EMB 2020

MR-guided programming of pacing parameters for heamodynamic optimization

Jakub Tomala

University of Dresden - Heart Center

Department of Electrophysiology

MR-guided programming of pacing parameters for heamodynamic optimization

Agenda

Clinical Problem: Suboptimal response to CRT

What are the causes?

How can MRI help?

Implanted CRT – End of the story?

MR-guided programming of pacing parameters for heamodynamic optimization

Clinical Problem: Suboptimal response to CRT

- Despite delivering CRT for over two decades, a significant proportion (~30%) fail to improve as demonstrated in the EHRA survey of CRT.

- Disappointingly, this proportion has remained static over a period of extensive technology and technique development.

Daubert J-C, Saxon L, Adamson PB, Auricchio A, Berger RD, Beshai JF, et al. 2012 EHRA/HRS expert consensus statement on cardiac resynchronization therapy in heart failure: implant and follow-up recommendations and management. Europace [Internet]. 2012 Sep [cited 2015 Jan 7];14(9):1236-86.

Dickstein K., Normand, C., Auricchio, A., et al. 2018, CRT Survey II: a European Society of Cardiology survey of cardiac resynchronisation therapy in 11 088 patients—who is doing what to whom and how?. Eur J Heart Fail, 20: 1039-1051.

MR-guided programming of pacing parameters for heamodynamic optimization

What are the causes?

Causes of suboptimal CRT response are multi-factorial and include:

- suboptimal LV lead placement
- ineffective electro-mechanical resynchronization
- ineffective atrioventricular (AV) and ventriculoventricular (VV) timings with respect to device optimization
- untreated anaemia

Mullens W, Grimm R a, Verga T, Dresing T, Starling RC, Wilkoff BL, et al. Insights from a cardiac resynchronization optimization clinic as part of a heart failure disease management program. J Am Coll Cardiol [Internet]. American College of Cardiology Foundation; 2009 Mar 3 [cited 2014 Nov 16];53(9):765–73.

MR-guided programming of pacing parameters for heamodynamic optimization

How can MRI help?

Assessment prior to CRT implant

- LV- and RV-Function
- LV tissue, characteristics including scar area
- Type and extent of dyssynchrony
- Cardiac vein mapping

MR-guided programming of pacing parameters for heamodynamic optimization

LV- and RV-Function

- CMR is superior to echocardiography across all LVEF subgroups and diagnoses, regardless of technique used

- LV interobserver and interstudy: 4–9% for end-systolic volume, 2–7% for EF, 3–5% for mass, 3–5% for end-diastolic volume[1]

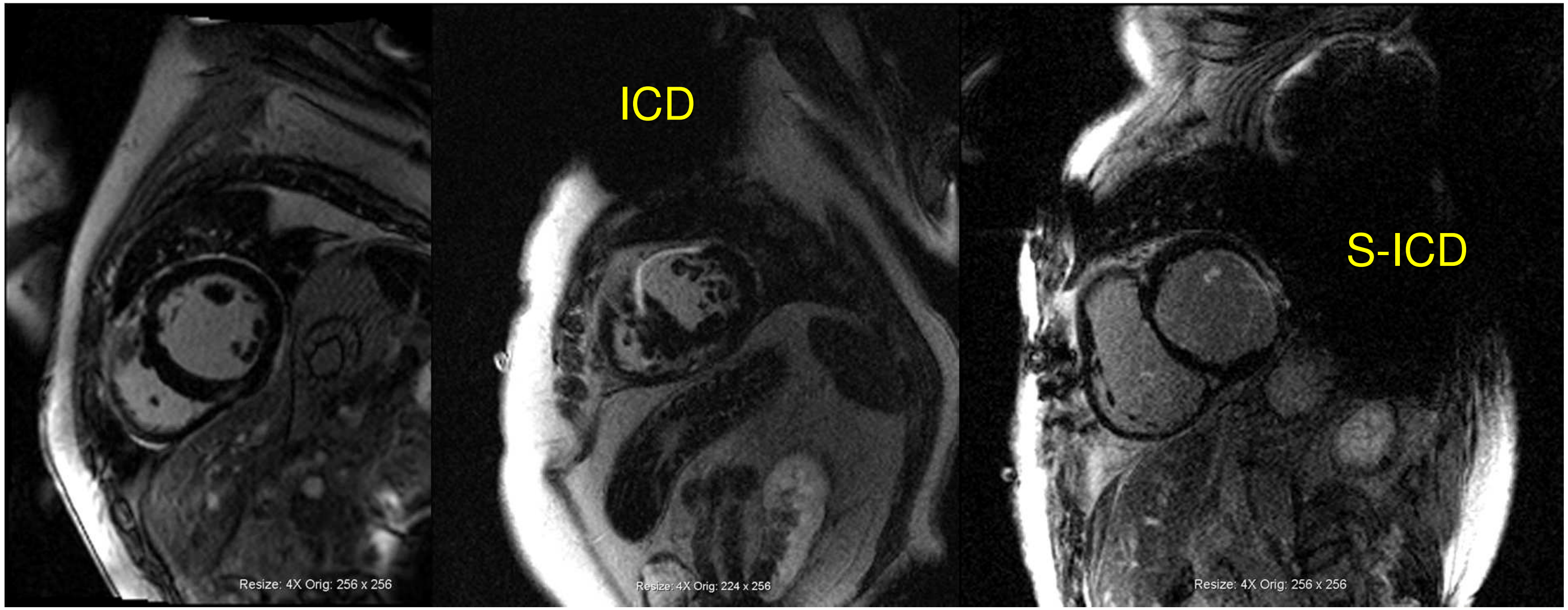
- RV interstudy variability: 6% for end-diastolic volume, 14% for end-systolic volume, 8% for EF, and 9% for RV mass[2]

1 Grothues F, Smith GC, Moon JC, et al. Comparison of interstudy reproducibility of cardiovascular magnetic resonance with two-dimensional echocardiography in normal subjects and in patients with heart failure or left ventricular hypertrophy. Am J Cardiol. 2002;90:29–34.
2 Grothues F, Moon JC, Bellenger NG, Smith GS, Klein HU, Pennell DJ. Interstudy reproducibility of right ventricular volumes, function, and mass with cardiovascular magnetic resonance. Am Heart J. 2004;147:218–23.

MR-guided programming of pacing parameters for heamodynamic optimization

LV tissue characteristics including infarct area

CMR provides accurate, non-invasive assessment of regional myocardial fibrosis using LGE, while diffuse interstitial myocardial fibrosis is accurately assessed with post-contrast T1 mapping.

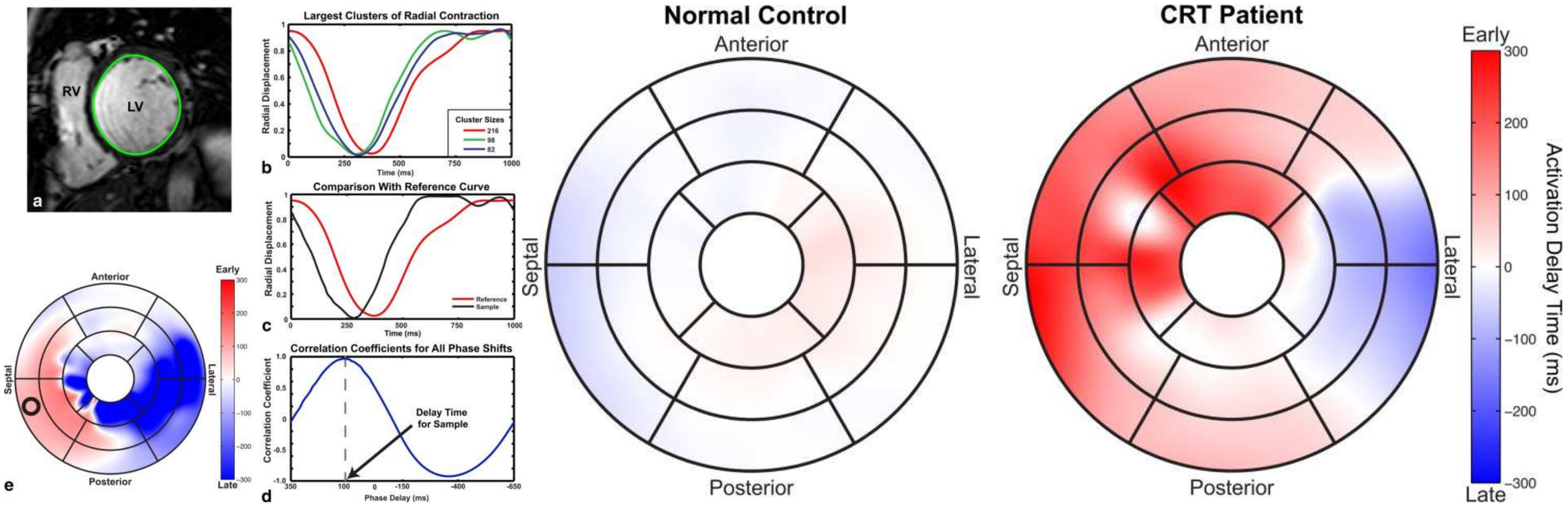


Histological validation of cardiac magnetic resonance analysis of regional and diffuse interstitial myocardial fibrosis, Leah MI, Andris HE, Huw L,et al., European Heart Journal – Cardiovascular Imaging (2015) 16, 14–22, doi:10.1093/ehjci/jeu182

MR-guided programming of pacing parameters for heamodynamic optimization

Type and extent of dyssynchrony

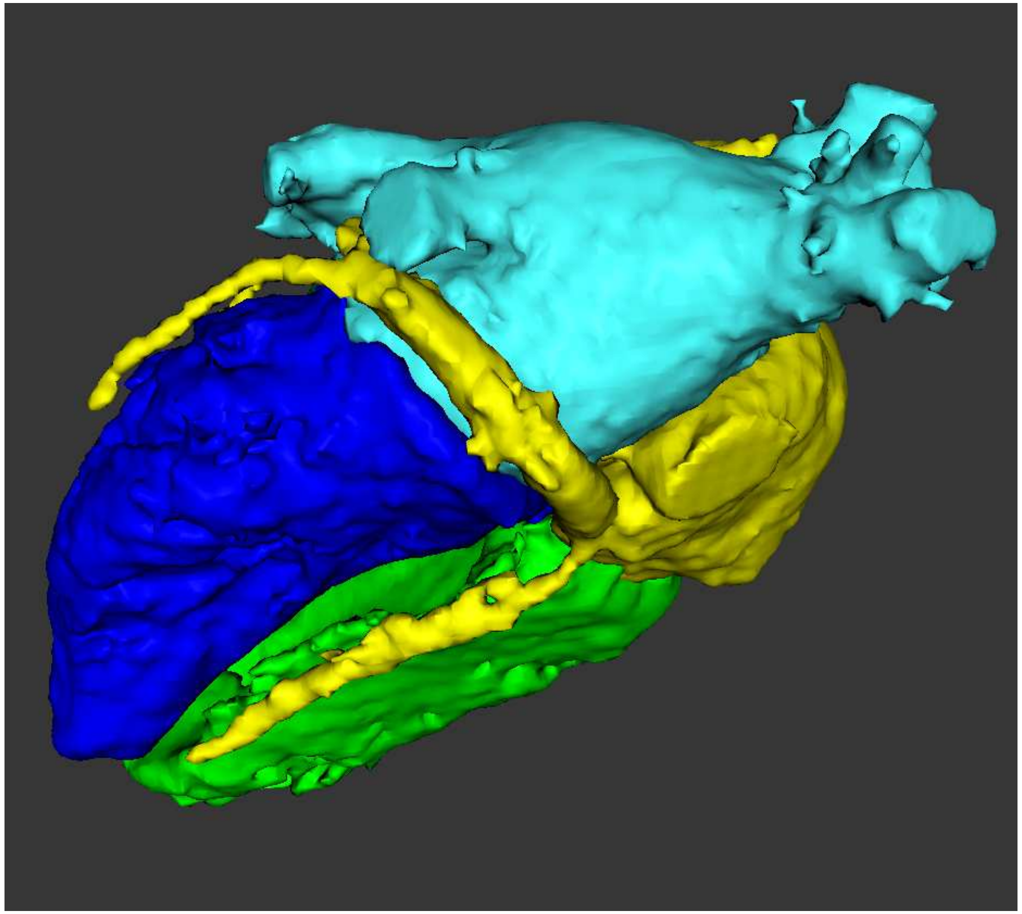
The site of latest mechanical delay varies widely among patients eligible for CRT and is thought to be the ideal location for LV lead placement. Regional delay times can be reliably calculated from cine steady-state free-precession (SSFP) images. Maps of regional dyssynchrony could be used to identify the latest-contracting segment to assist in CRT lead implantation.

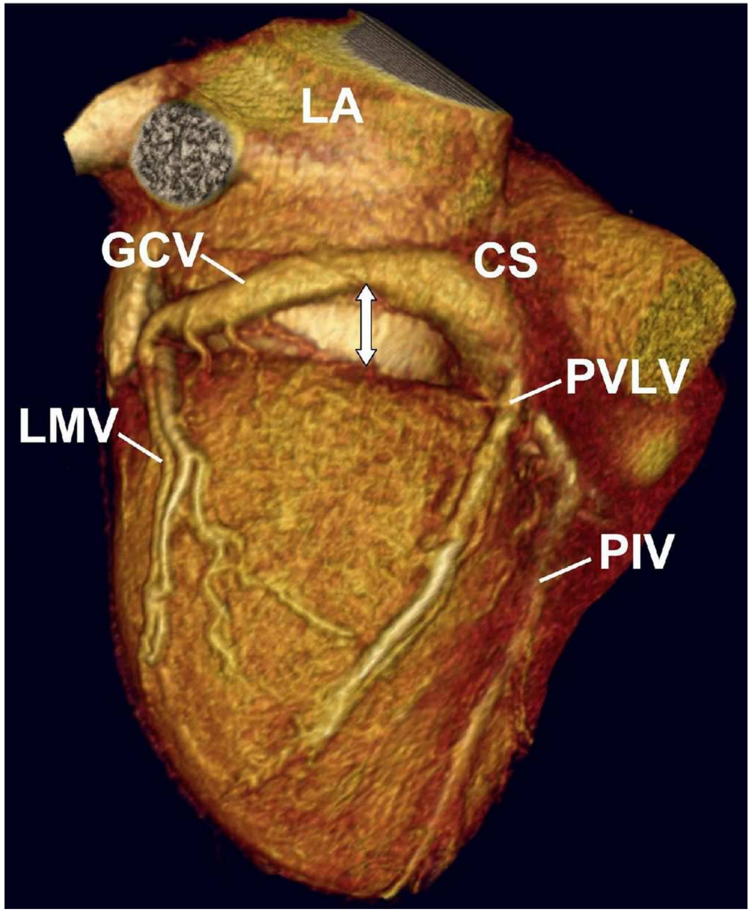


Method to create regional mechanical dyssynchrony maps from short-axis cine steady-state free-precession images, Suever JD, Fornwalt BK, Neuman RL, J. Magn. Reson. Imaging 2014;39:958–965.

MR-guided programming of pacing parameters for heamodynamic optimization

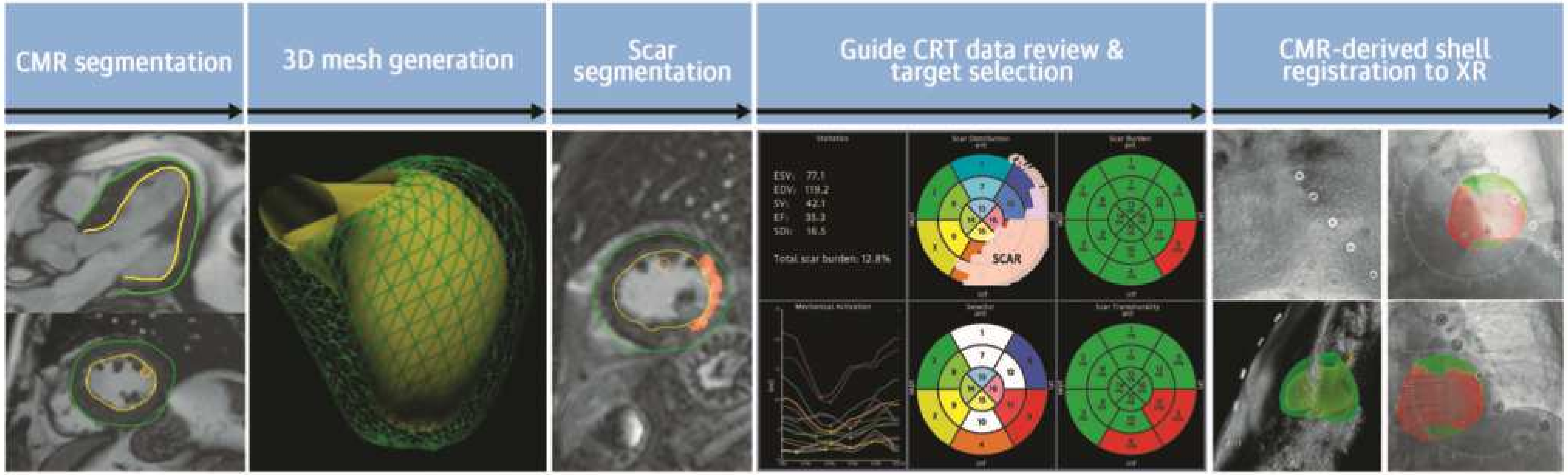
Cardiac vein and branch mapping





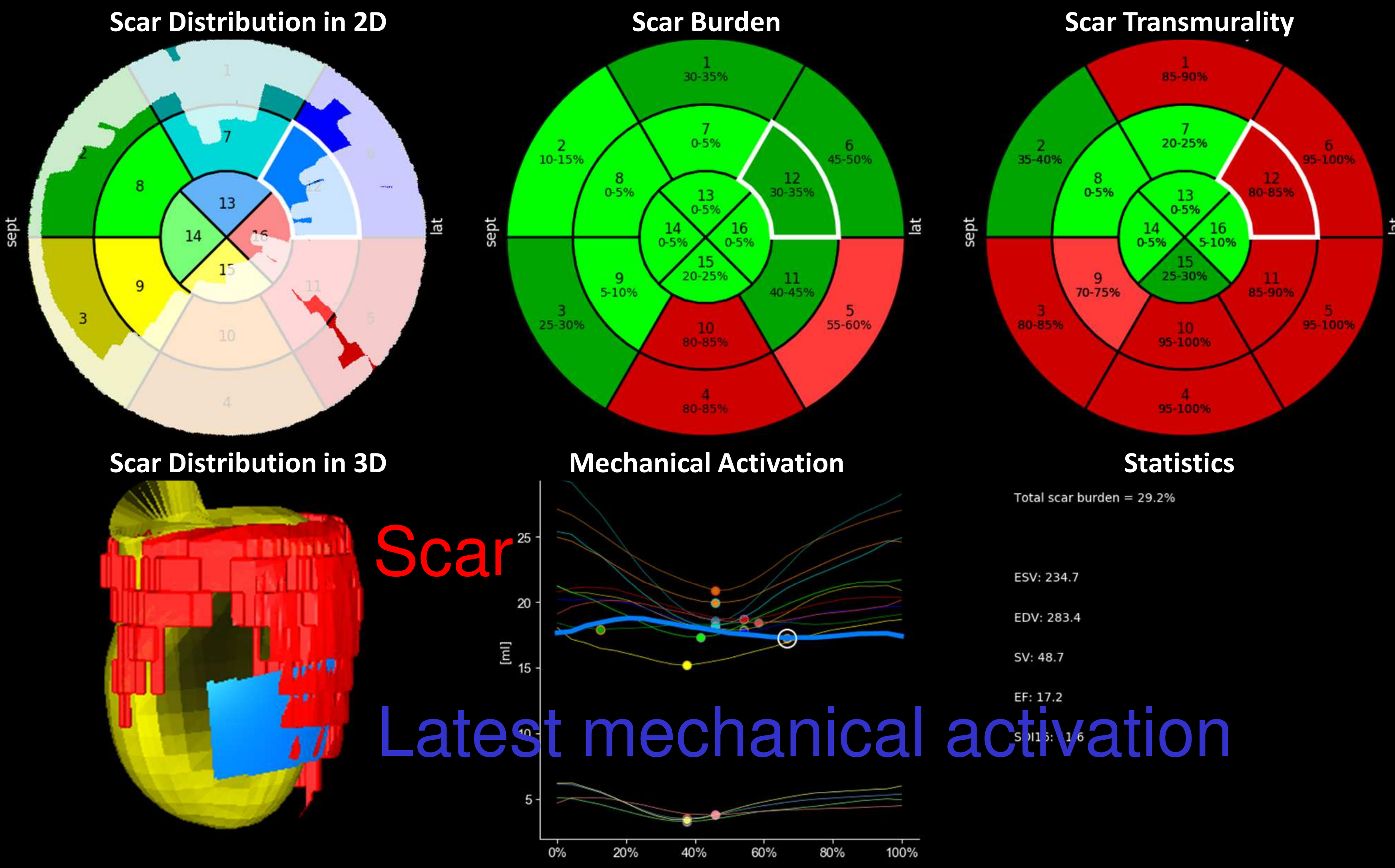
MR-guided programming of pacing parameters for heamodynamic optimization

Integrated guidance module for LV lead implantation

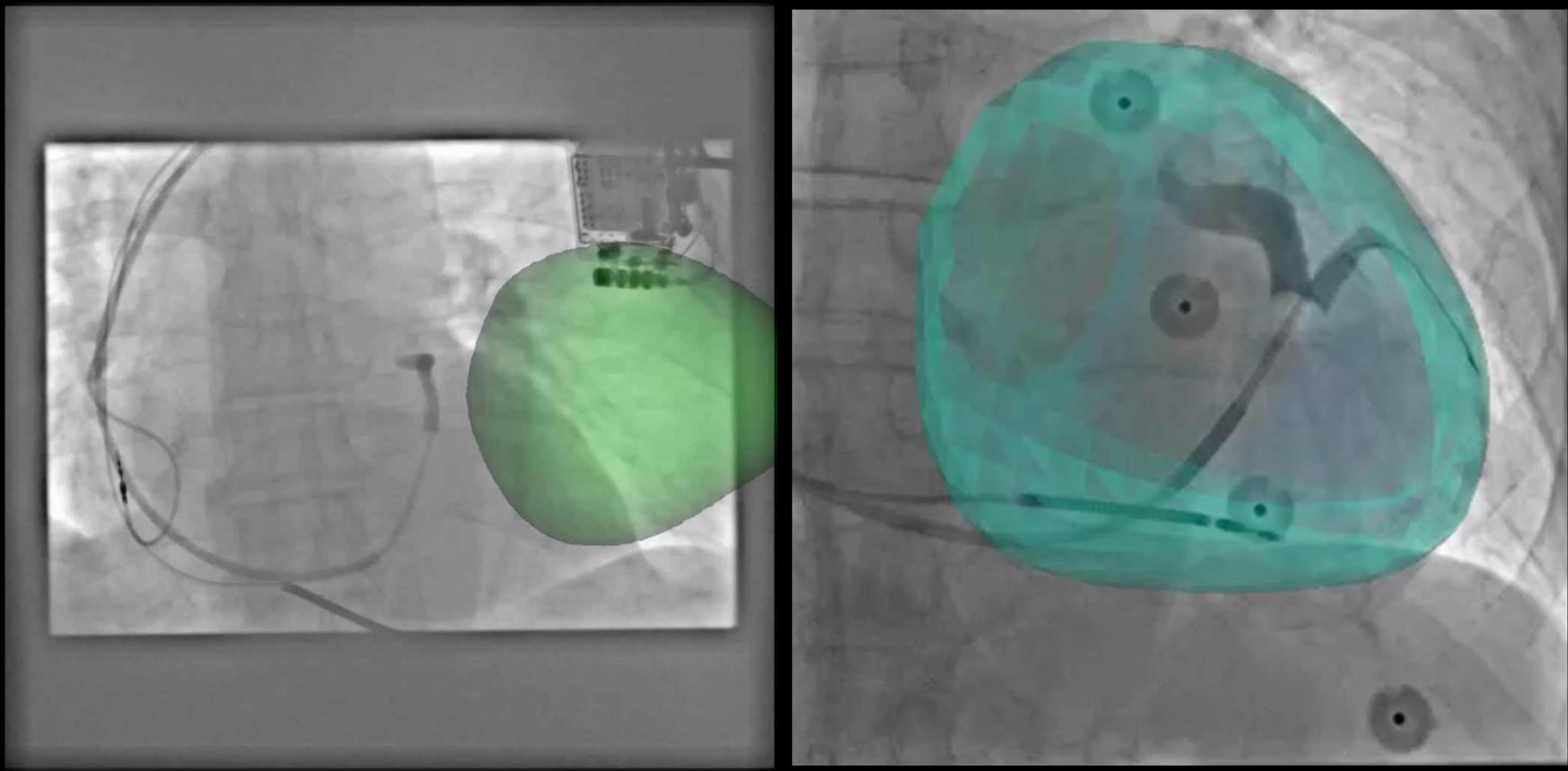


Real-Time X-MRI-Guided Left Ventricular Lead Implantation for Targeted Delivery of Cardiac Resynchronization Therapy, Behar JM, Mountney P, Toth D, JACC: CLINICAL ELECTROPHYSIOLOGY VOL. 3, NO. 8, AUGUST 2017:803 - 1 4

Segmentation and assessment

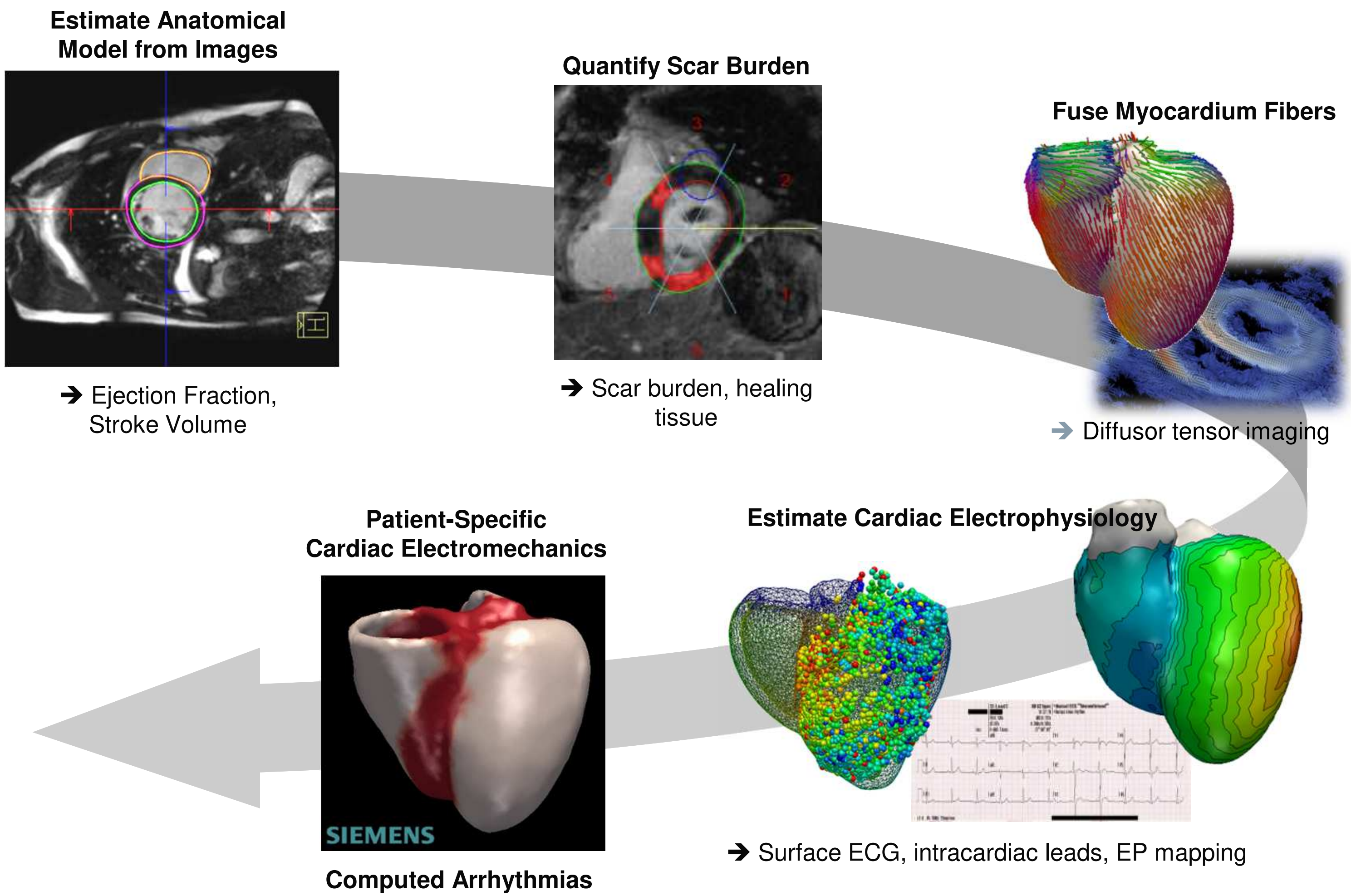


Fluoroscopic Overlay with motion tracking



MR-guided programming of pacing parameters for heamodynamic optimization

Virtual therapy prediction – ‚Virtual Heart Model'



MR-guided programming of pacing parameters for heamodynamic optimization

Implanted CRT – End of the story?

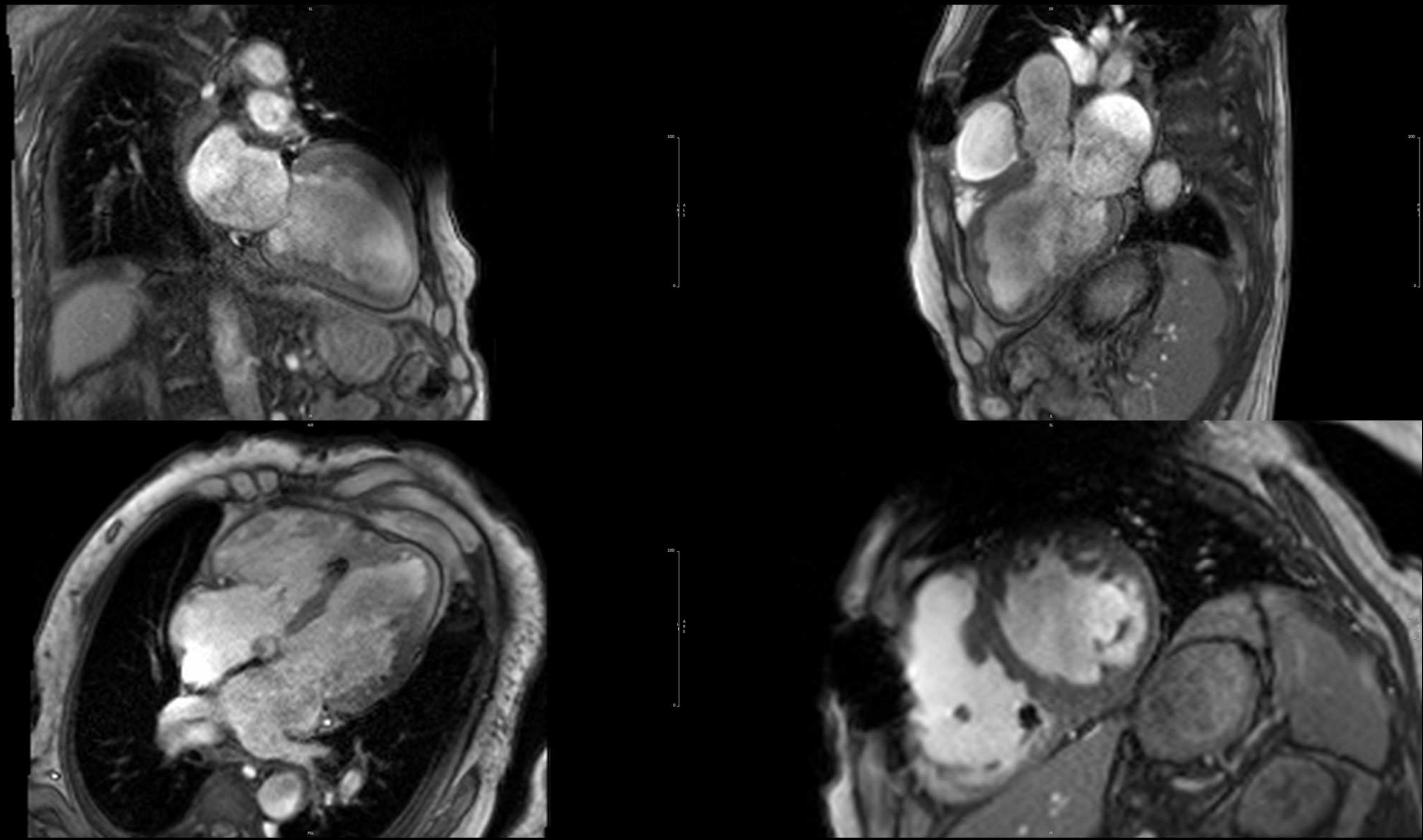
Potential parameters for cardiac MR assessment in CRT patients:

- LVEF, RVEF, Volumes, cardiac haemodynamic indices, asynchrony

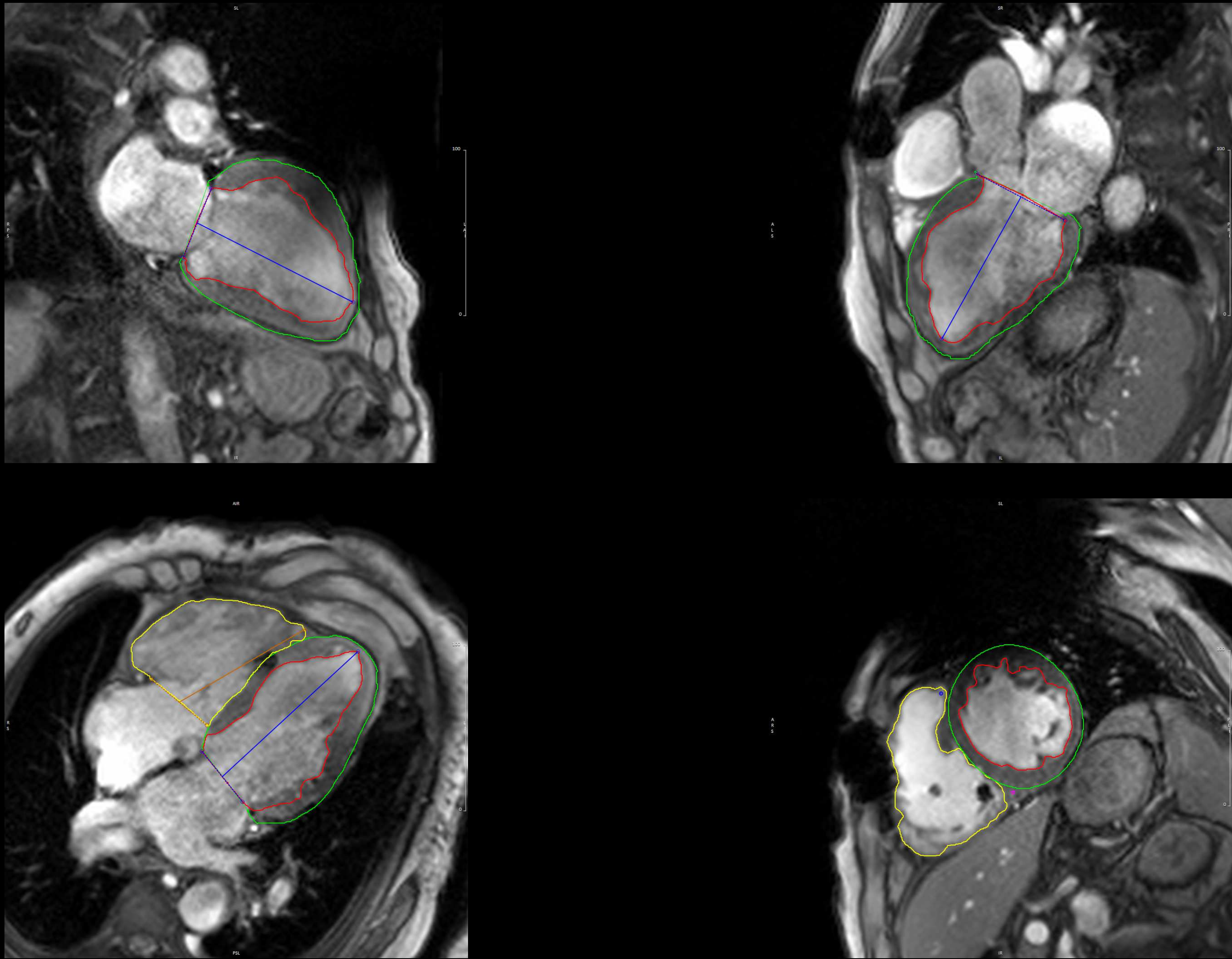
- Aortic and pulmonary flow

- Regional and global myocardial strain analysis

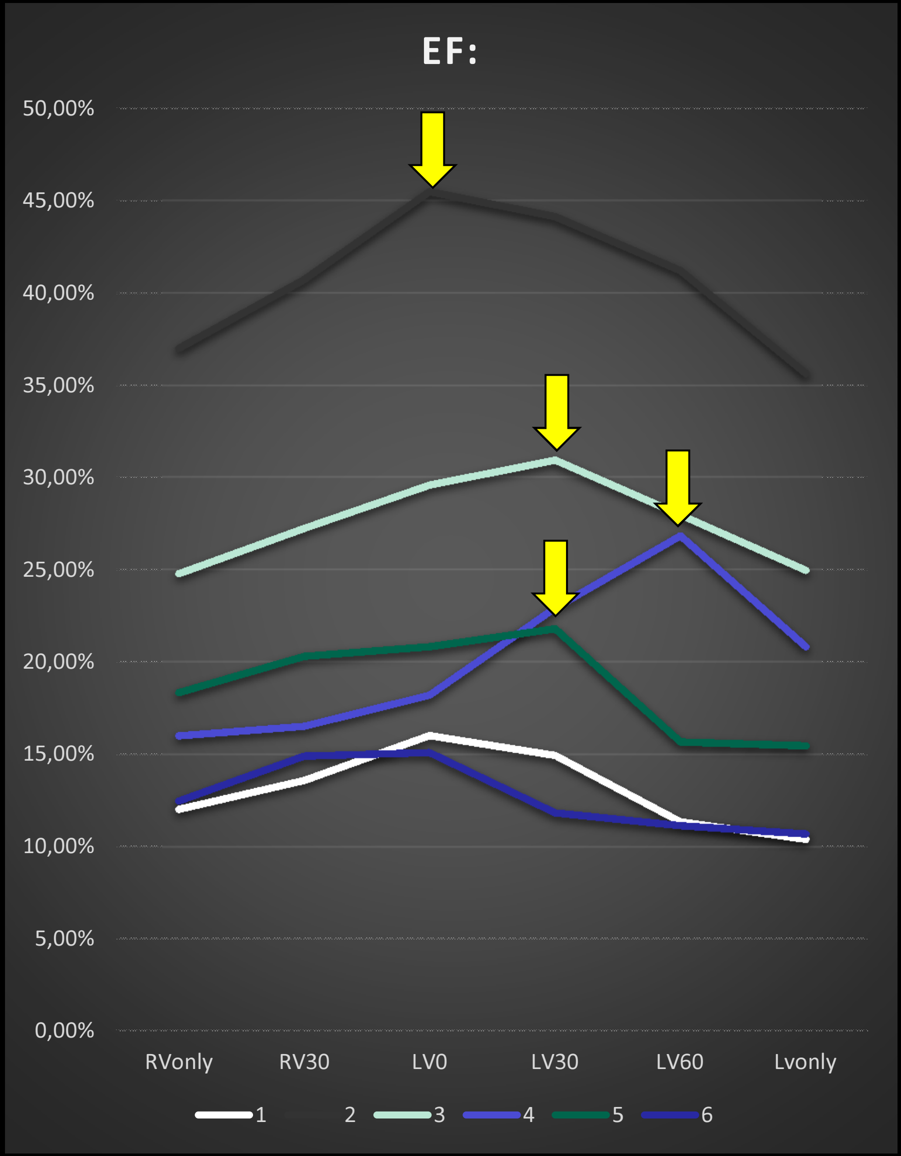
Assessment of LV-/RV-Function: Spoiled gradient echo CINE



Assessment of LV-/RV-Function: Spoiled gradient echo CINE



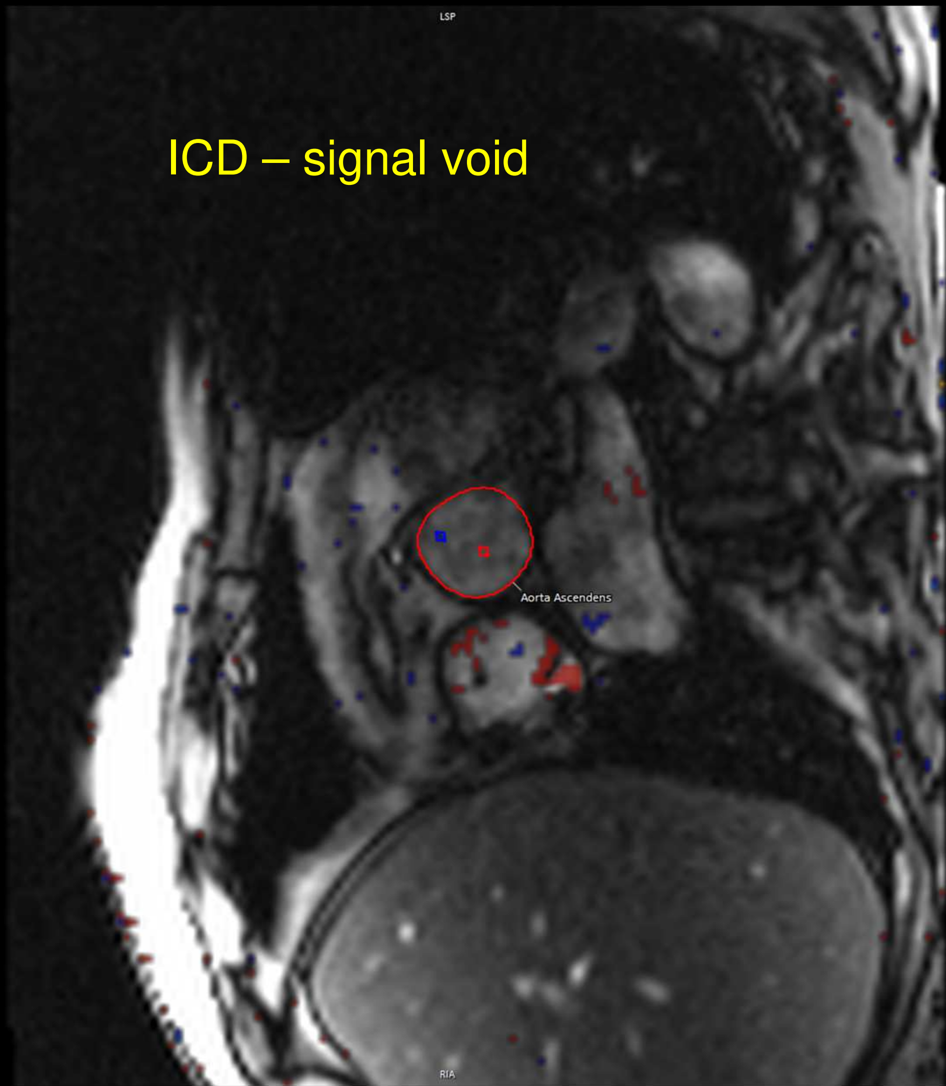
Spoiled gradient echo cine acquisitions obtained at 6 different interventricular delay settings



Spoiled gradient echo cine acquisitions obtained at 6 different interventricular delay settings

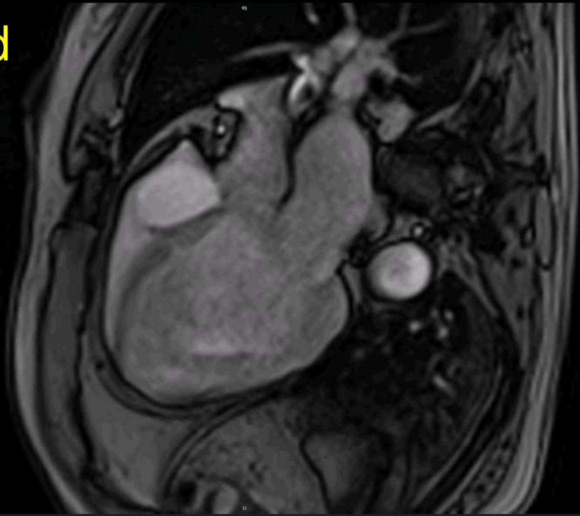
Results n=10			
	Without CRT	TTE-based	CMR-based
SV	49,5±12,3ml	56,3±11ml	64,7±14,8ml
LVEF	19,6±7,6%	23±12,1%	26±11,3%
Increase			
SV		+13% (p=0,08-ns)	+24% (p<0,01)
LVEF		+12% (p=0,04)	+25% (p=0,02)

Aortic flow measured with phase contrast

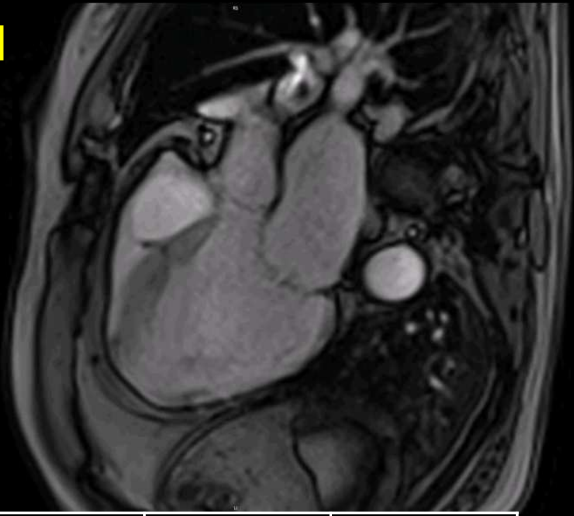


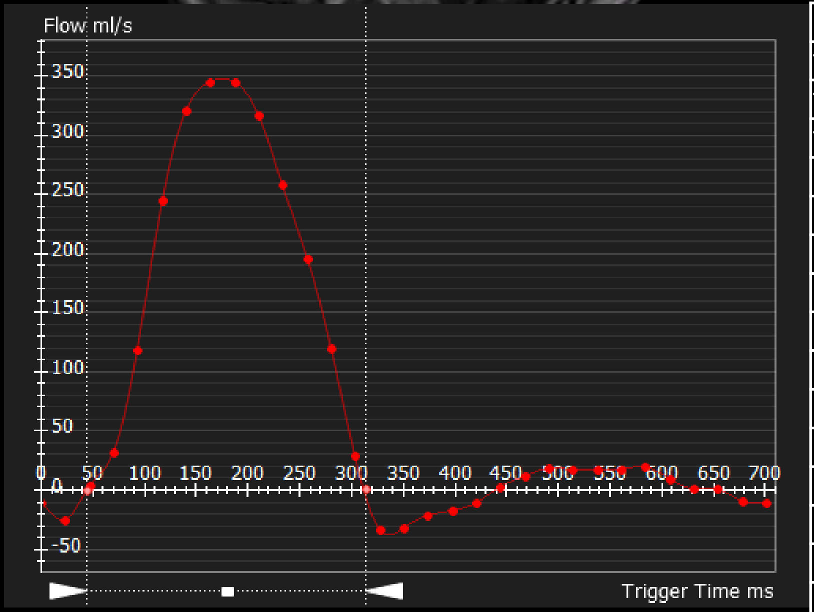
Aortic flow measured with phase contrast

LV paced



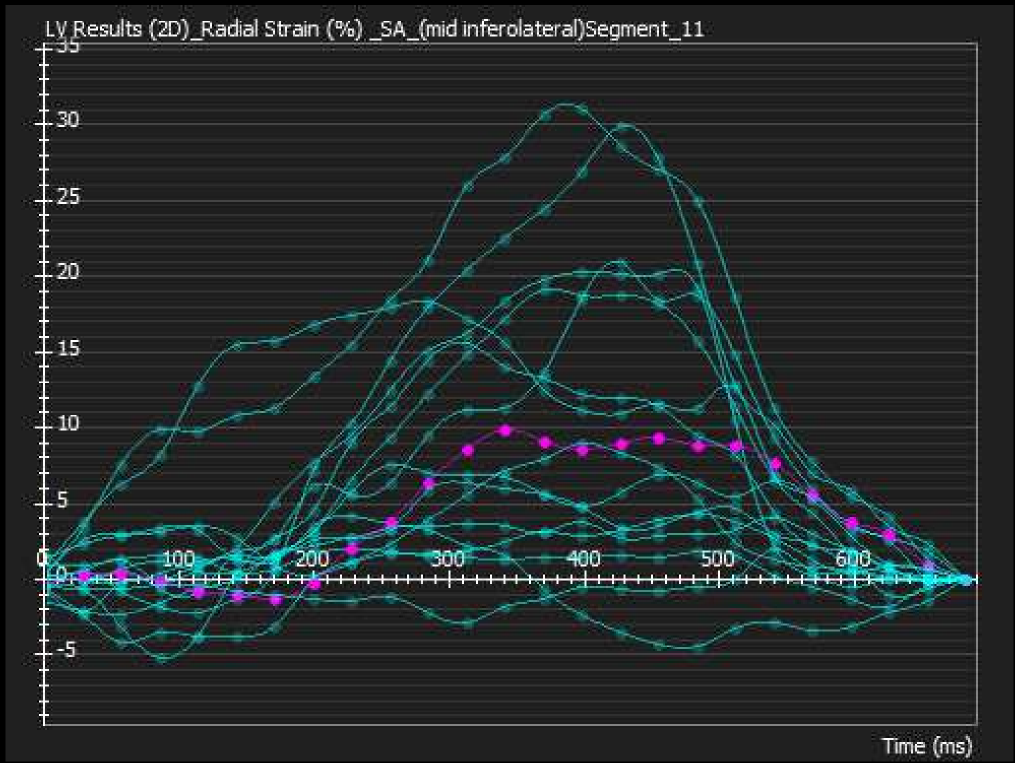
RV paced

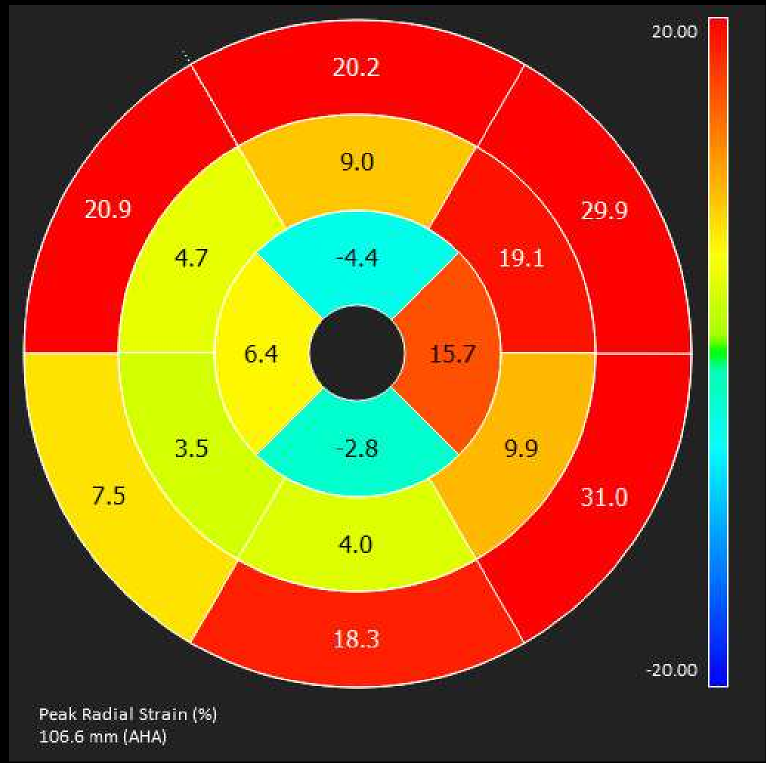


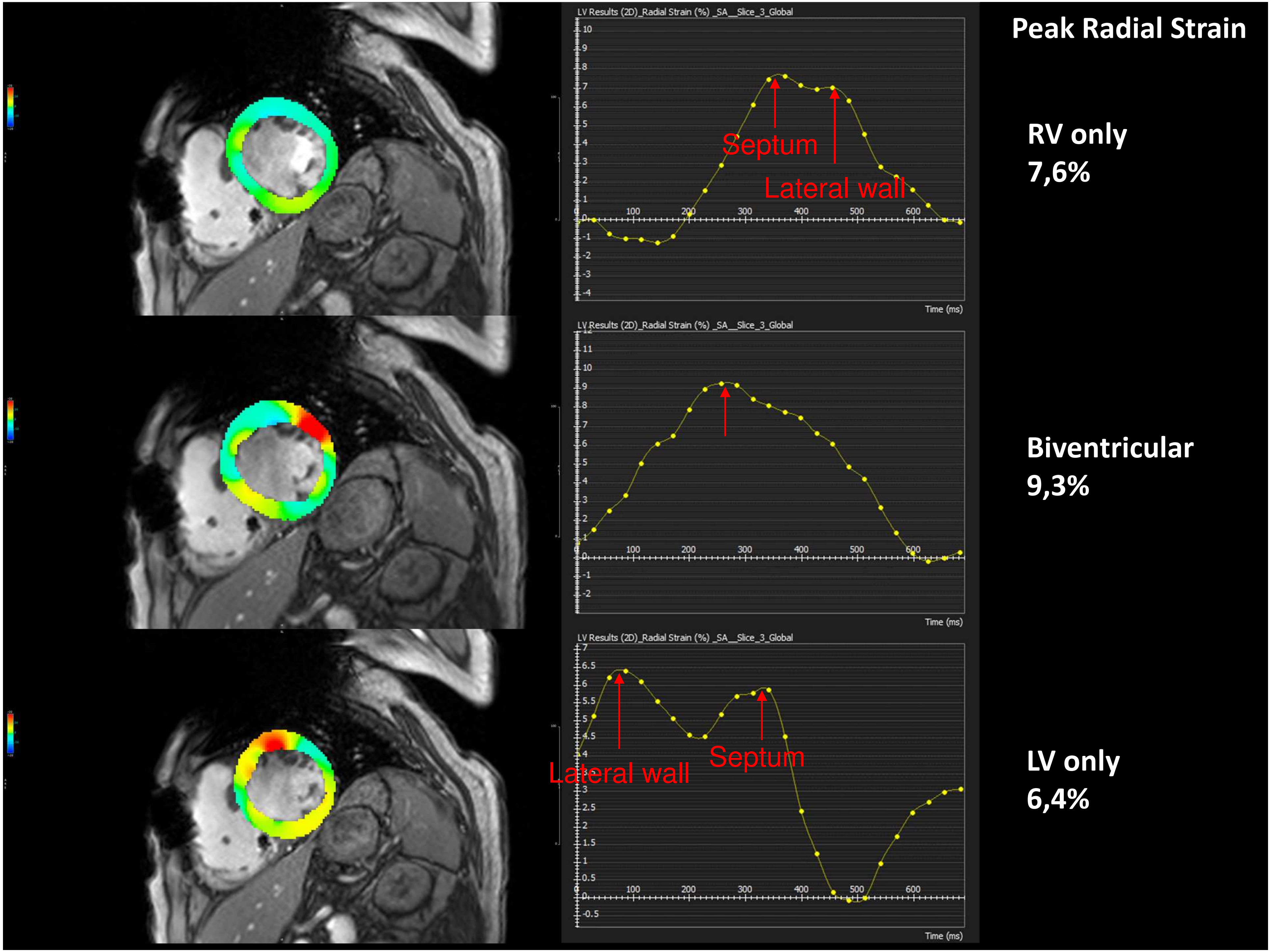


	LV	RV
Total Forward Volume:	55.03 ml	42.70 ml
Total Backward Volume:	-3.64 ml	-2.38 ml
Total Volume:	51.40 ml	40.32 ml
Regurgitation Fraction:	6.61%	5.57%
Heart Rate:	85/min	85/min
Max Pressure Gradient:	5.42 mmHg	3.72 mmHg
Mean Pressure Gradient:	1.05 mmHg	0.66 mmHg
Maximum Velocity (1x1 px):	116.40 cm/s	96.42 cm/s
Minimum Velocity (1x1 px):	-59.60 cm/s	-51.06 cm/s
Maximum Acceleration:	0.67 cm/s/s	0.55 cm/s/s
Minimum Acceleration:	-0.50 cm/s/s	-0.48 cm/s/s
Maximum Flow:	346.64 ml/s	278.60 ml/s
Minimum Flow:	-31.39 ml/s	-28.29 ml/s
Net Positive Volume:	62.81 ml	51.34 ml
Net Negative Volume:	-8.27 ml	-9.01 ml

Myocardial strain analysis (AHA Segmentation)

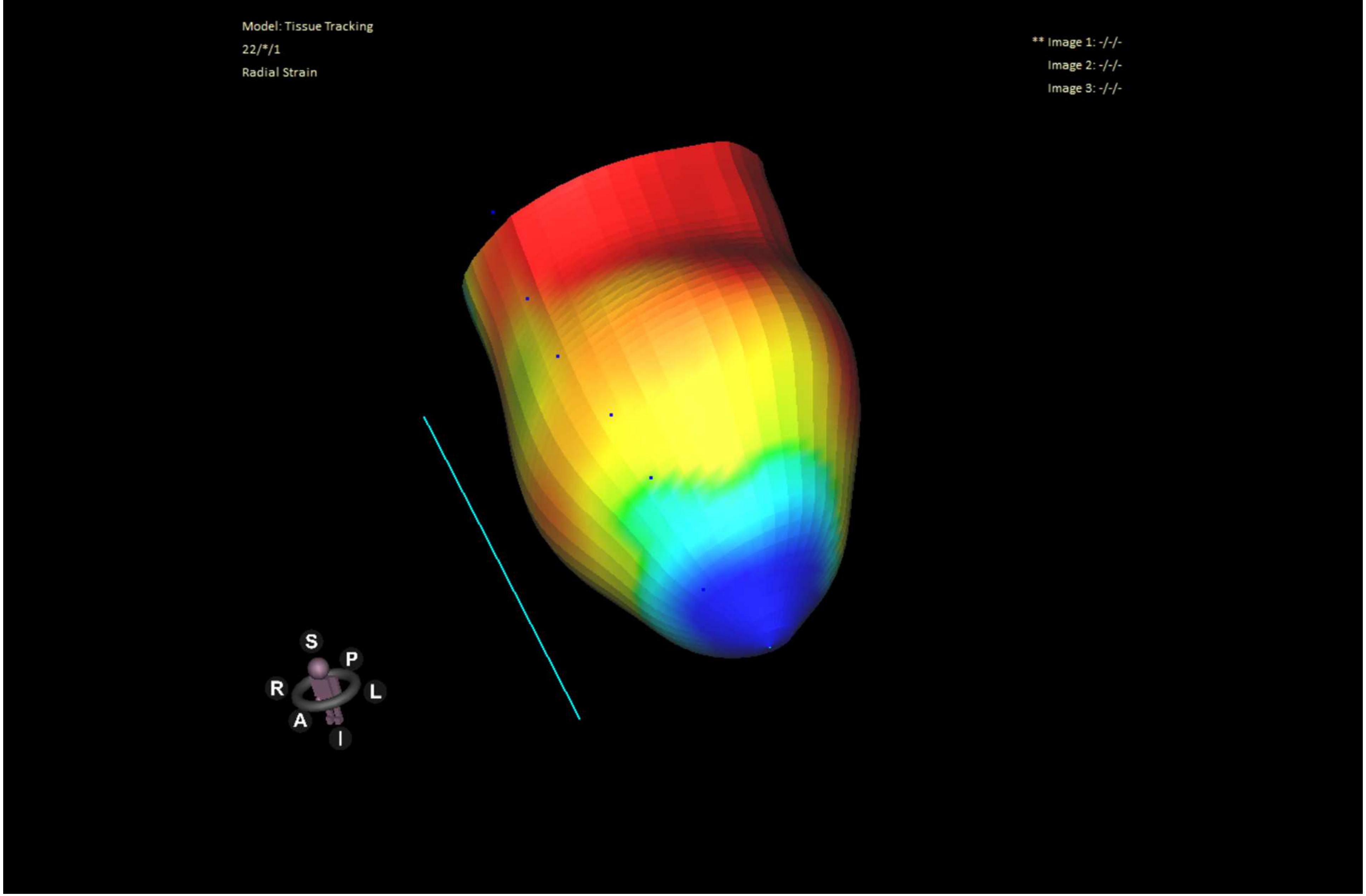






Peak Radial Strain
RV only
7,6%
Biventricular
9,3%
LV only
6,4%
LV Results (2D)_Radial Strain (%) _SA__Slice_3_Global
Septum
Lateral wall
Time (ms)

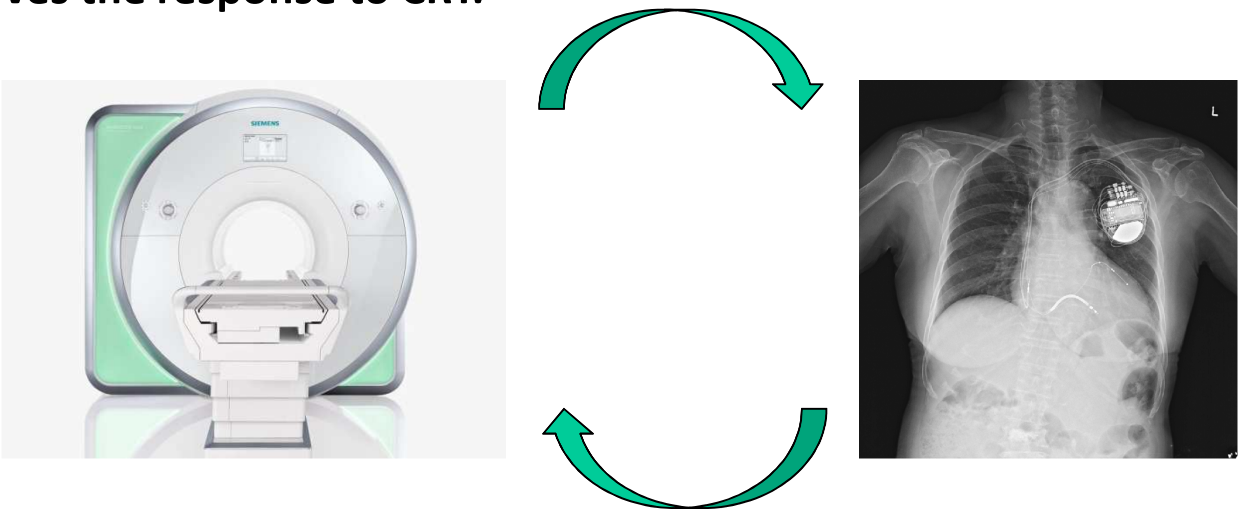
3D myocardial strain analysis in a patient with CRT-D and LV paced rhythm demonstrating dyssynchronous contraction



MR-guided programming of pacing parameters for heamodynamic optimization

Conclusion

Targeting late-contracting, viable segments, assessed using late gadolinium enhancement and feature-tracking CMR prior to device implantation improves the response to CRT.



With new technologies emerging in the field of CRT (multipolar leads with several pacing vectors, multipoint pacing, micro catheters), the ability to assess the haemodynamic response and contraction pattern after the implantation in the individual patient is becoming more important.

Taylor, R. J., Umar, F., Panting, J. R., Stegemann, B., & Leyva, F. (2016). Left ventricular lead position, mechanical activation, and myocardial scar in relation to left ventricular reverse remodeling and clinical outcomes after cardiac resynchronization therapy: A feature-tracking and contrast-enhanced cardiovascular magnetic resonance study. Heart Rhythm, 13(2), 481-489.

Thank you!