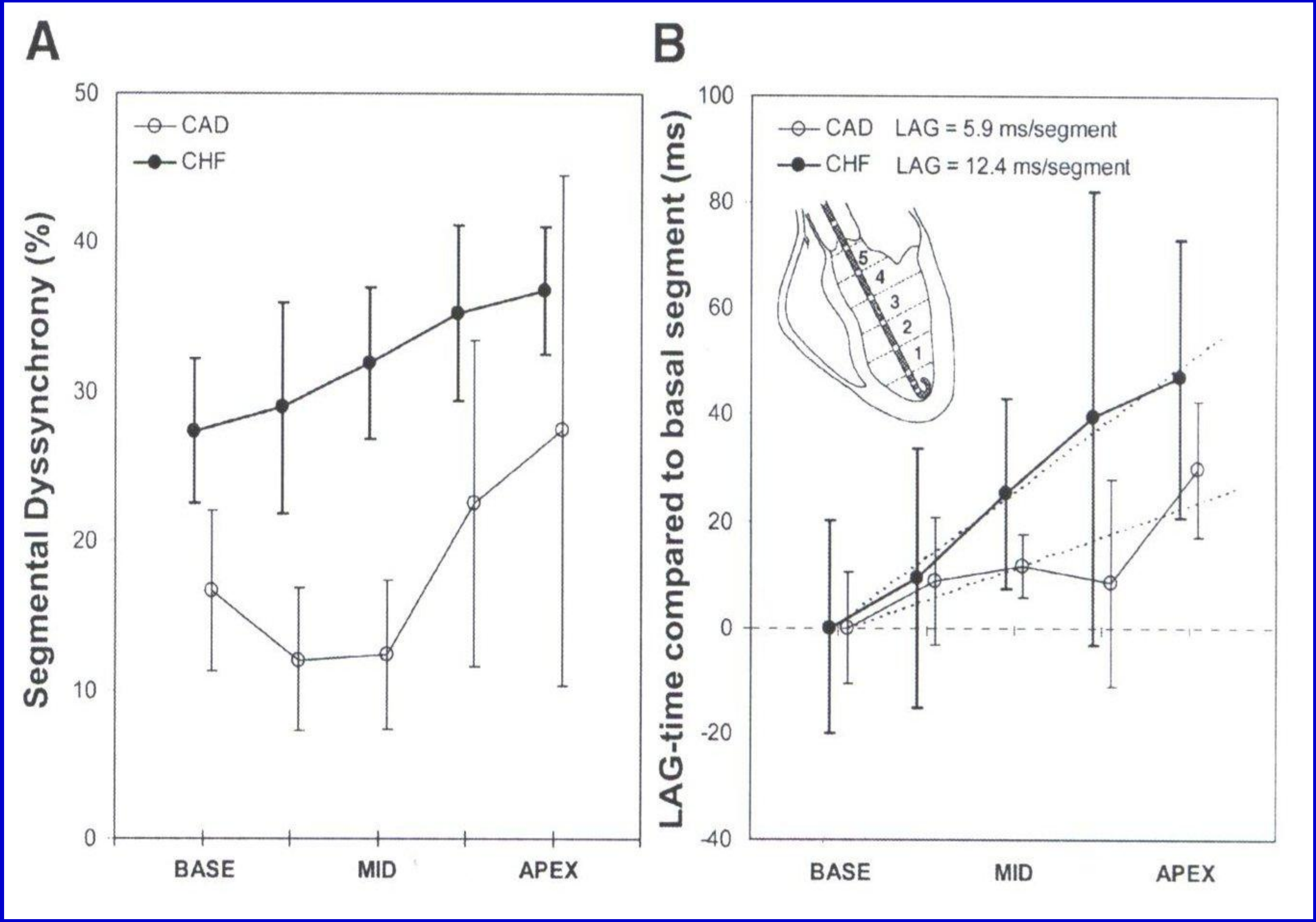
- *"It remains unknown whether dyssynchrony represents a central pathophysiological process or is a marker of progressing cardiac dysfunction in CHF"*
  Leclercq Circulation 2004

- *"It is conceivable that Dyssynchrony represents a newly appreciated pathophysiological process that directly depresses ventricular function and ultimately leads to ventricular dilatation and CHF"* Auricchio Circulation 2004

- *"It will be useful if addiotional methods can be developed that identify dyssynchrony"*
  Willerson Circulation 2004



Steendijk et al, Am J Physiol 2004



Steendijk et al, Am J Physiol 2004

Beat-to-Beat Effects of RV Ventricular Stimulation on LV Mechanical Dyssynchrony and Performance

J Schreuder, A Michelucci, L Padaletti

Careggi Hospital Florence, San Raffaele Hospital Milan

Objective

To evaluate beat-to-beat hemodynamic effects of RV lead position in patients with normal EF undergoing an EP study.

End-point was evaluated according to the following variables:

- Mechanical dyssynchrony
- Systolic and diastolic performance
- Loading conditions

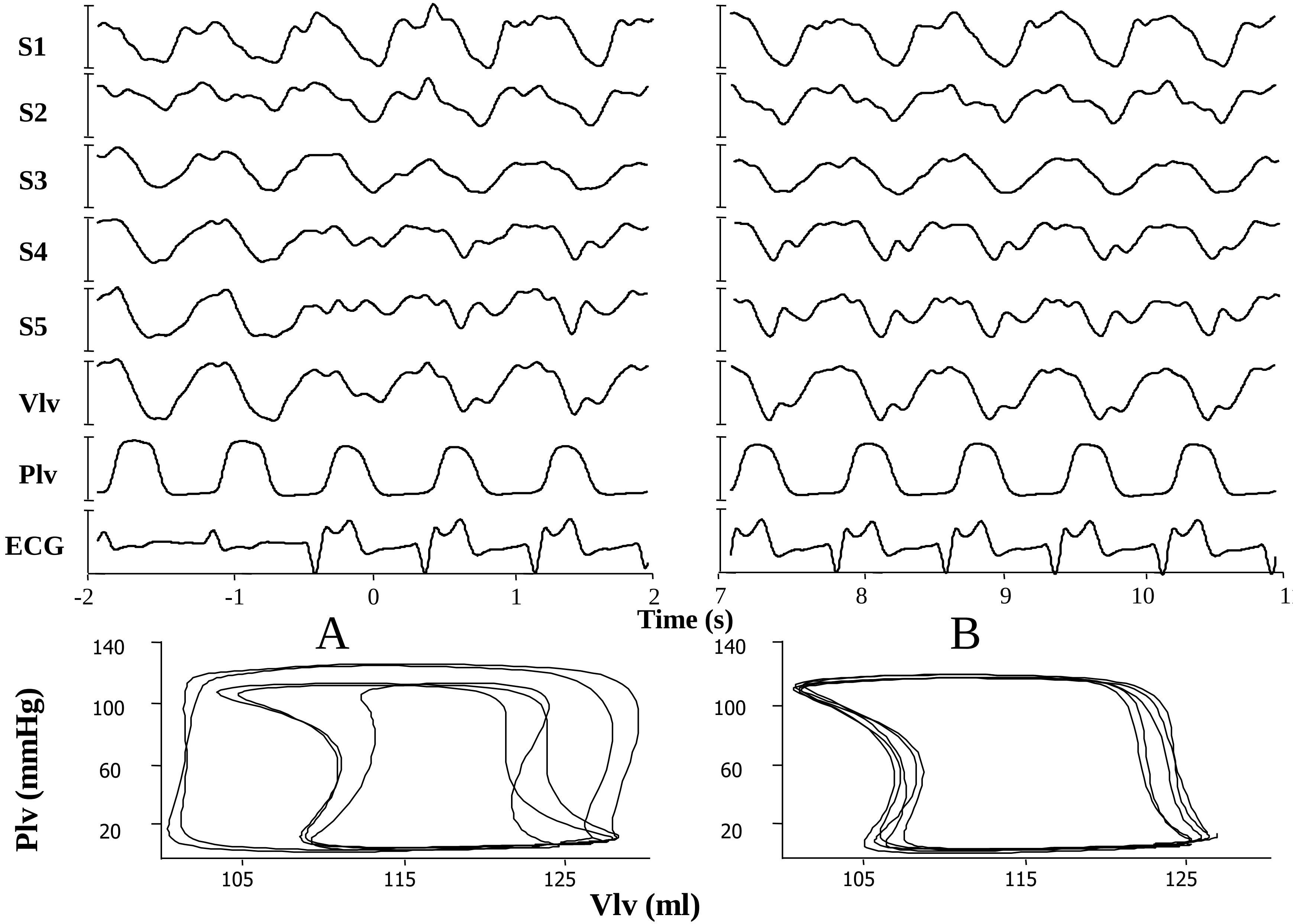
Methods

Stimulation Selective sites:

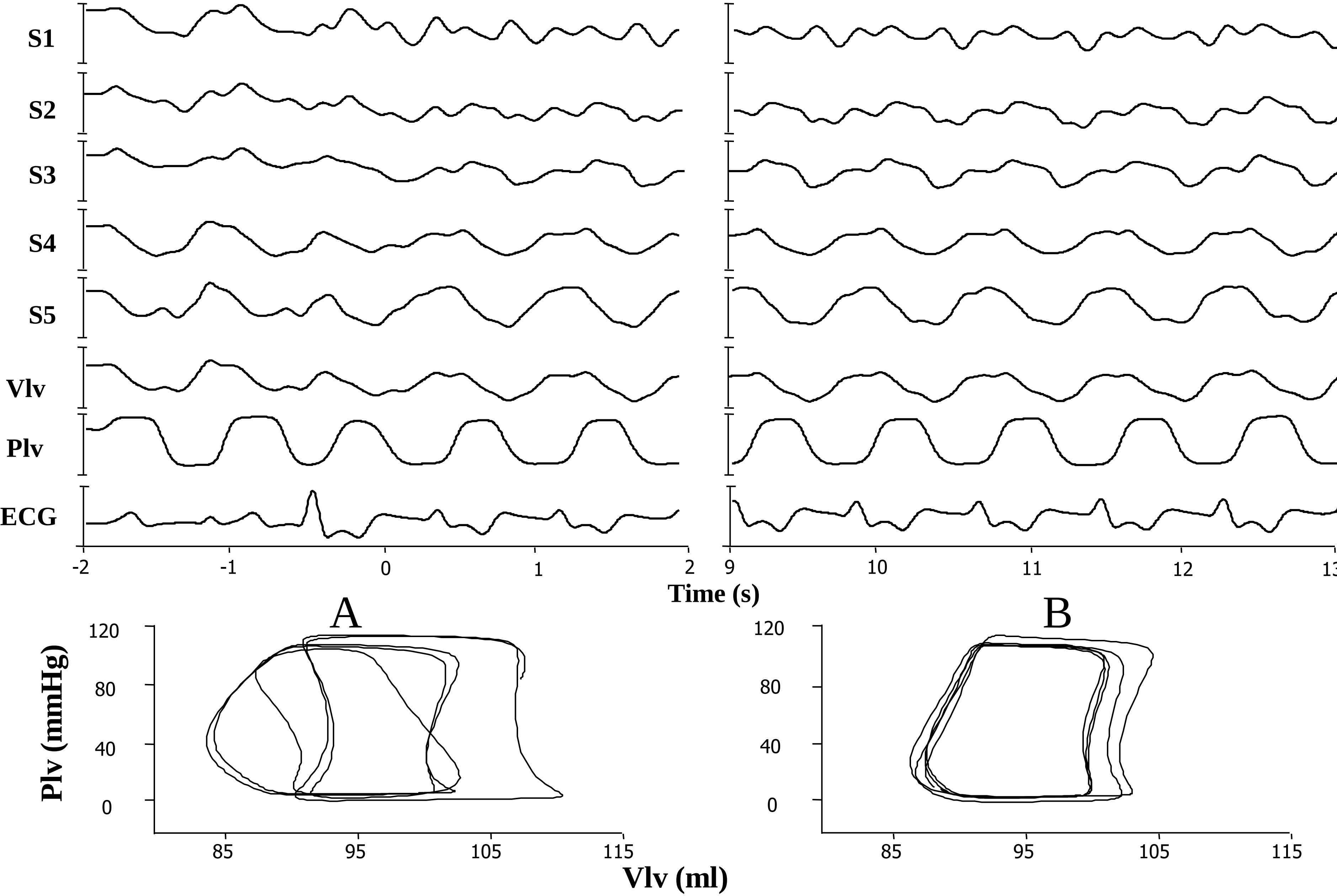
- AAI
- DDD-Apex
- DDD-Free wall
- DDD-RVOT-S

Beat-to-Beat performance analysis from the LV Pressure-Volume plane and LV ventricular dyssynchrony analysis

60 s recordings

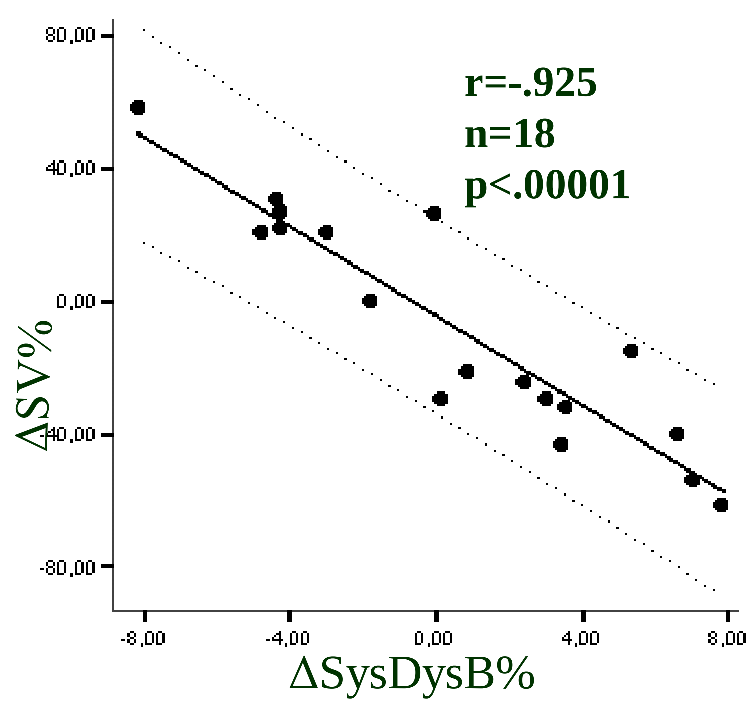


S1
S2
S3
S4
S5
Vlv
Plv
ECG
-2
-1
0
1
2
7
8
9
10
11
Time (s)
A
B
Plv (mmHg)
140
100
60
20
105
115
125
Vlv (ml)



S1
S2
S3
S4
S5
Vlv
Plv
ECG
-2
-1
0
1
2
9
10
11
12
13
Time (s)
A
B
120
80
40
0
Plv (mmHg)
85
95
105
115
Vlv (ml)

		AAI	RV-2s	RV-9s	RV-60s	AAI-10s
		a	b	c	d	e
SV	ml	62 19	37 9[aa]	45 13[aabb]	45 13[aa]	64 18[dd]
EF	%	52 13	37 13[aa]	42 14[aab]	43 14[aa]	53 12[dd]
LVEDV	ml	126 54	118 56	120 54	118 50[a]	125 49[d]
LVESV	ml	61 40	65 43	63 41	61 38	62.6 38
+dP/dt	mmHg/s	1645 319	1509 238	1603 243[bb]	1564 278	1648 313
-dP/dt	mmHg/s	1738 300	1217 284[aa]	1411 307[aabb]	1516 344[aacc]	1690 333[dd]
Tau	ms	31 6	41 8[aa]	38 7[aa]	35.6 6.6[aacc]	33 6
DiaDysT	%	20.9 7	26 4[aa]	23.3 7[b]	21.8 6.3[a]	19.6 7.2
SysDysB	%	13 9	17 8[aa]	14 10[b]	14.4 9	14 8.5
DiaDysA	%	21 7	26 7[aa]	23.3 8[a]	23.2 6[a]	21 7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ΔSV%
ΔSysDysB%
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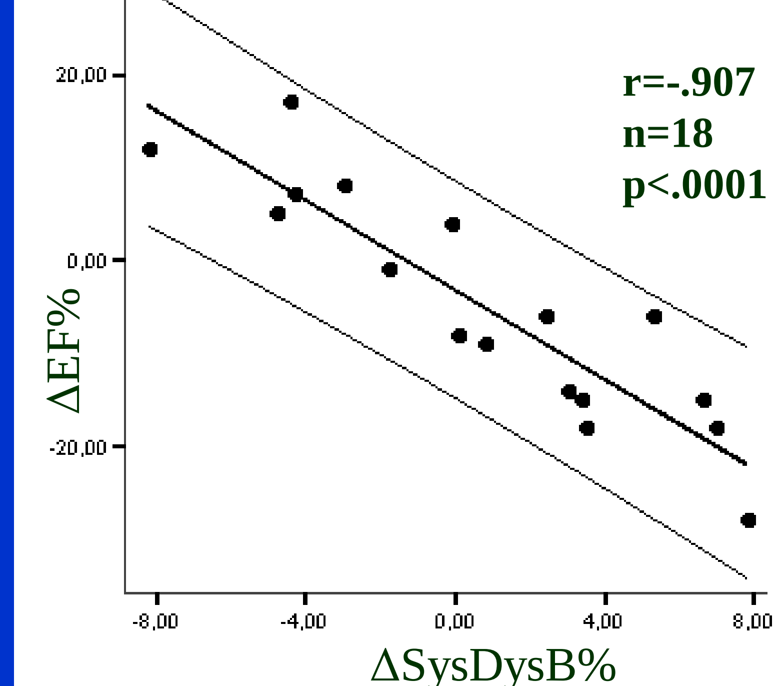
0,00
4,00
8,00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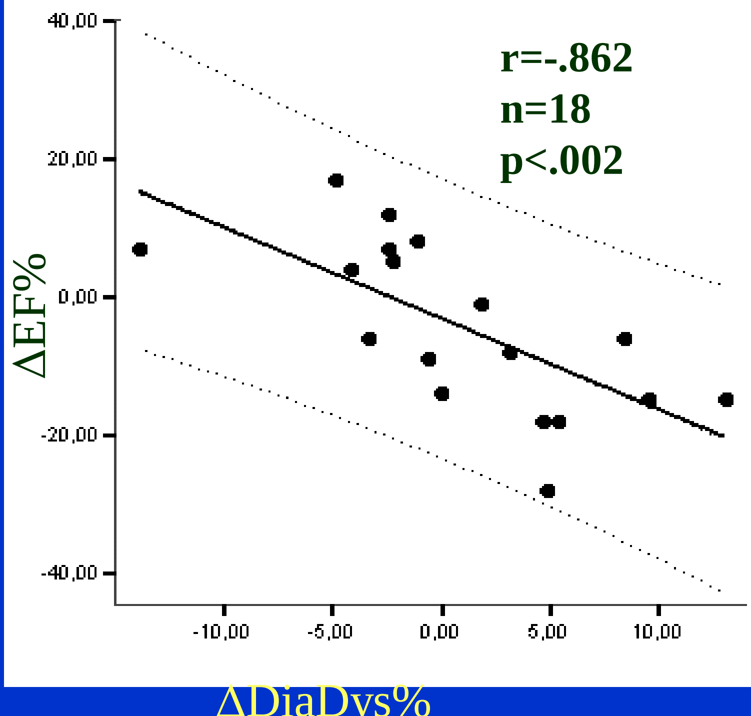
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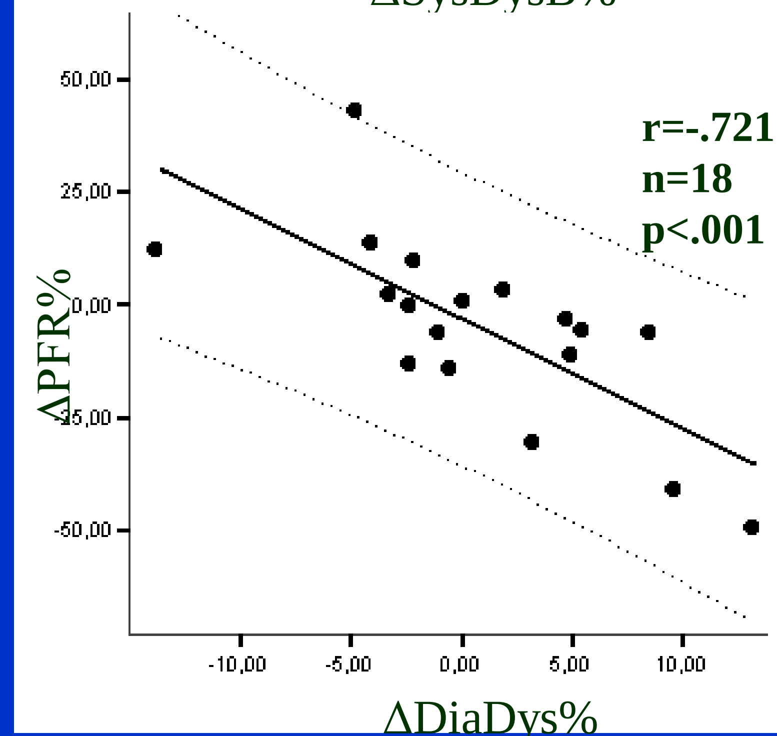
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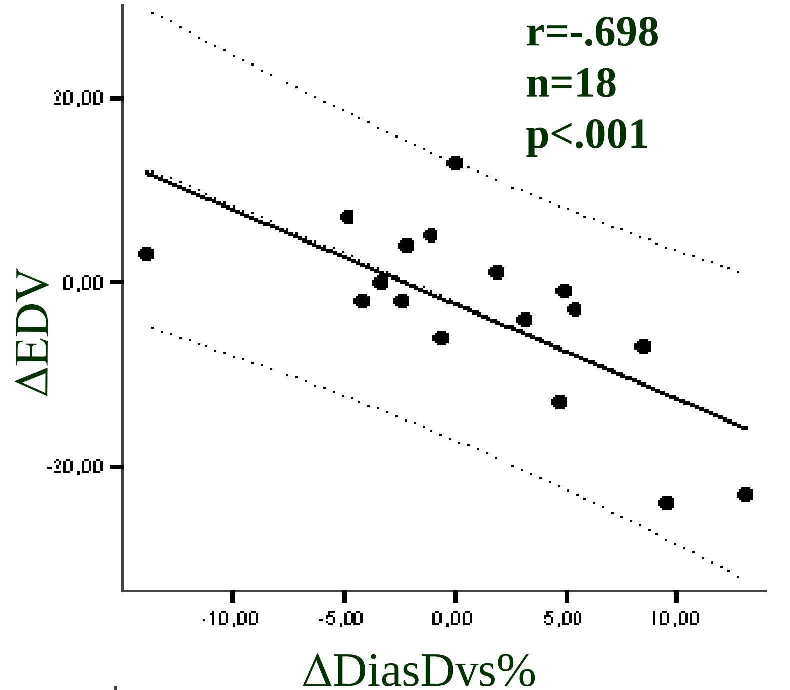
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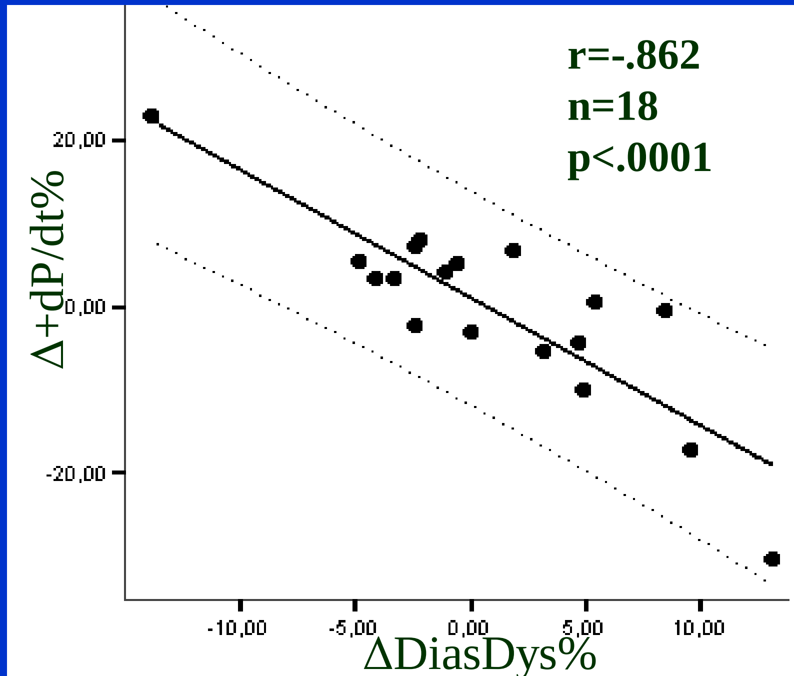
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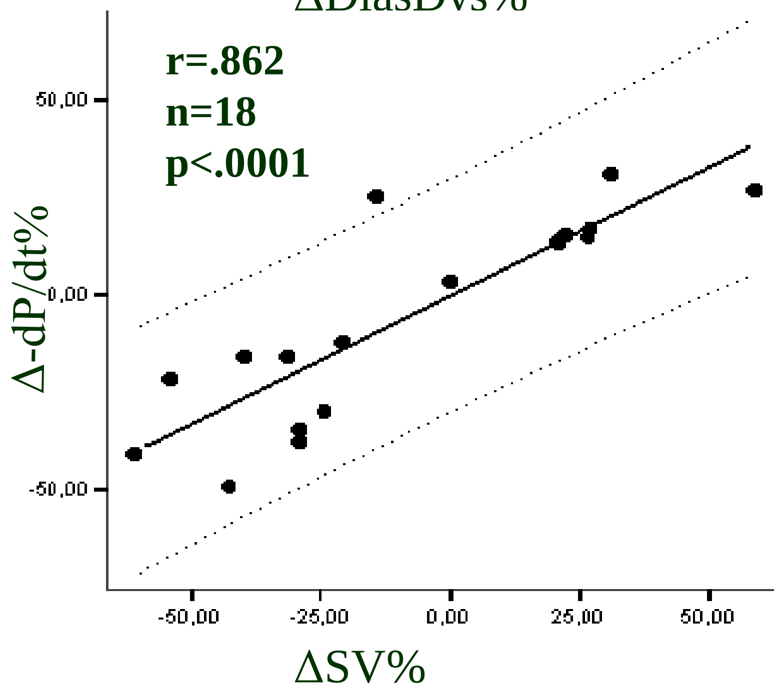
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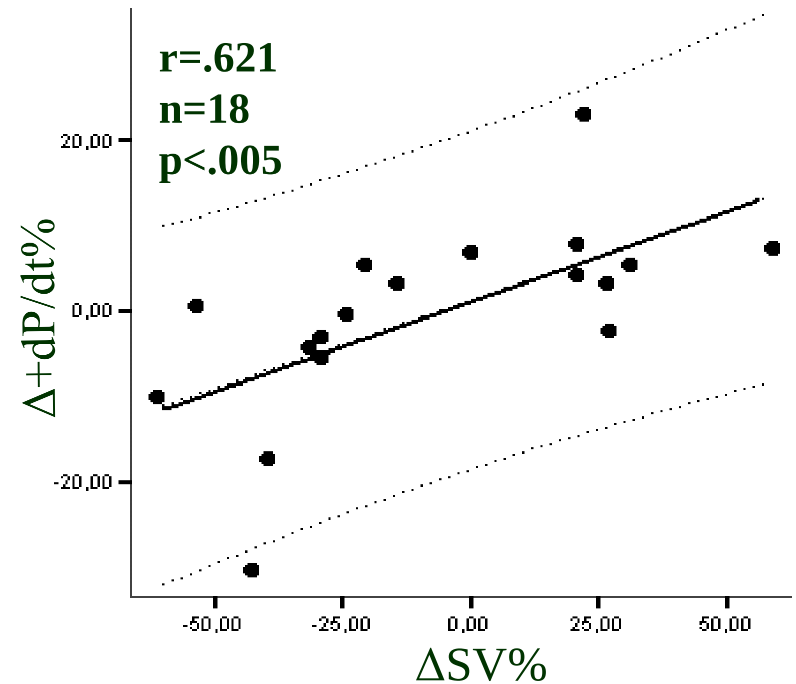
50,00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Δ+dP/dt%
ΔSV%
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25,00
50,00

Conclusions

- RV pacing acutely increased Systolic and Diastolic Dyssynchrony, decreased SV, and impaired diastolic relaxation
- Recovery of Systolic Dyssynchrony was observed within a 10s time-span, suggesting intrinsic cardiac Dyssynchrony restoring properties
- Reciprocally LV or BiV pacing at best lead positioning (setting) should result in an acute Systolic Dyssynchrony decrease

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- *"It is conceivable that Dyssynchrony represents a newly appreciated pathophysiological process that directly depresses ventricular function and ultimately leads to ventricular dilatation and CHF"*
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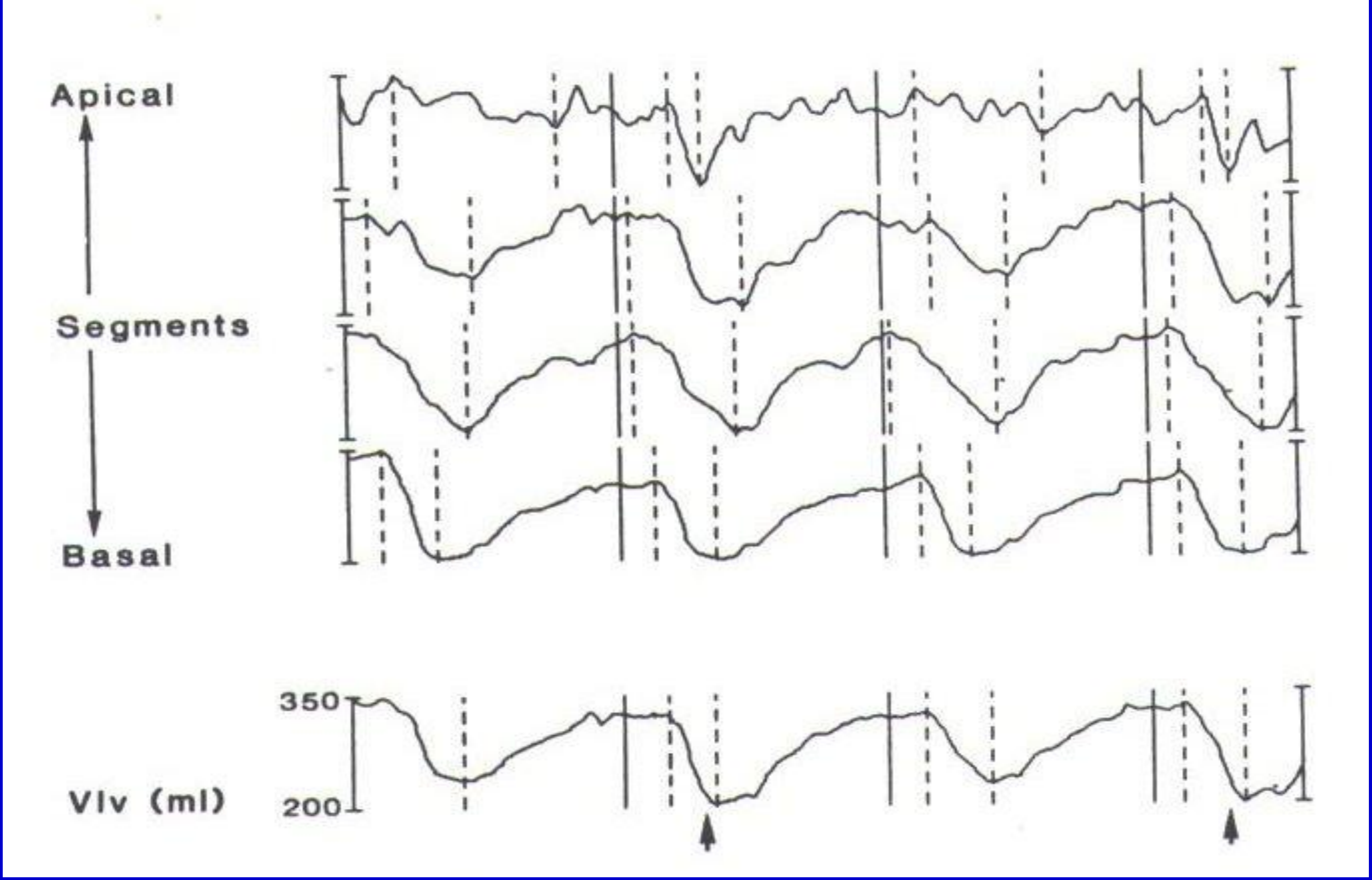
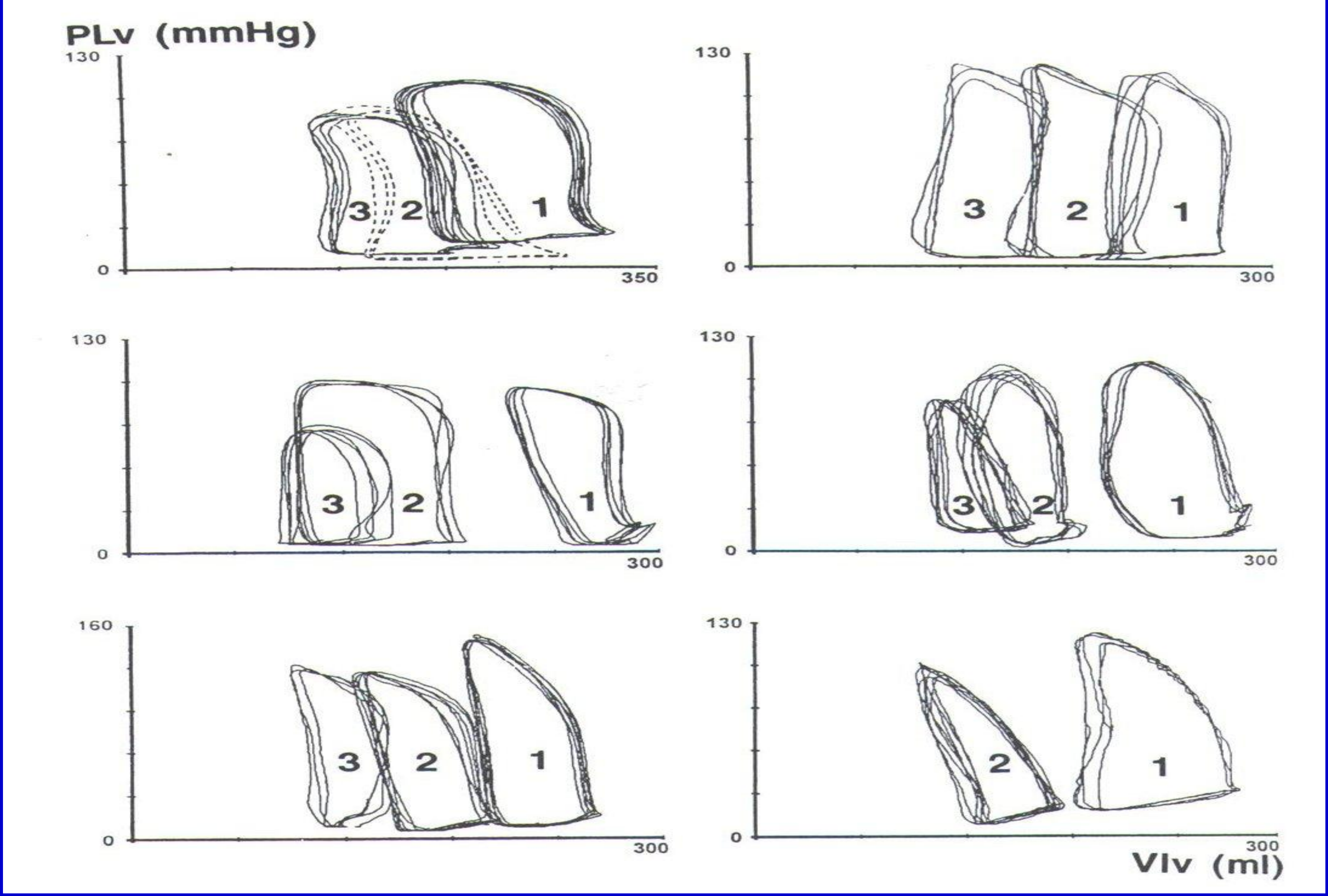
Synchronizing Effects of Cardiomyo-stimulation on Segmental Ventricular Volumes



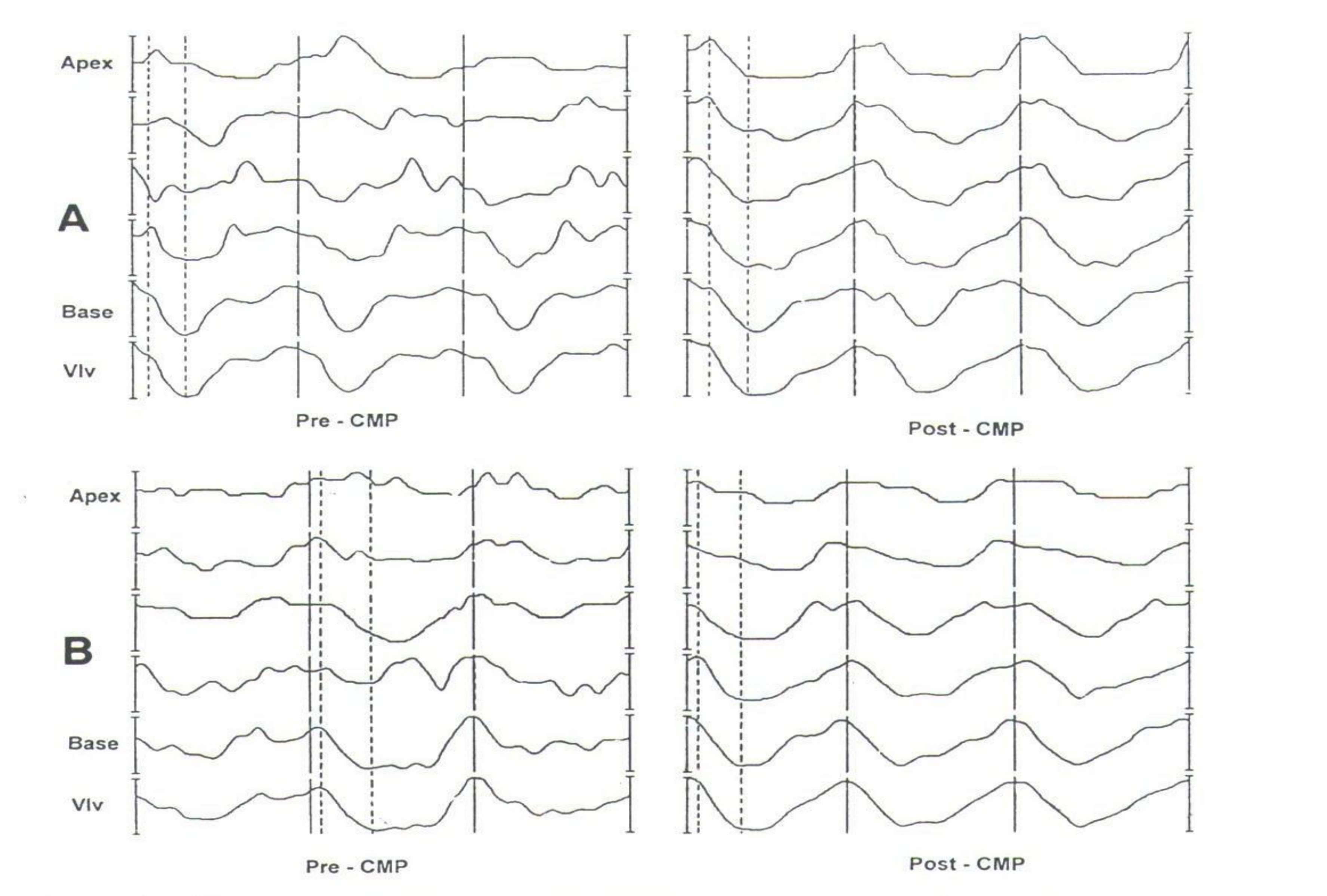
Schreuder et al, Circ 1995

P-V Effects of Cardiomyoplasty Before (1) Six (2) and Twelve Months (3) After



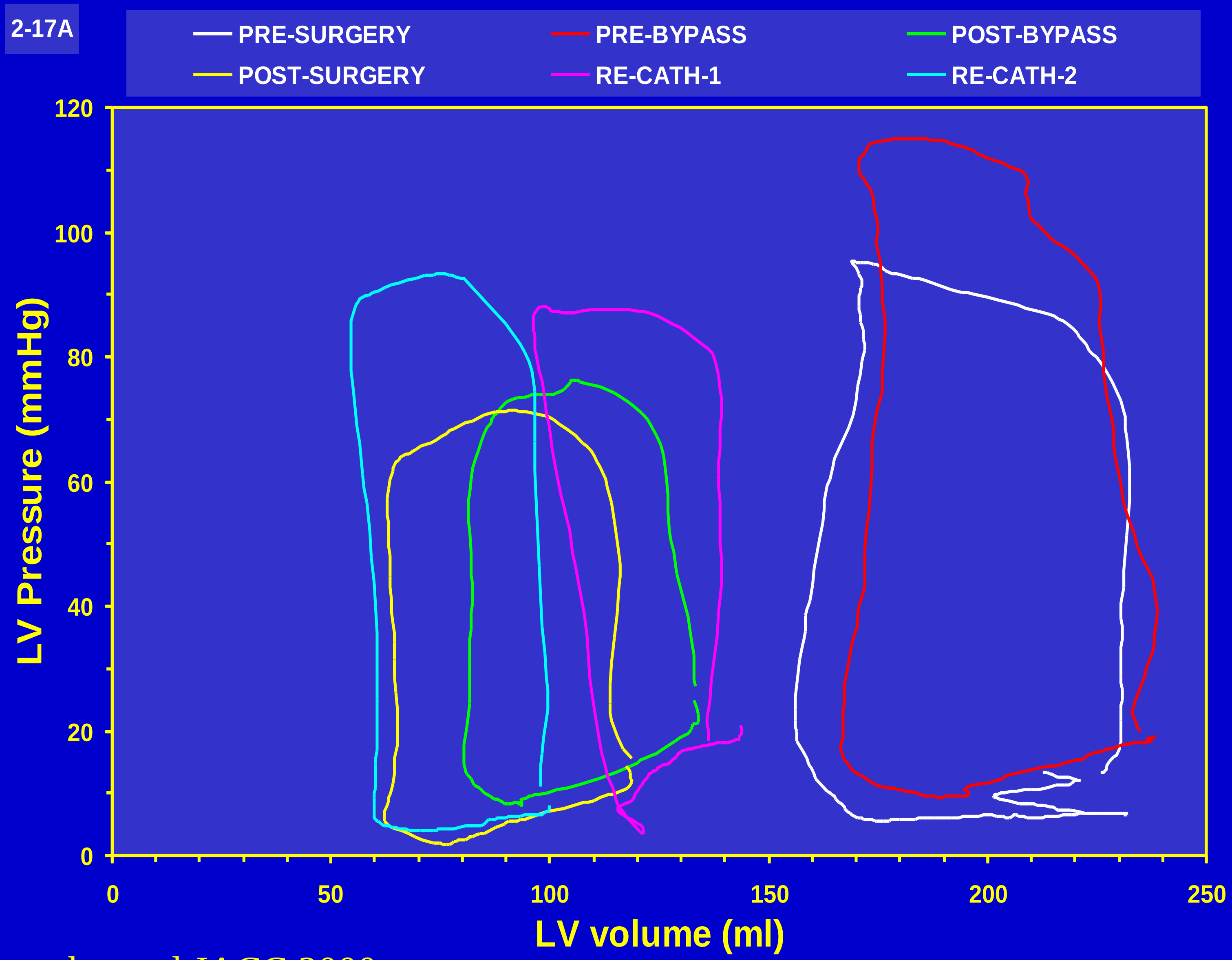
Schreuder et al, Circ 1997

Dyssynchrony Before and After Cardiomyoplasty

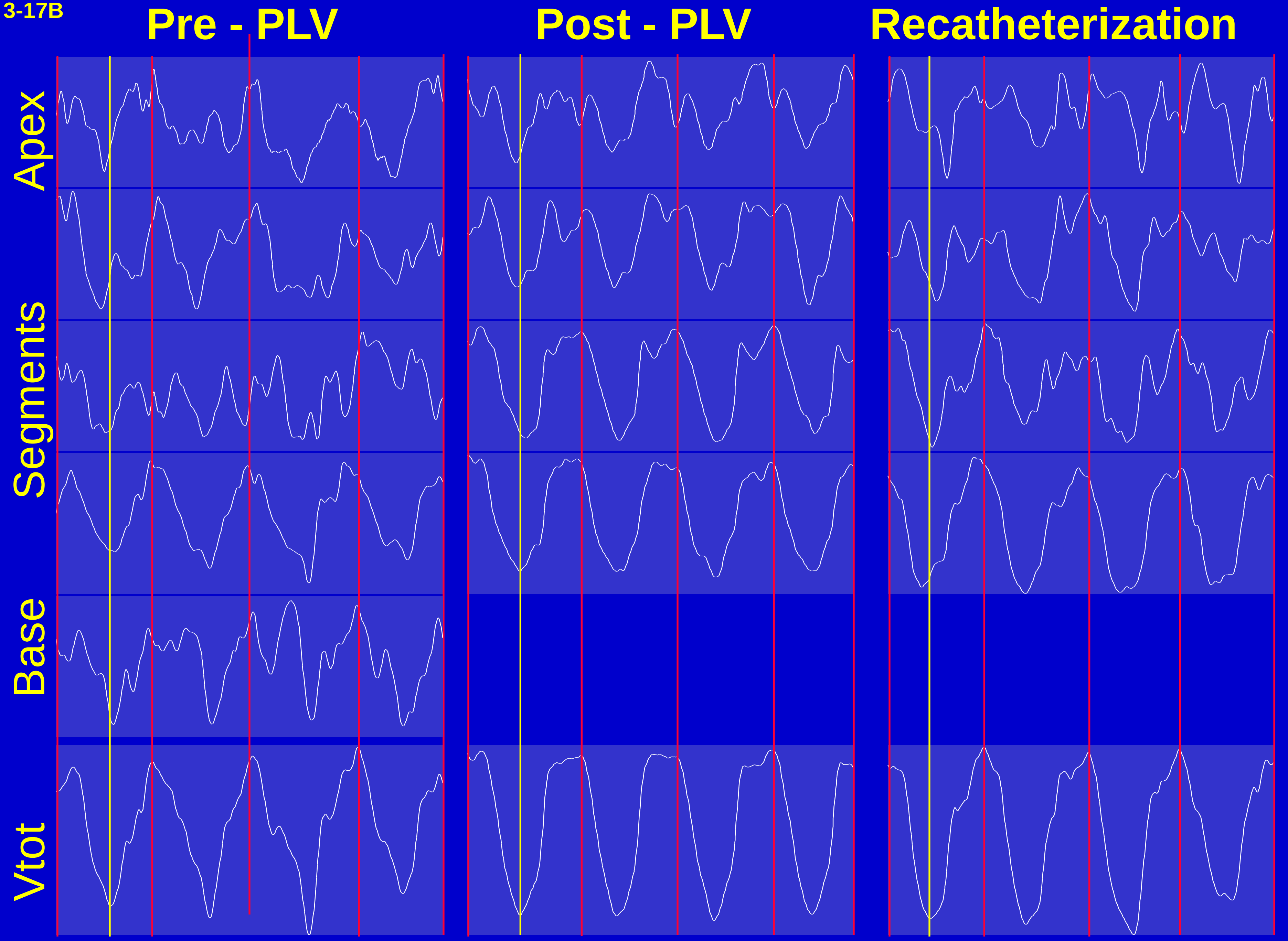


Schreuder et al, Circ 1997

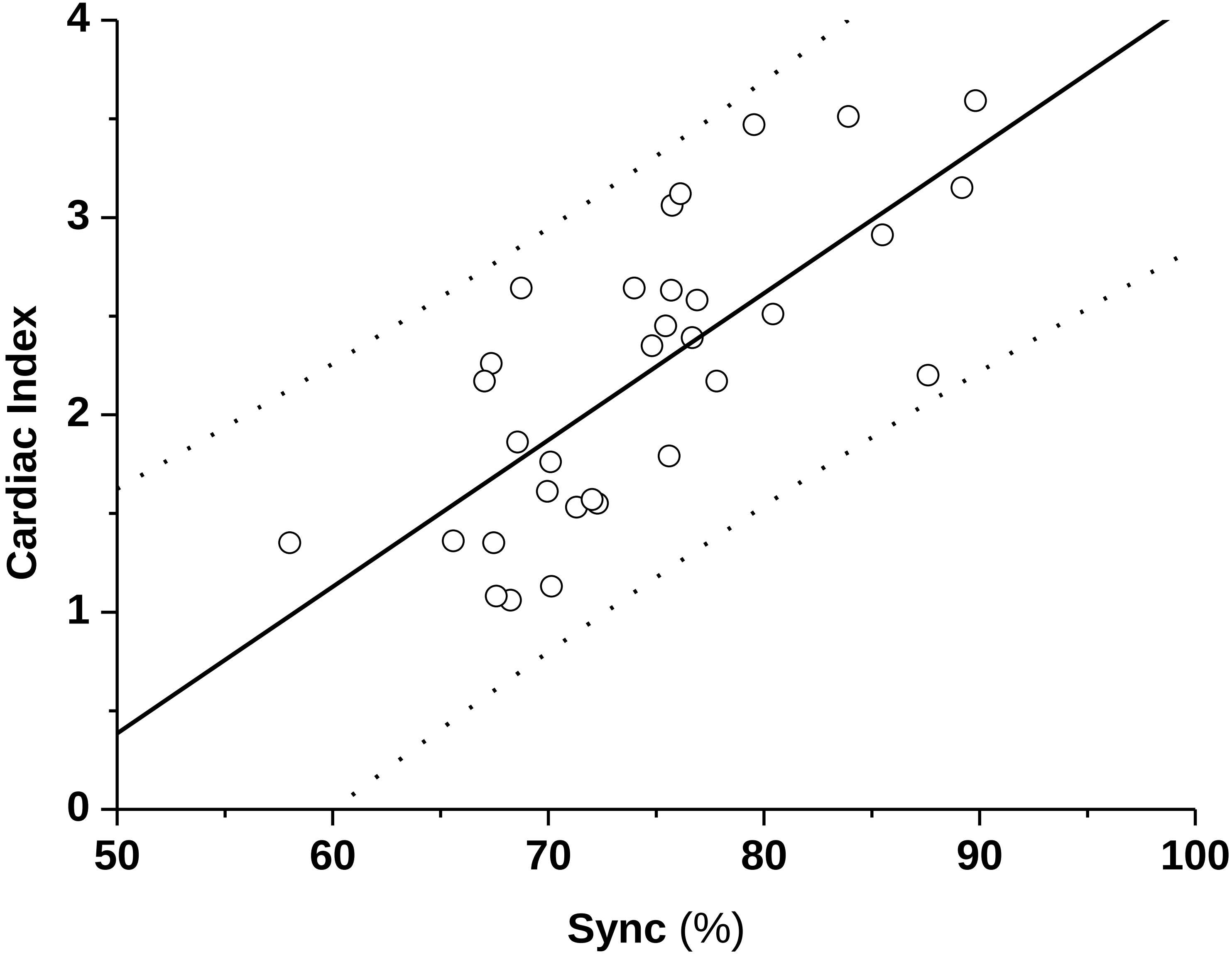
Partial Left Ventriculectomy according to Batista



Schreuder et al JACC 2000



Schreuder et al. JACC 2000



Schreuder et al, JACC 2000

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