# Speckle Tracking Echocardiography in Congenital Heart Disease – Transposition of Great Arteries


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- Cardiology
- Many patients
- Big experience
- Good cardiosurgery
- Many innovations; tehnology

- Pediatric cardiology
- Different CHD
- Variable hemodynamics
- Difficult cardiosurgery
- Different thinking

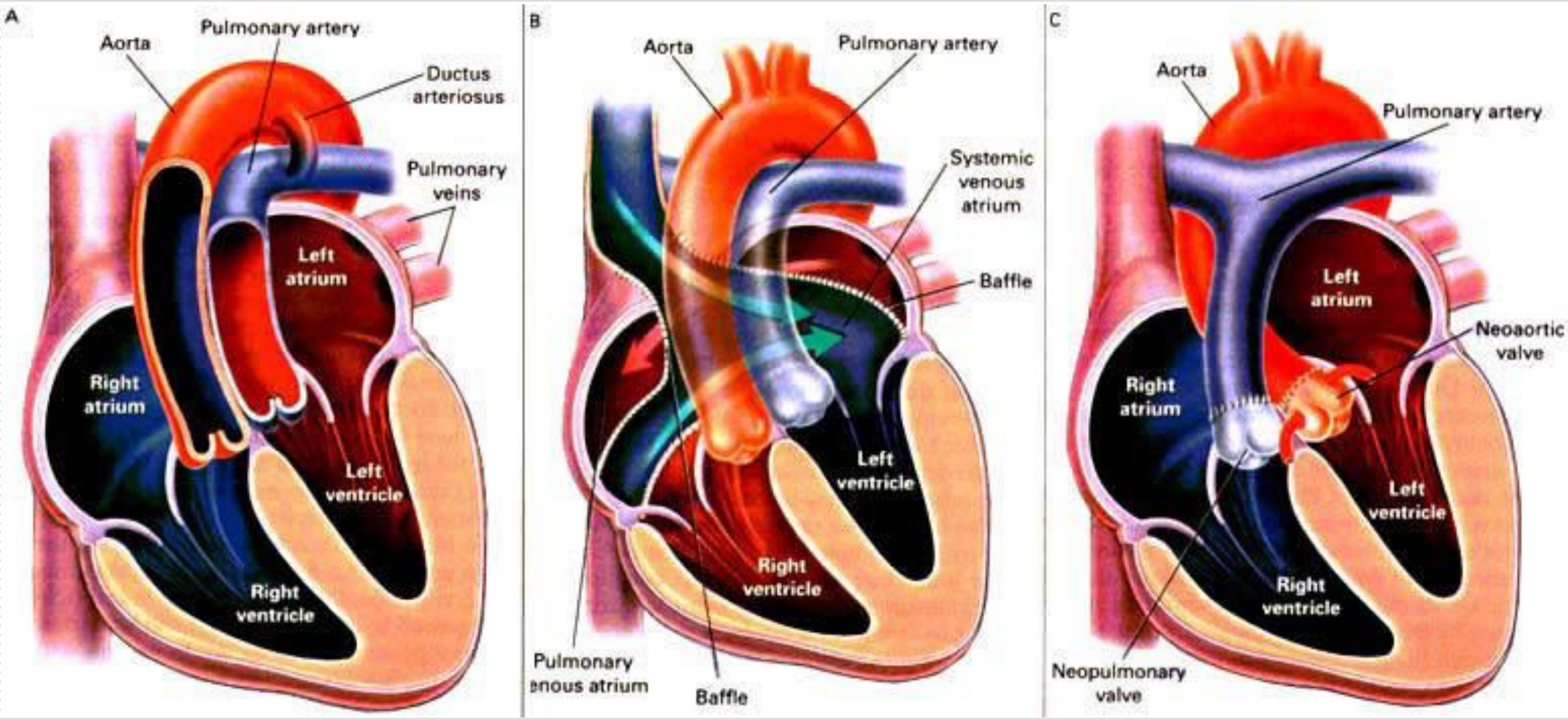
Cross-point?
GUCH patients!

# What is TGA?

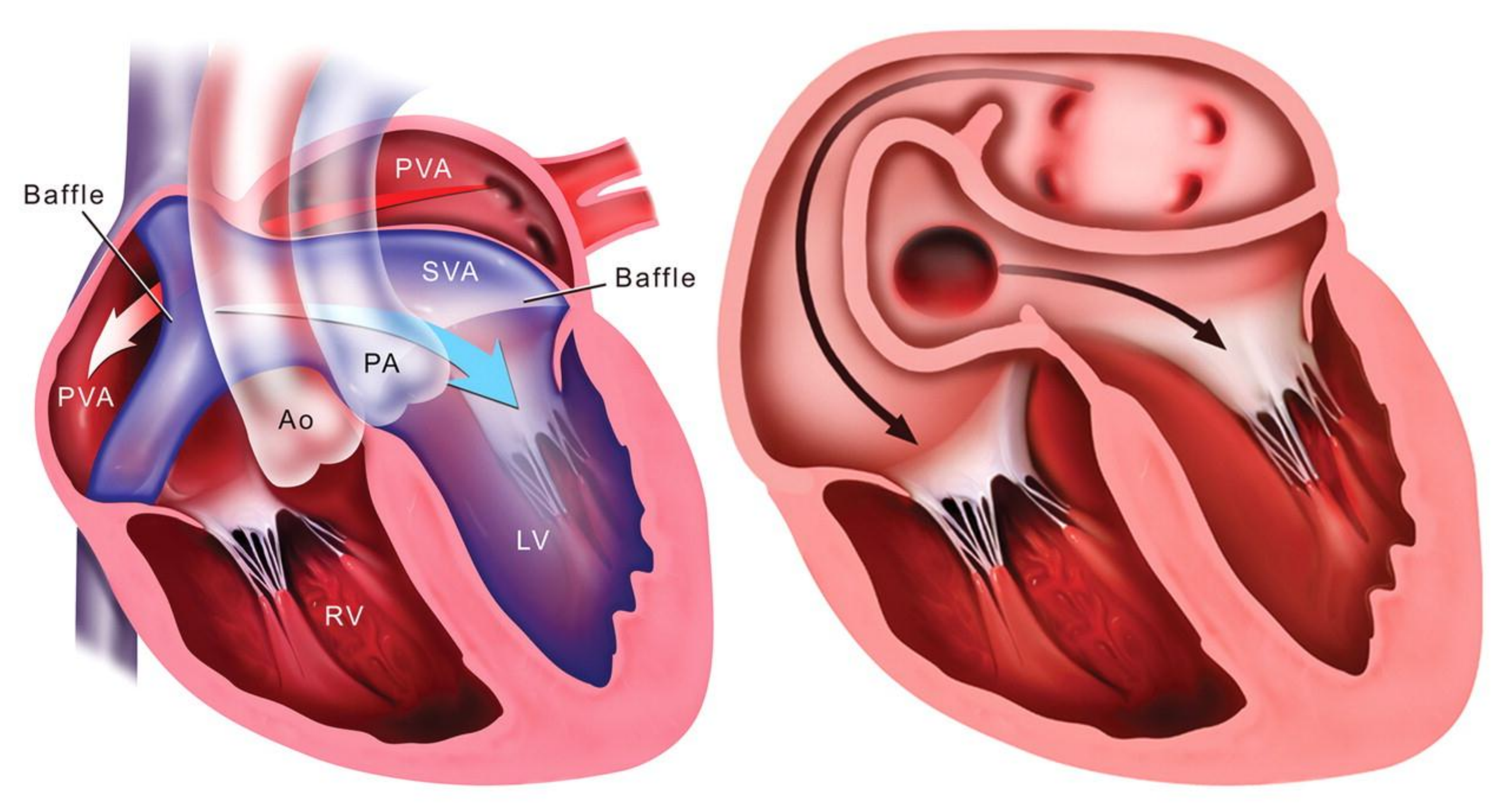
- Not uncommon - 8% of CHD.
- Potentially lethal without treatment
- Treatment is surgery!
- Two possible operations:
  - Atrial switch - Senning–Brom – 1964-1985-Physiological correction;
  - Arterial switch - anatomic correction-1980-............

# What is TGA?

TGA Senning Arterial switch

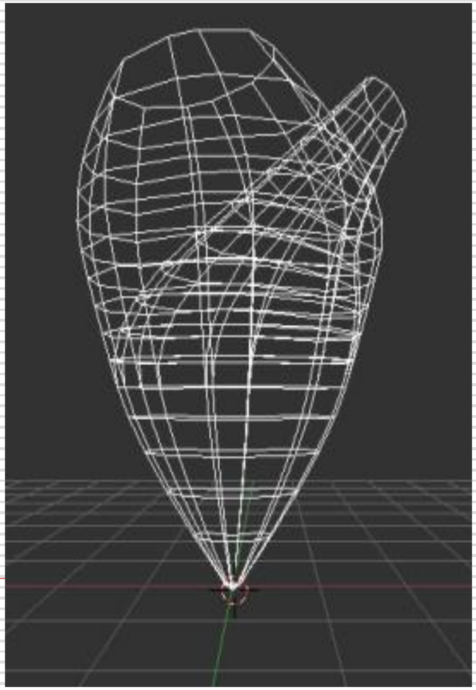


# Senning Operation



# Anatomic characteristics of the systemic RV

- Relatively small papillary muscles
- Hypokinetic part – infundibulum
- Systolic movement of septum towards LV
- Abnormal volume load
- Different coronary perfusion
- Different structure of the wall



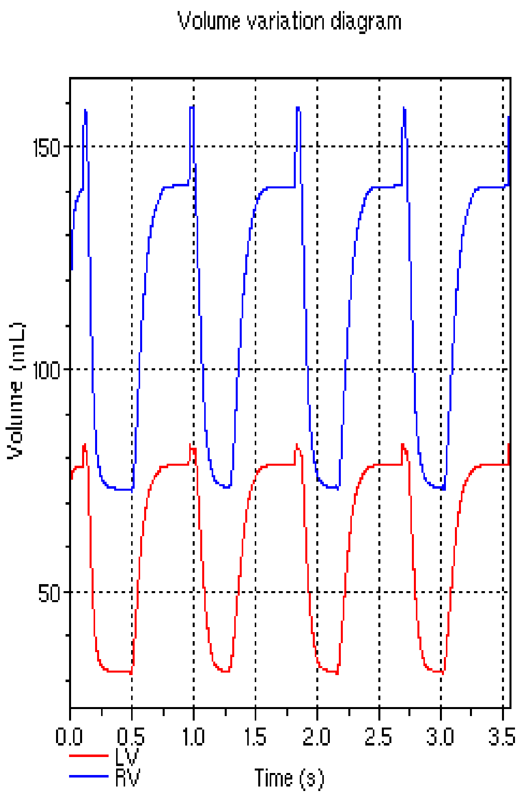
**Potentially dysfunctional**

# Long-term problems after Senning operation - pathophysiology

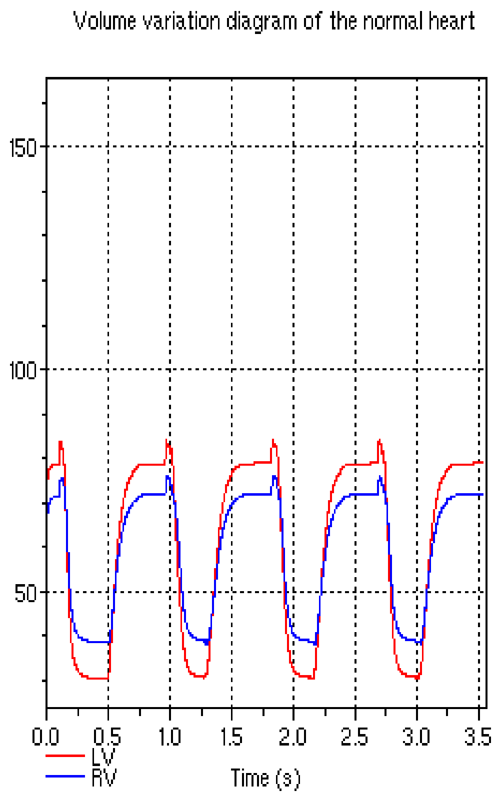
- Long-term volume overload
- Ischemia
- Fibrosis and remodeling of RV

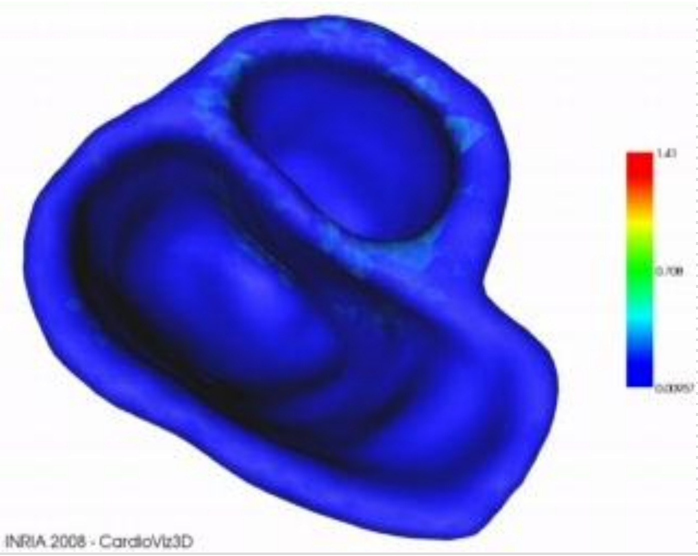
# RV Volume

Post Senning




Normal heart




N.Poirier-J.Th.Cardiovasc.Surg.2004

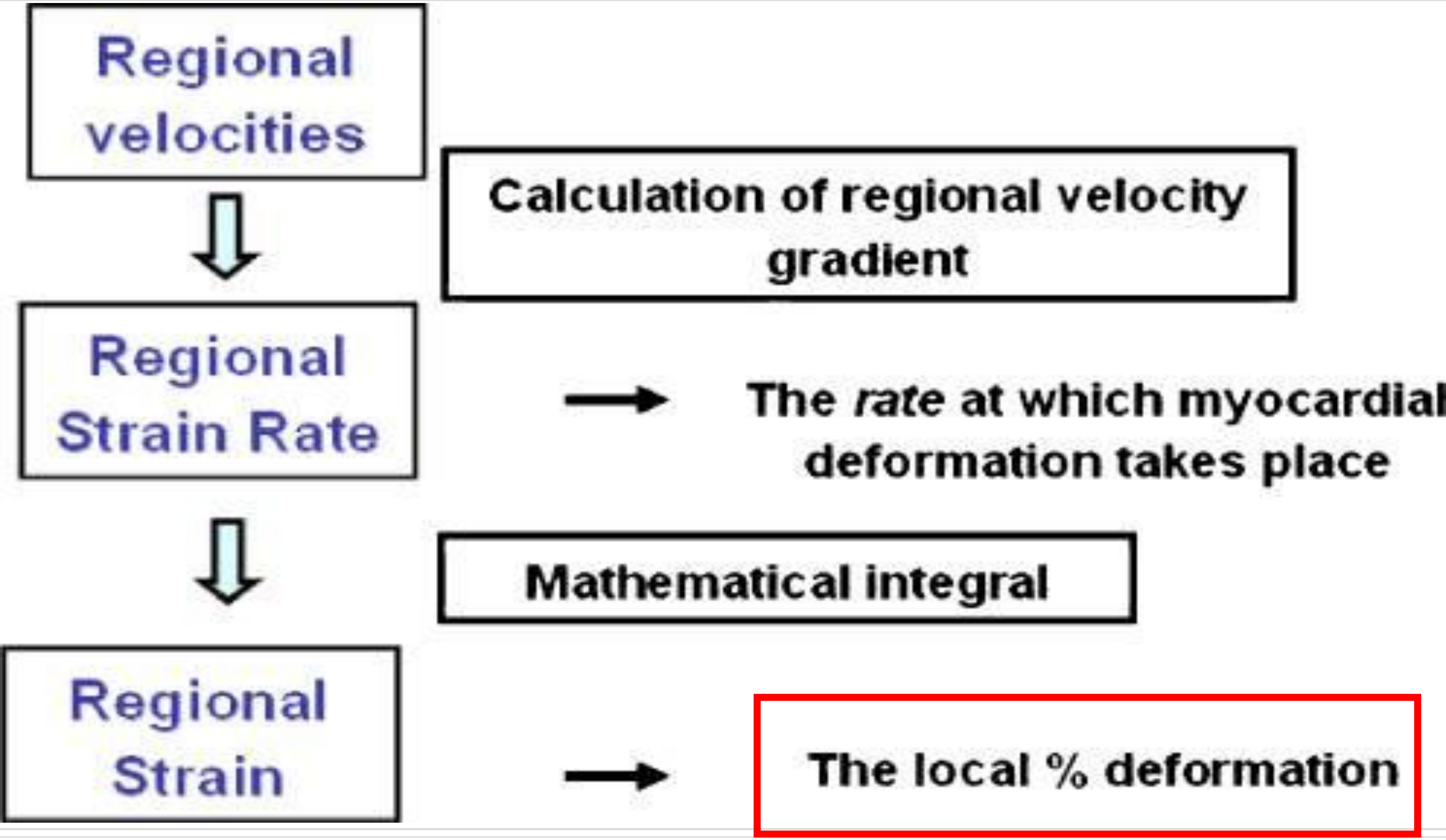
# Long-term problems after Senning operation

- Systemic venous or pulmonary venous obstruction
- RV- Dysfunction
- TR
- Arrhythmias

# Diagnostic methods for RV

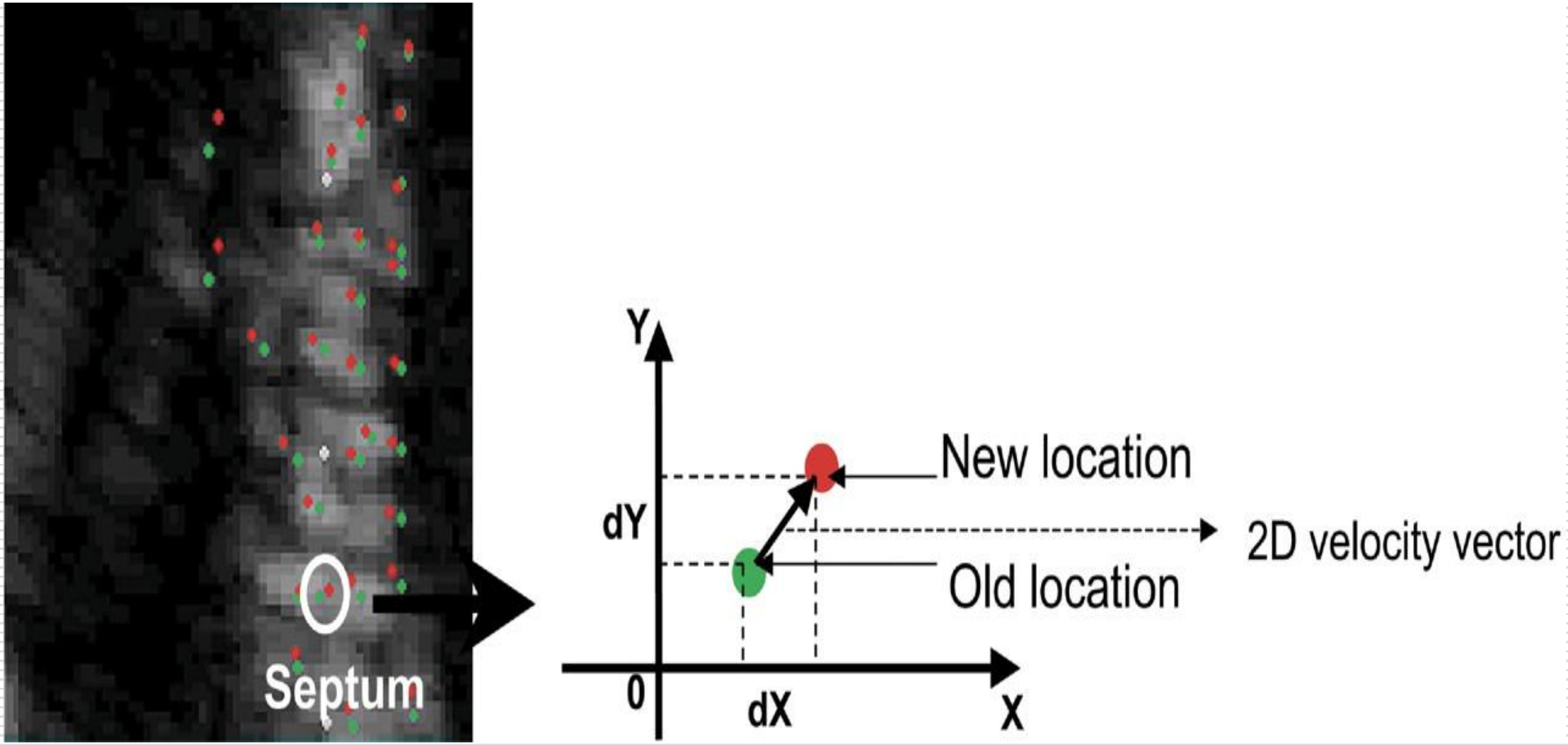
- Echocardiography
  - Conventional echo
  - TDI strain, strain rate
  - Speckle tracking strain and strain rate
  - 3D
- MRI – reference method
- Perfusion scyntigraphy

# Strain as a marker of deformation



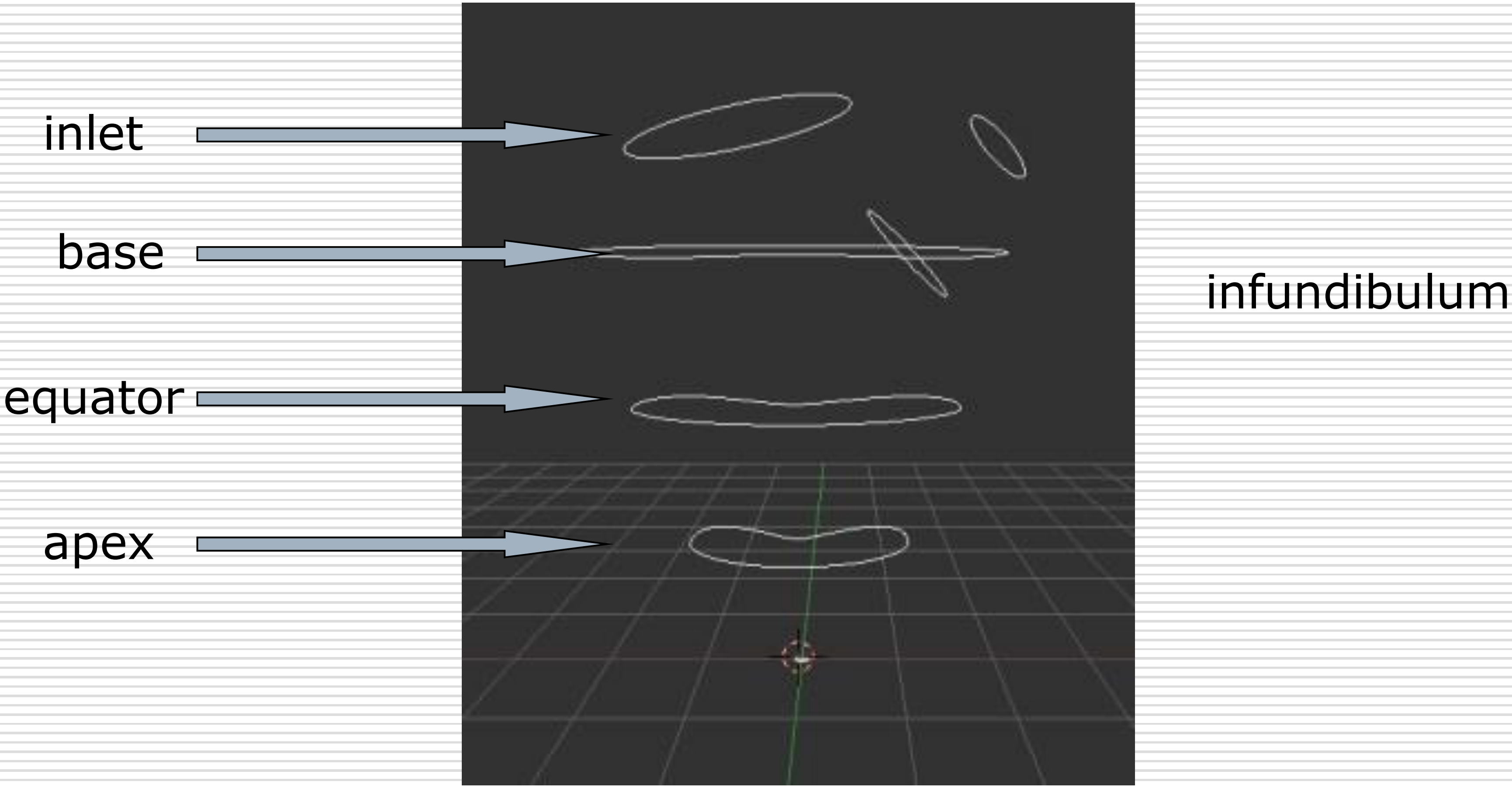

Strain represents myocardial deformation and strain rate represents the rate at which this deformation takes place.

# Speckle tracking




Two-dimensional (2D) strain is based on comparison of the image texture from frame to frame. The distortion of this pattern permits assessment of strain in the axis of movement rather than the axis of the ultrasound beam.

# Key parts of the right ventricle



# STE - validation in pediatric patients LV

'able 2: Values of longitudinal and circumferential strain and SR in adults and children.

| Apical 4 Chambers segmental mean Systolic Strain % | | | | | | |
|---|---|---|---|---|---|---|
| | Bas Sept | Mid Sept | Ap sept | Ap lat | Mid lat | Bas Lat |
| Children | -20.6 ± 4.4 | -20.9 ± 3.9 | -25.4 ± 6.1 | -19.8 ± 5.8 | -23.3 ± 4.2 | -22.9 ± 3.4 |
| Adults | -15.8 ± 3.5 | -17.7 ± 4.1 | -24.0 ± 0.8 | 19.9 ± 4.82 | -18.9 ± 4.9 | -17.9 ± 5.2 |
| **P value** | **0.0002** | **0.0133** | 0.4664 | 0.4236 | **0.0052** | **0.0013** |

Table 3: Values of global longitudinal and circumferential Strain and SR in normal adults and children.

| | | | |
|---|---|---|---|
| Global Longitudinal Strain (all subjects) | -20.16 ± 3.37 | Global Longitudinal SR (all subjects) | -1.16 ± 0.22 |
| Global Longitudinal Strain Adults | -19.05 ± 3.05 | Global Longitudinal SR Adults | -1.07 ± 0.19 |
| Global Longitudinal Strain Children | -22.18 ± 3.06 | Global Longitudinal SR Children | -1.30 ± 0.20 |
| Global Circumferential Strain (all subjects) | -24.86 ± 6.76 | Global Circumferential SR (all subjects) | -1.78 ± 0.58 |
| Global Circumferential Strain Adults | -24.93 ± 7.35 | Global Circumferential SR Adults | -1.67 ± 0.55 |
| Global Circumferential Strain Children | -25.60 ± 7.08 | Global Circumferential SR Children | -1.95 ± 0.60 |

Cardiovasc.Ultrasound 2009 7:8

# STE - validation in pediatric patients- RV

Table 2—Peak strain and strain rate in each segment ($x \pm s$)

| Group | NO. | Right ventricular free wall BS | Right ventricular free wall MS | Right ventricular free wall AS | Septum BS | Septum MS | Septum AS |
|---|---|---|---|---|---|---|---|
| Ss(%) | | | | | | | |
| 1 | 31 | −24.47 ± 1.41 | −23.36 ± 1.84 | −23.89 ± 1.29 | −24.14 ± 1.21 | −24.56 ± 2.84 | −24.77 ± 2.09 |
| 2 | 32 | −23.95 ± 1.59 | −24.22 ± 1.38 | −23.67 ± 2.00 | −24.31 ± 1.24 | −24.57 ± 1.38 | −23.88 ± 1.44 |
| 3 | 29 | −24.36 ± 1.40 | −24.15 ± 2.12 | −24.18 ± 1.74 | −24.55 ± 1.40 | −23.95 ± 1.57 | −24.37 ± 1.22 |
| 4 | 31 | −23.92 ± 3.22 | −24.23 ± 1.49 | −24.49 ± 0.82 | −23.88 ± 1.20 | −24.58 ± 1.49 | −24.77 ± 0.82 |
| 5 | 28 | −24.70 ± 2.06 | −24.47 ± 2.01 | −24.58 ± 1.73 | −24.32 ± 1.86 | −24.32 ± 2.01 | −24.70 ± 1.53 |
| SRs($s^{-1}$) | | | | | | | |
| 1 | 31 | −2.55 ± 0.35 | −2.49 ± 0.51 | −2.58 ± 0.81 | −2.59 ± 0.30 | −2.59 ± 0.30 | −2.64 ± 0.11 |
| 2 | 32 | −2.64 ± 0.57 | −2.57 ± 1.32 | −2.58 ± 0.54 | −2.67 ± 0.54 | −2.58 ± 1.12 | −2.63 ± 0.74 |
| 3 | 29 | −2.58 ± 0.85 | −2.61 ± 0.32 | −2.63 ± 0.44 | −2.64 ± 0.74 | −2.67 ± 0.11 | −2.53 ± 0.77 |
| 4 | 31 | −2.60 ± 1.26 | −2.56 ± 0.74 | −2.65 ± 1.35 | −2.70 ± 1.06 | −2.67 ± 0.30 | −2.65 ± 0.40 |
| 5 | 28 | −2.71 ± 0.59 | −2.61 ± 0.30 | −2.66 ± 0.20 | −2.68 ± 0.26 | −2.61 ± 0.49 | −2.66 ± 0.37 |
| SRd($s^{-1}$) | | | | | | | |
| 1 | 31 | 2.08 ± 0.47 | 2.18 ± 0.57 | 1.98 ± 0.13 | 2.18 ± 0.33 | 2.18 ± 0.33 | 2.18 ± 0.33 |
| 2 | 32 | 2.11 ± 0.95 | 2.00 ± 0.89 | 2.19 ± 0.40 | 2.15 ± 0.40 | 2.07 ± 0.80 | 2.11 ± 0.78 |
| 3 | 29 | 2.15 ± 0.48 | 2.09 ± 0.55 | 2.02 ± 0.35 | 2.11 ± 0.39 | 2.09 ± 0.55 | 2.18 ± 0.33 |
| 4 | 31 | 2.09 ± 0.82 | 2.11 ± 1.27 | 2.20 ± 1.06 | 2.14 ± 0.44 | 2.21 ± 0.27 | 2.20 ± 0.46 |
| 5 | 28 | 2.16 ± 0.70 | 2.18 ± 0.32 | 2.07 ± 0.86 | 2.15 ± 0.75 | 2.18 ± 0.55 | 2.27 ± 0.46 |

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*Original Article*

# Regional right and left ventricular function after the Senning operation: an ultrasonic study of strain rate and strain

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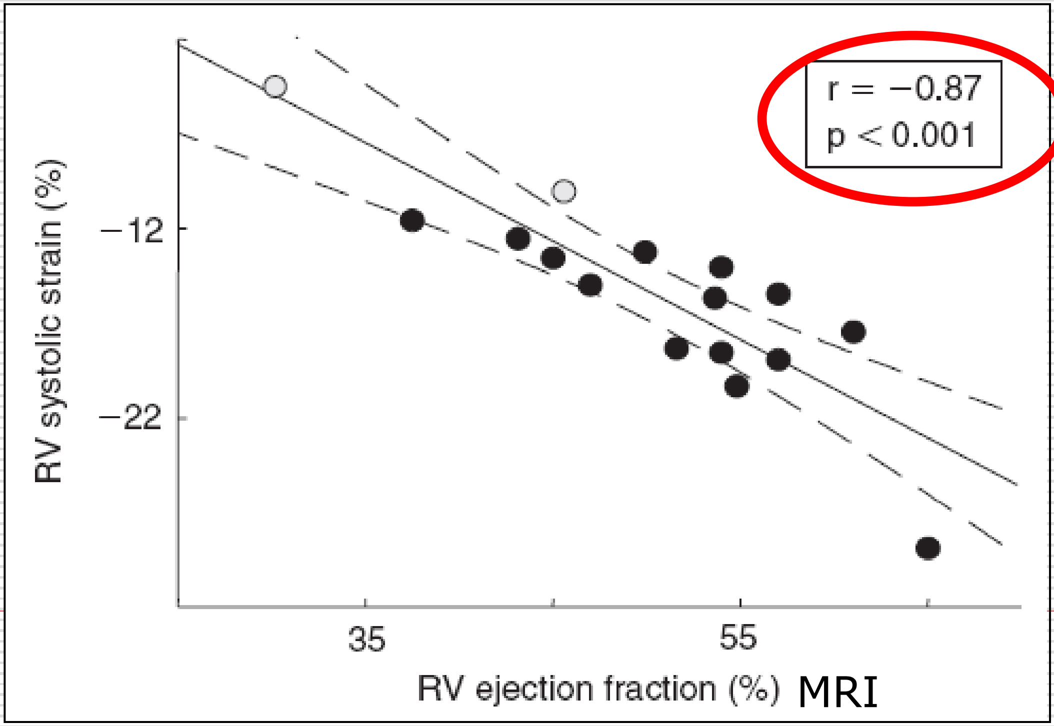

# Right Ventricular Function with Standard and Speckle-Tracking Echocardiography and Clinical Events in Adults with D-Transposition of the Great Arteries Post Atrial Switch

Andreas P. Kalogeropoulos, MD, Anjan Deka, MD, William Border, MBChB, MPH, Maria A. Pernetz, RDCS, Vasiliki V. Georgiopoulou, MD, Jawad Kiani, MD, Michael McConnell, MD, Stamatios Lerakis, MD, Javed Butler, MD, MPH, Randolph P. Martin, MD, and Wendy M. Book, MD, *Atlanta, Georgia*

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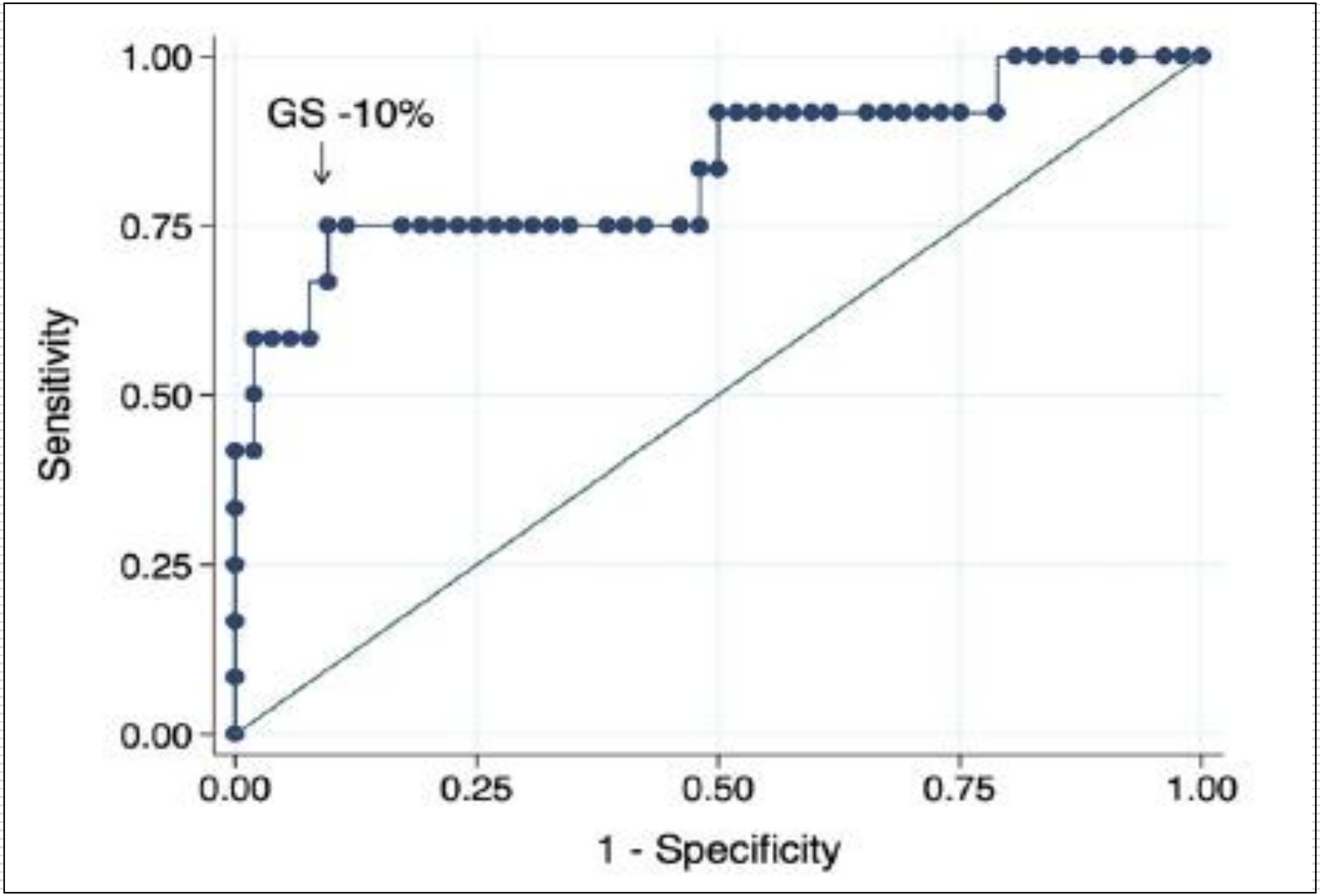
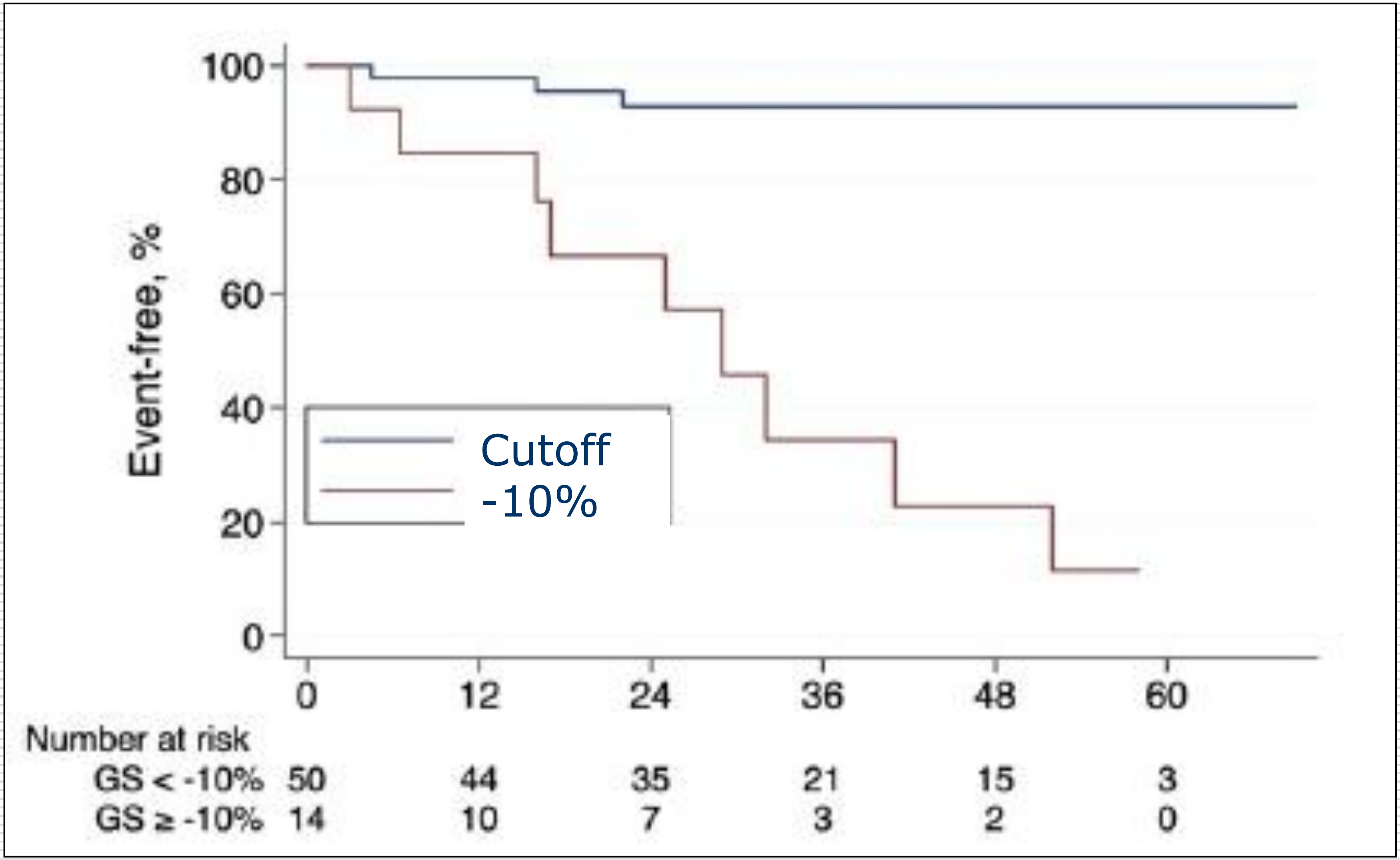
2012; in Press

Table 2 Echocardiographic parameters and association with clinical events

| Parameter | Value | HR (95% CI) | *P* |
|---|---|---|---|
| Standard | | | |
| RV fractional area change (%)* | 22.9 ± 7.5 | 1.08 (1.00–1.17) | .047 |
| RV diameter (base) (mm) | 45.6 ± 5.6 | 1.11 (0.99–1.23) | .072 |
| RV wall thickness (mm) | 10.0 ± 1.8 | 1.17 (0.86–1.58) | .32 |
| RV area at diastole ($cm^2$) | 41.4 ± 7.9 | 1.03 (0.96–1.10) | .37 |
| RV area at diastole ($cm^2/m^2$) | 21.8 ± 3.7 | 0.93 (0.80–1.09) | .36 |
| Tricuspid s′ velocity (cm/sec)* | 5.1 ± 1.8 | 1.16 (0.83–1.63) | .39 |
| Tricuspid e′ velocity (cm/sec)* | 5.4 ± 2.3 | 1.04 (0.83–1.30) | .76 |
| RV isovolumic velocity (cm/sec)* | 4.0 ± 1.6 | 1.12 (0.78–1.61) | .53 |
| RV isovolumic acceleration ($m/sec^2$)* | 1.33 ± 0.68 | 1.33 (0.48–3.68) | .58 |
| RV MPI† | 0.63 ± 0.13 | 1.01 (0.97–1.06) | .51 |
| TAPSE (mm)* | 9.8 ± 2.8 | 1.00 (0.81–1.23) | .97 |
| Tricuspid regurgitation severity‡ | 1.5 ± 1.3 | 0.94 (0.56–1.59) | .82 |
| Left (subpulmonic) ventricular ejection fraction (%)* | 61.6 ± 9.0 | 1.00 (0.95–1.06) | .93 |
| Deformation based | | | |
| RV global strain (%) | –12.5 ± 3.0 | 1.35 (1.14–1.58) | <.001 |
| RV global systolic SR ($sec^{-1}$)† | –0.59 ± 0.14 | 1.06 (1.02–1.11) | .006 |
| RV global early diastolic SR ($sec^{-1}$)§ | 0.68 ± 0.22 | 1.04 (1.00–1.07) | .031 |
| RV global late diastolic SR ($sec^{-1}$)§,¶ | 0.32 ± 0.17 | 1.02 (0.98–1.06) | .42 |


GS -10%
1.00
0.75
0.50
0.25
0.00
Sensitivity
0.00
0.25
0.50
0.75
1.00
1 - Specificity



Event-free, %
100
80
60
40
20
0
Cutoff
-10%
0
12
24
36
48
60
Number at risk
GS < -10% 50 44 35 21 15 3
GS ≥ -10% 14 10 7 3 2 0

# Speckle tracking derived strain – clinical applications

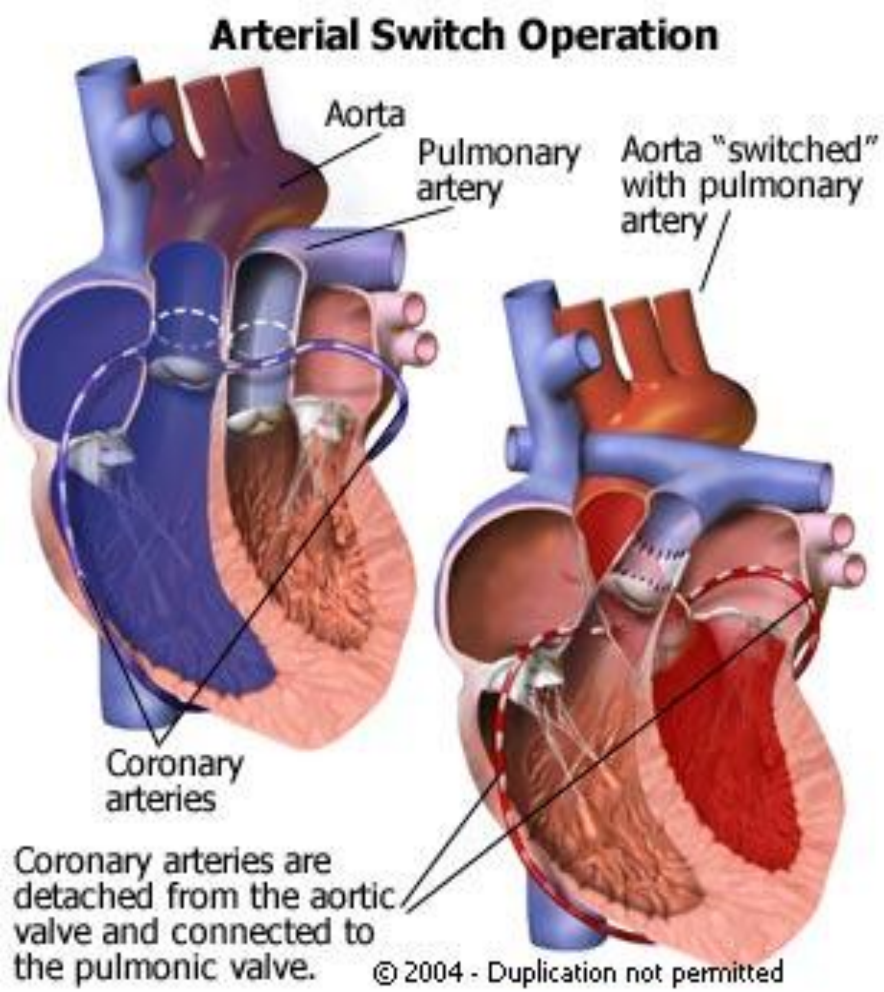
**Supports decision making in:**

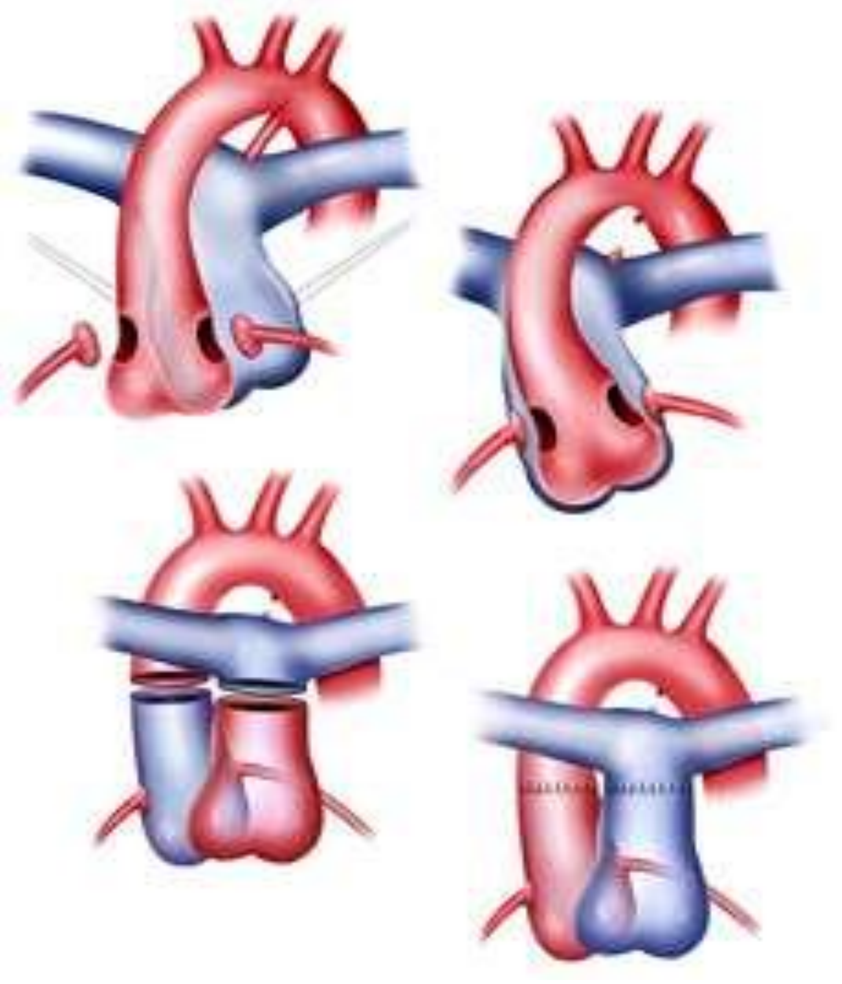
- Heart failure therapy
- Further investigation (Cath., MRI)
- Re-operation:
  tricuspid valve repair
  conversion to arterial switch

# Conclusion

- Patients after Senning op. have significantly reduced RV strain, and it correlates with MRI derived EF.
- RV Strain < -10% correlates with adverse outcome in patients after Senning OP.

# Arterial switch operation



# Arterial switch– late complications

- RV outflow tract obstruction
- LV outflow tract obstruction
- Ao regurgitation
- Epicardial coronary artery stenosis
- Perfusion defects
- Wall motion abnormalities
- Dysrhythmia

- 40% of arterial switch patients have scyntigraphy perfusion defects, undetected by angiography. All of them have regional wall motion abnormality due to microcirculatory disturbances

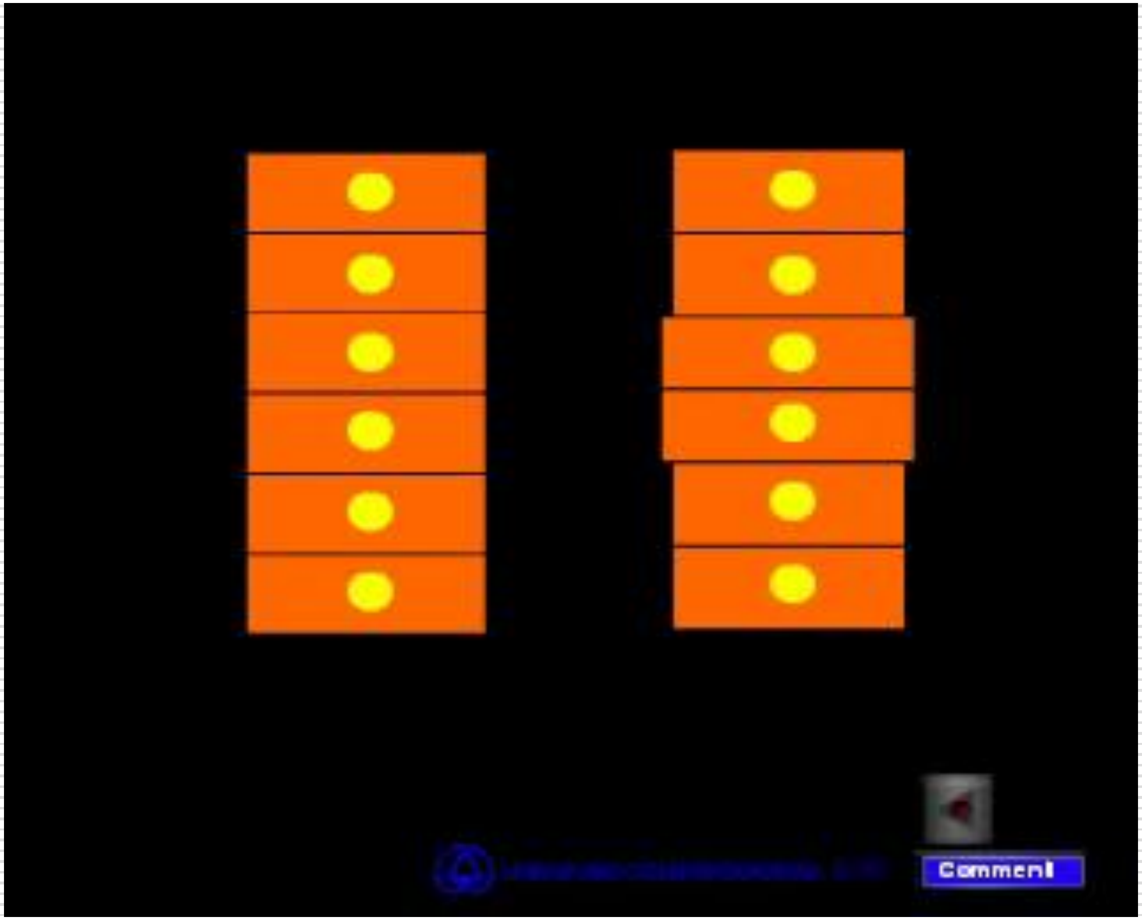
# Abnormal microcirculation

- Progressive intimal proliferation due to coronary translocation
- Denervation of coronary arteries in the operation
- Frequently abnormally high origin of the coronary arteries
- Reduced coronary flow reserve

Late myocardial ischemia after Arterial switch operation is asymtpomatic because of coronary intraoperative denervation!

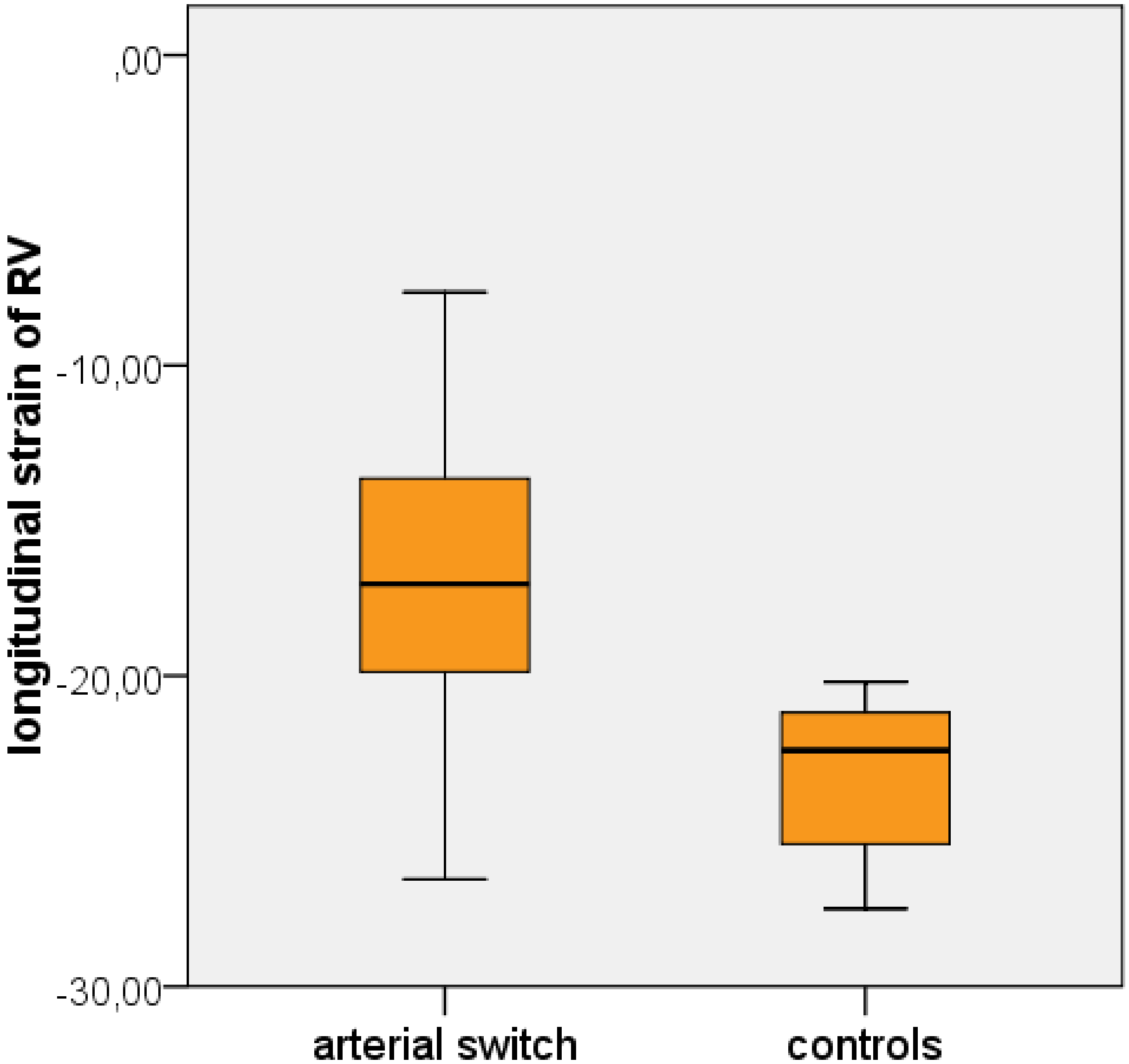
# Coronary circulation- evaluation

- Perfusion scintigraphy
- MRI
- Heart catheterization
- Echocardiography - STE?


Comment

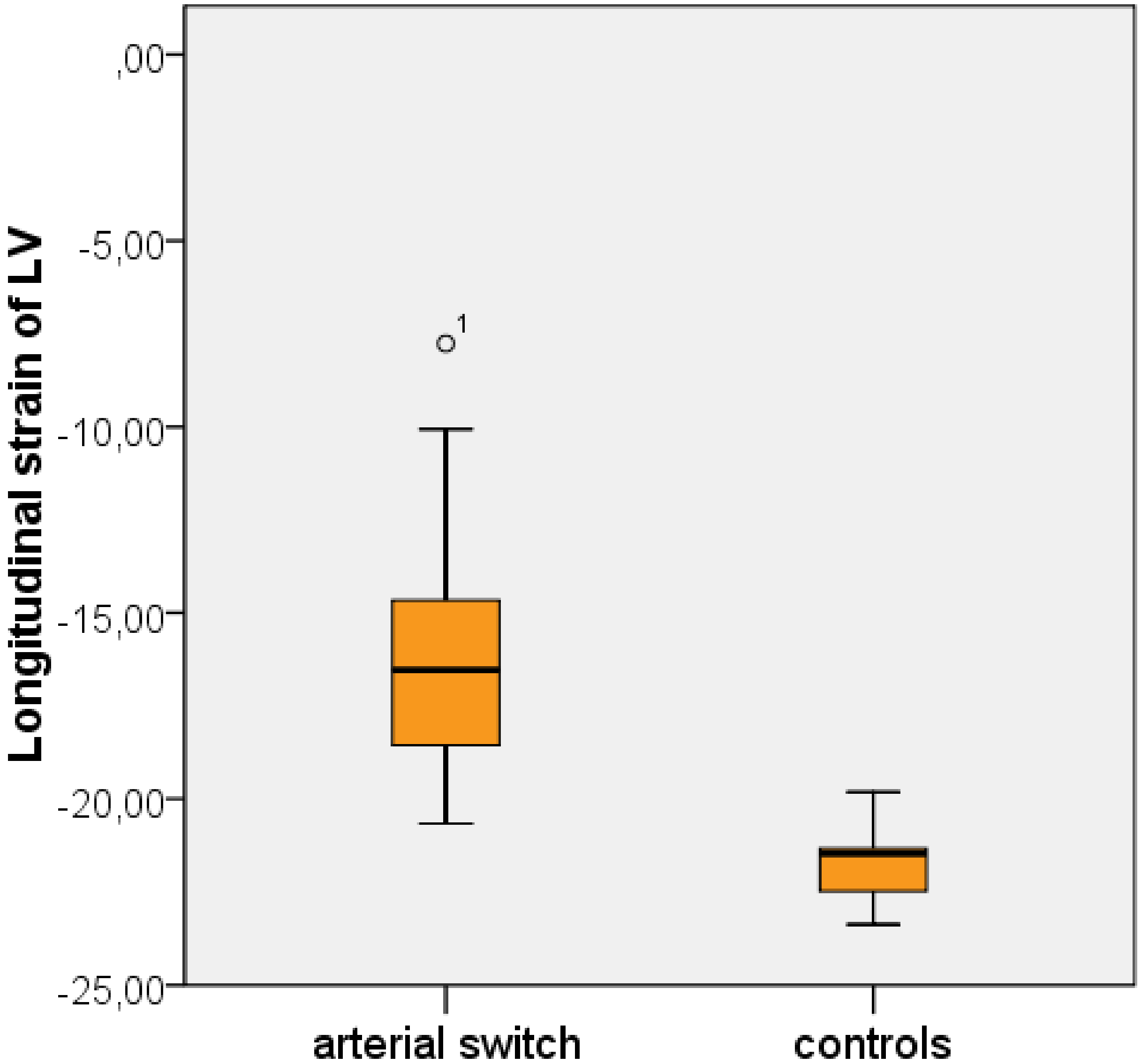
# STE strain and strain rate after arterial switch – our study …

- 09.2011 – ongoing
- 58 arterial switch patients
  - 1-18 years old
- 17 healthy controls
- STE – offline analyze by  Siemens-Syngo US Workplace VVI

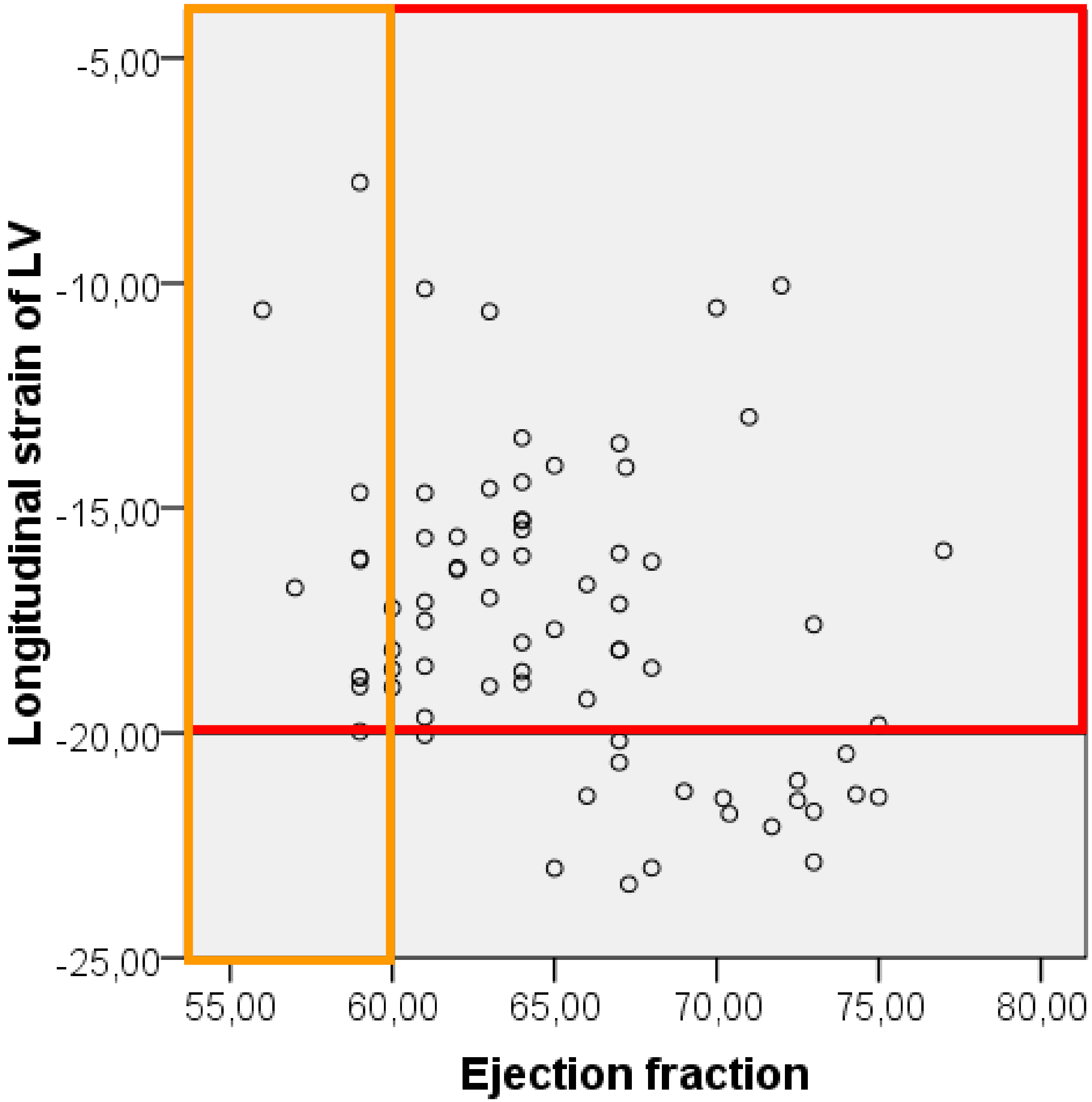


longitudinal strain of RV
,00
-10,00
-20,00
-30,00
arterial switch
controls

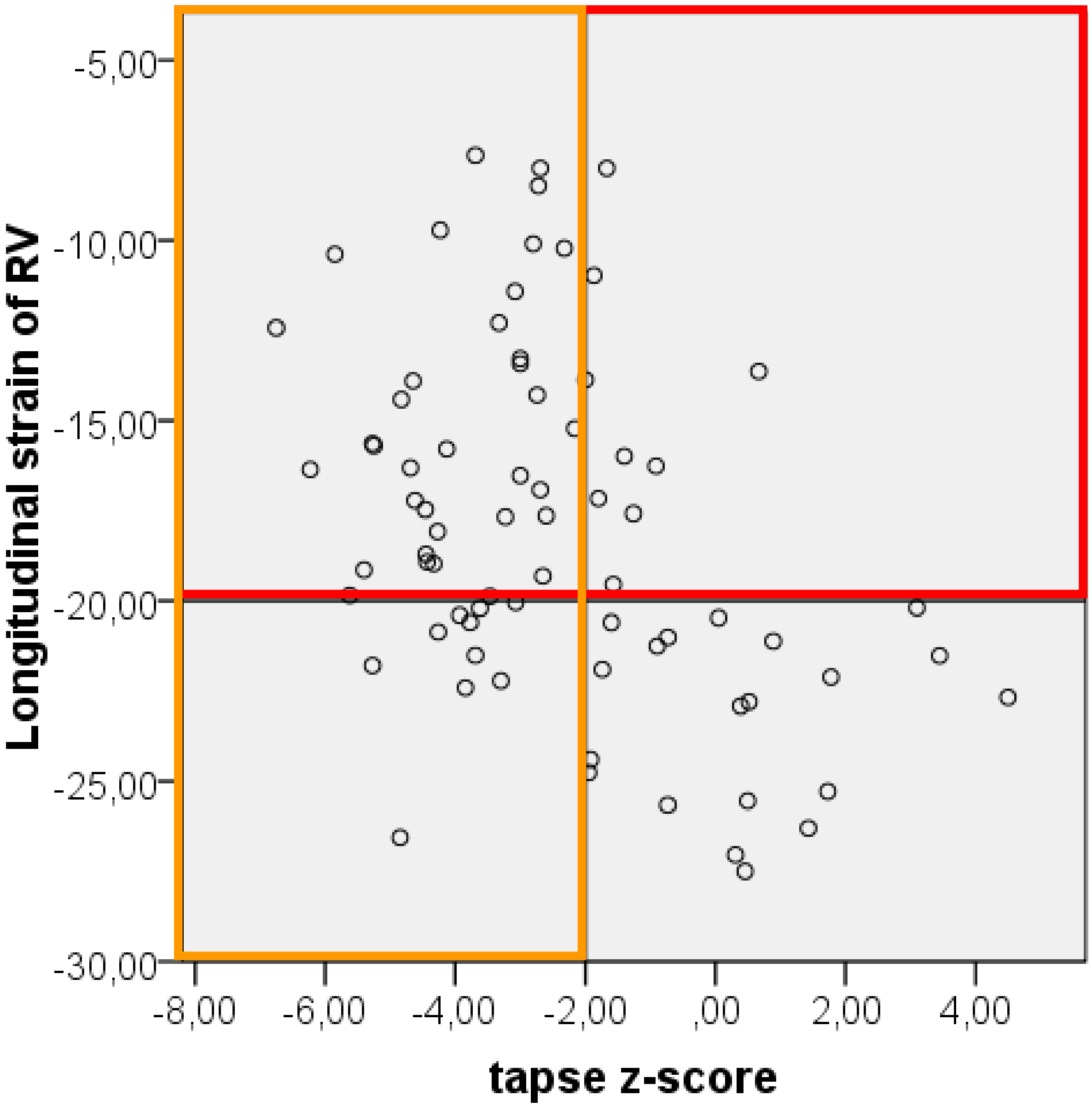

P<0,05


Longitudinal strain of LV
,00
-5,00
-10,00
-15,00
-20,00
-25,00
1
arterial switch
controls

P<0,05



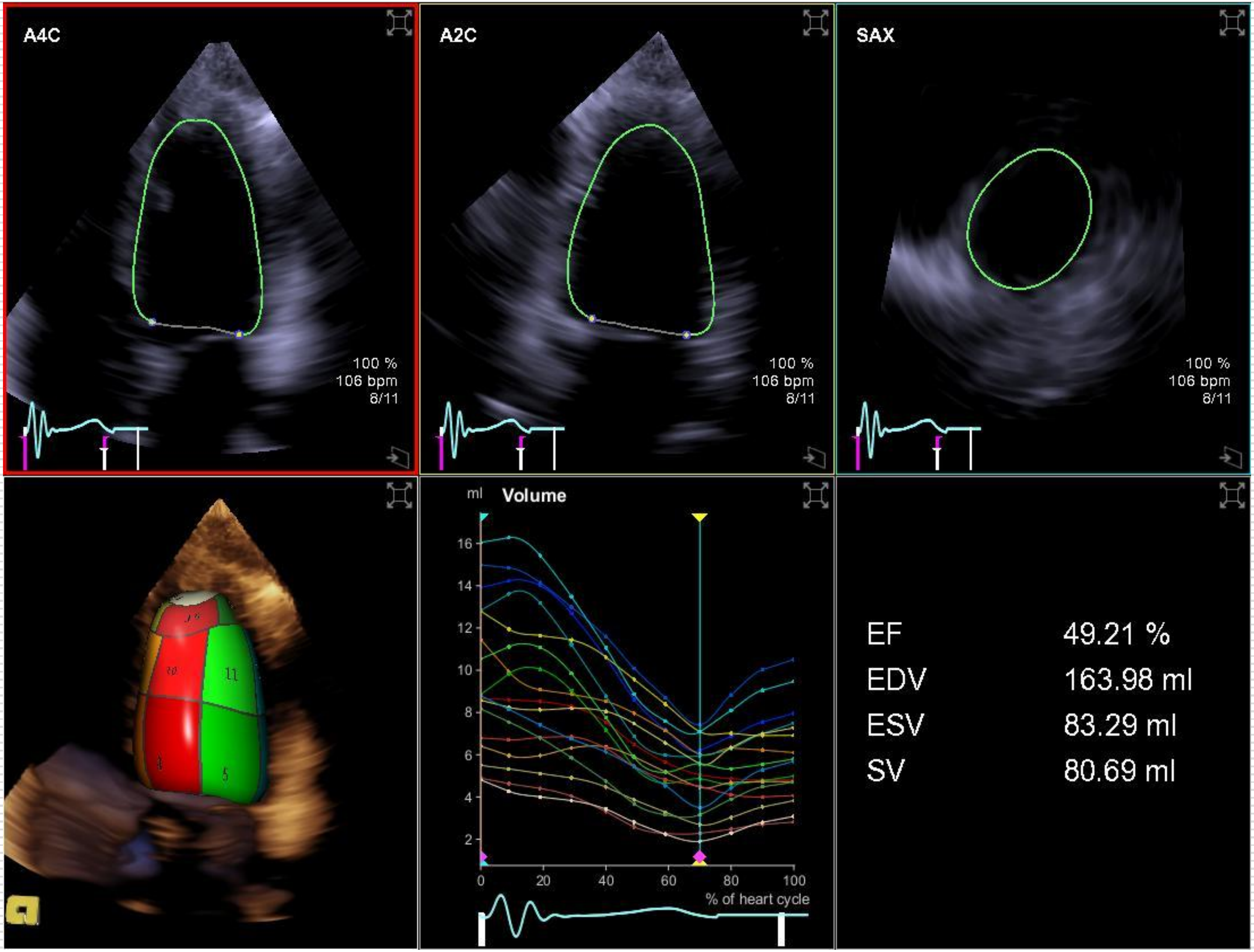
-5,00
-10,00
-15,00
-20,00
-25,00
Longitudinal strain of LV
55,00
60,00
65,00
70,00
75,00
80,00
Ejection fraction

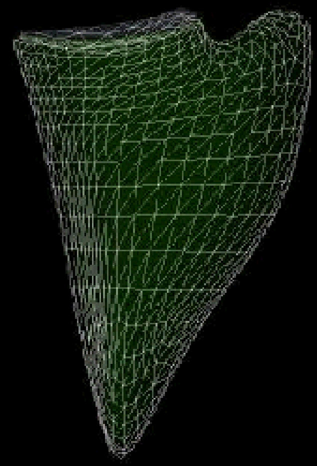


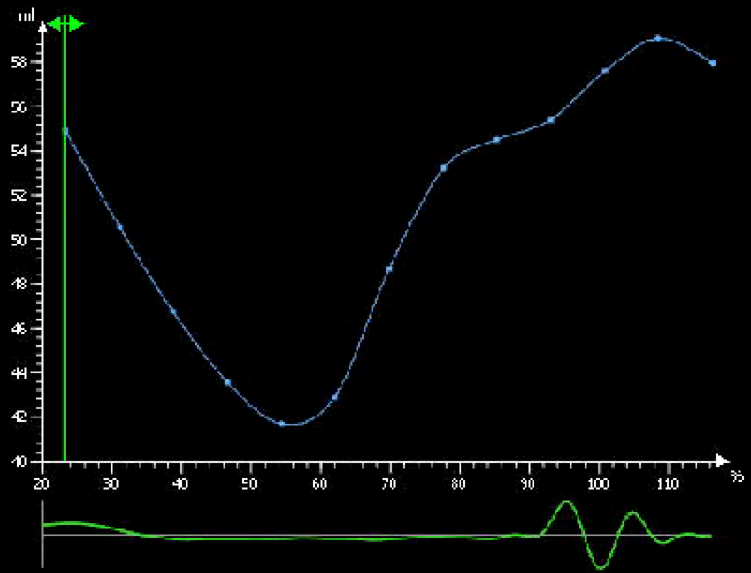
-5,00
-10,00
-15,00
-20,00
-25,00
-30,00
Longitudinal strain of RV
-8,00
-6,00
-4,00
-2,00
,00
2,00
4,00
tapse z-score

# Considerations

- Strain adds information regarding systolic function of LV and RV in patients after arterial switch.
- Microcirculatory coronary abnormalities result in regional wall dyskinesia.
- Potential clinical applications of STE strain in patients with congenital heart disease have to be further evaluated.


A4C
100 %
106 bpm
8/11
A2C
100 %
106 bpm
8/11
SAX
100 %
106 bpm
8/11
ml
Volume
16
14
12
10
8
6
4
2
0
20
40
60
80
100
% of heart cycle
EF 49.21 %
EDV 163.98 ml
ESV 83.29 ml
SV 80.69 ml






ESV 41.60 ml
EDV 59.02 ml
SV 17.42 ml
EF 29.52 %

003