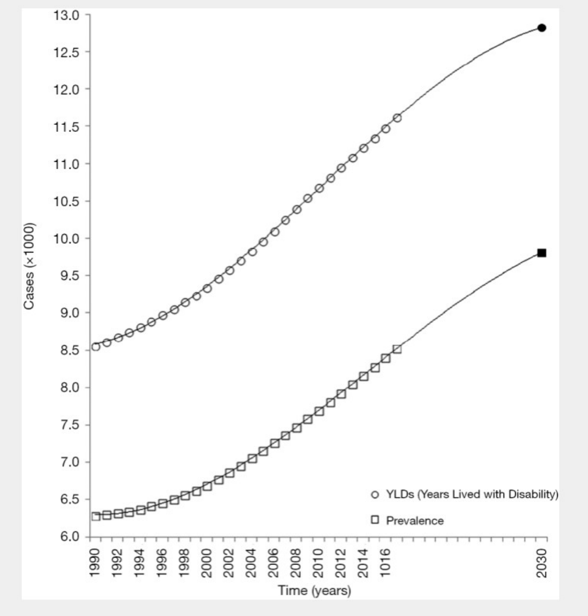
PETROVSKY NATIONAL RESEARCH CENTRE OF SURGERY
(FSBSI « PETROVSKY NRCS»)
MOSCOW

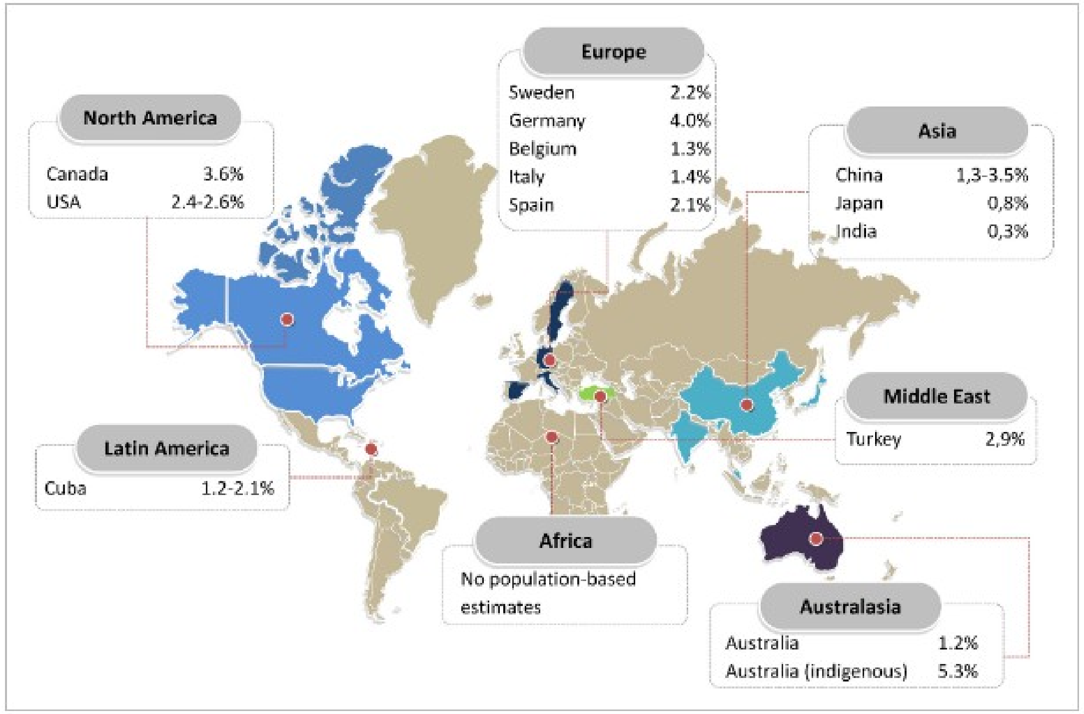
Solutions for Optimal Cardiac Resynchronization Therapy

Dr. DMITRIY PODOLYAK



Heart Failure

This is a pathophysiological syndrome in which, as a result of one or another disease of the cardiovascular system, there is a decrease in the pumping function of the heart, which leads to an imbalance between the hemodynamic demand of the body and the capabilities of the heart.



Epidemiology Heart Failure

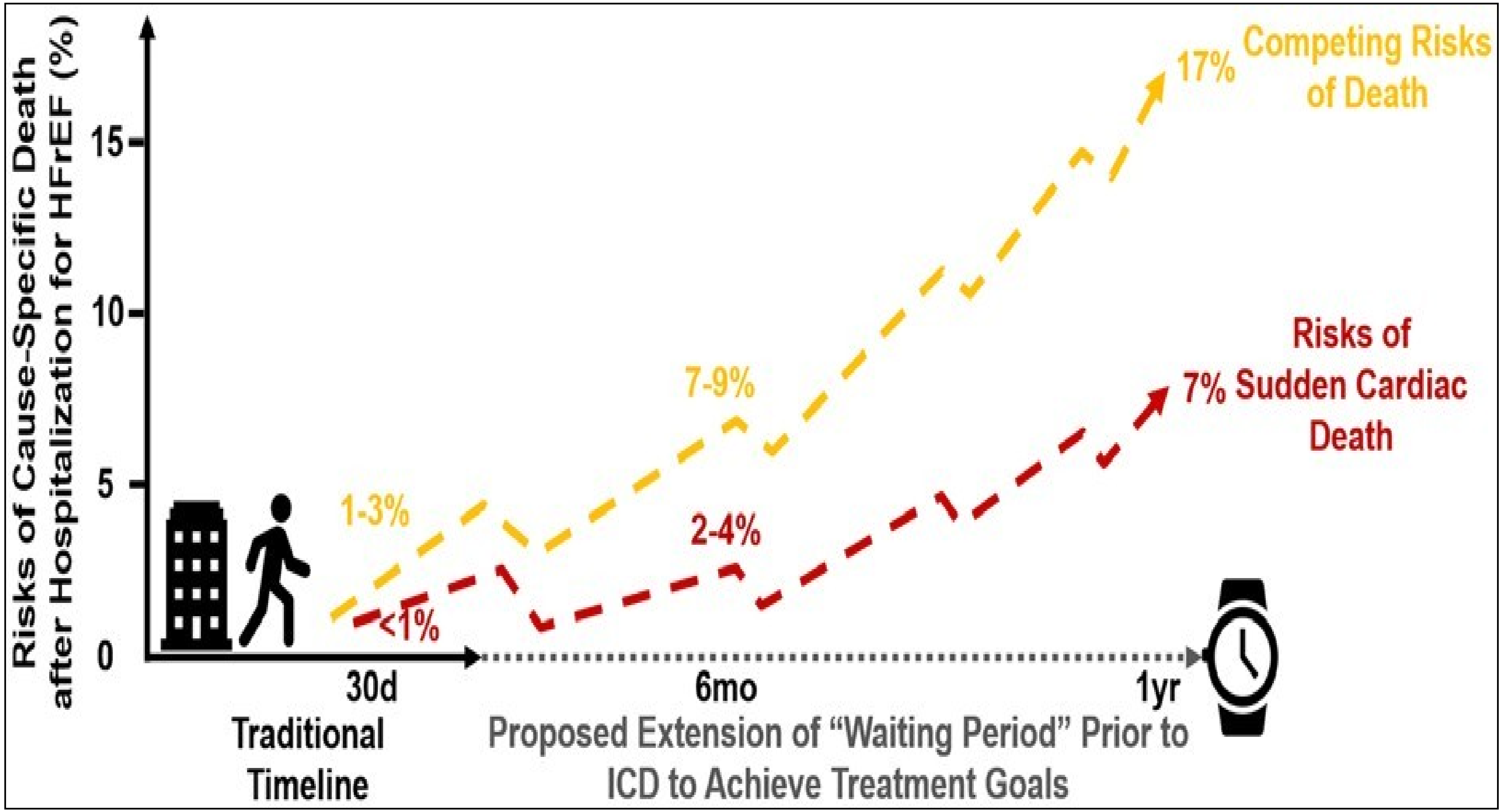
26- million people in the world. By 2030 y.- 30 mln. p.

In Russia, *HF (I-IV) NYHA* (2016 г) - 14,9 mln.p.

Among them, in severe form - 6,0 mln.p. *ФК III-IV NYHA*

One – year mortality is 880-980 thousand people.

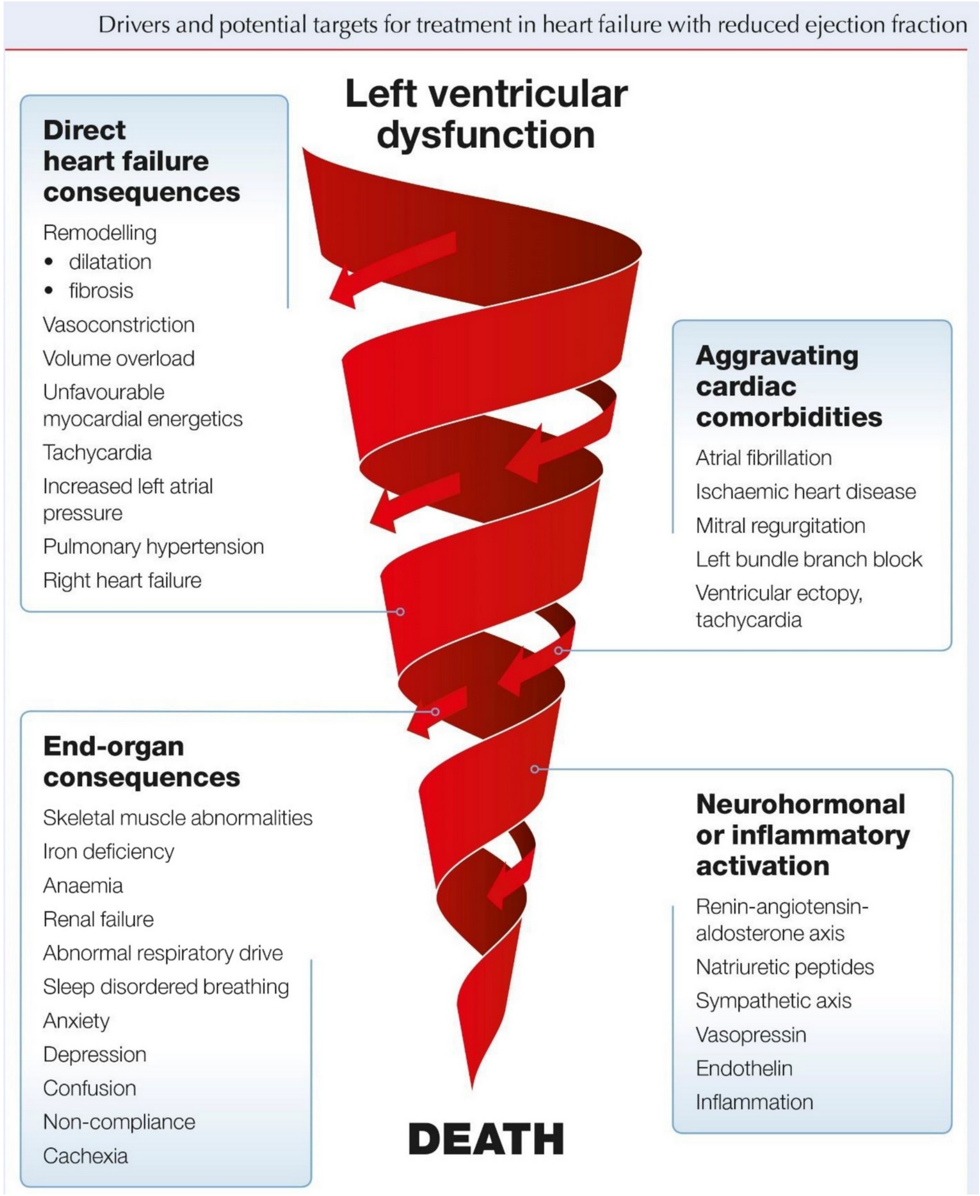
Risks of Cause-Specific Death after Hospitalization patients with Heart Failure



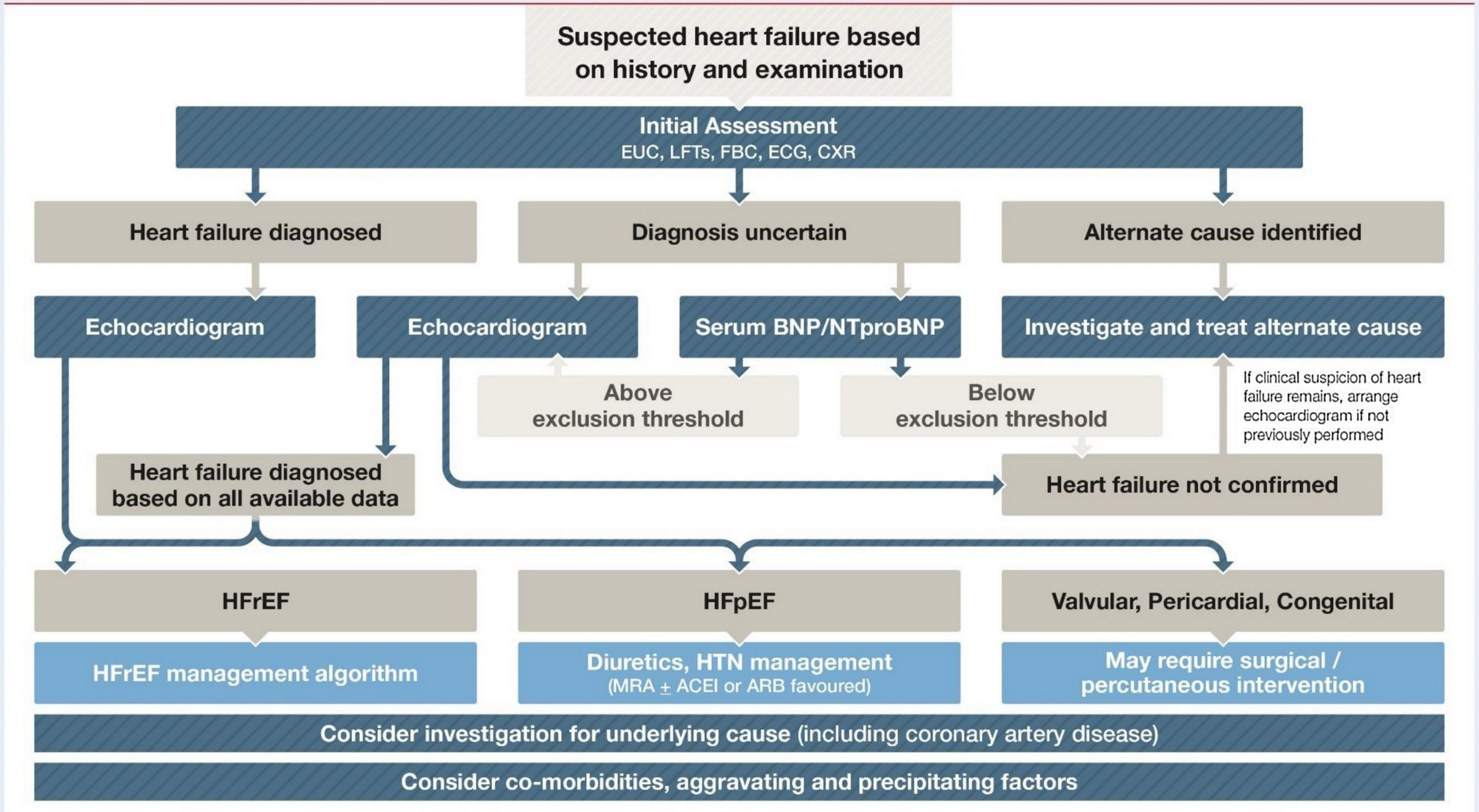
DeFilippis et al; Waiting Period Before ICD Implantation *Circ Heart Fail.* 2017

The main goals of treatment of patients with HF

1. Elimination of clinical symptoms
2. Prevention of target organ damage
3. Risk reduction SCD
4. Improving the quality and duration of life

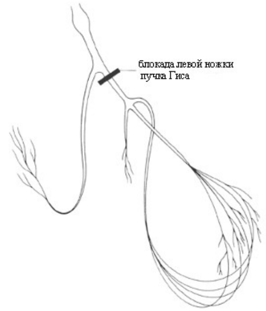


Diagnostic workup of a patient with suspected heart failure



EUC	LFTs	FBC	ECG	CXR	BNP	NTproBNP	HFrEF	HFpEF	HTN	MRA	ACEI	ARB
electrolytes / urea / creatinine	liver function tests	full blood count	electrocardiogram	chest X-ray	B-type natriuretic peptide	N-terminal pro-B type natriuretic peptide	heart failure with reduced ejection fraction	heart failure with preserved ejection fraction	hypertension	mineralocorticoid receptor antagonist	angiotensin converting enzyme inhibitor	angiotensin receptor blocker

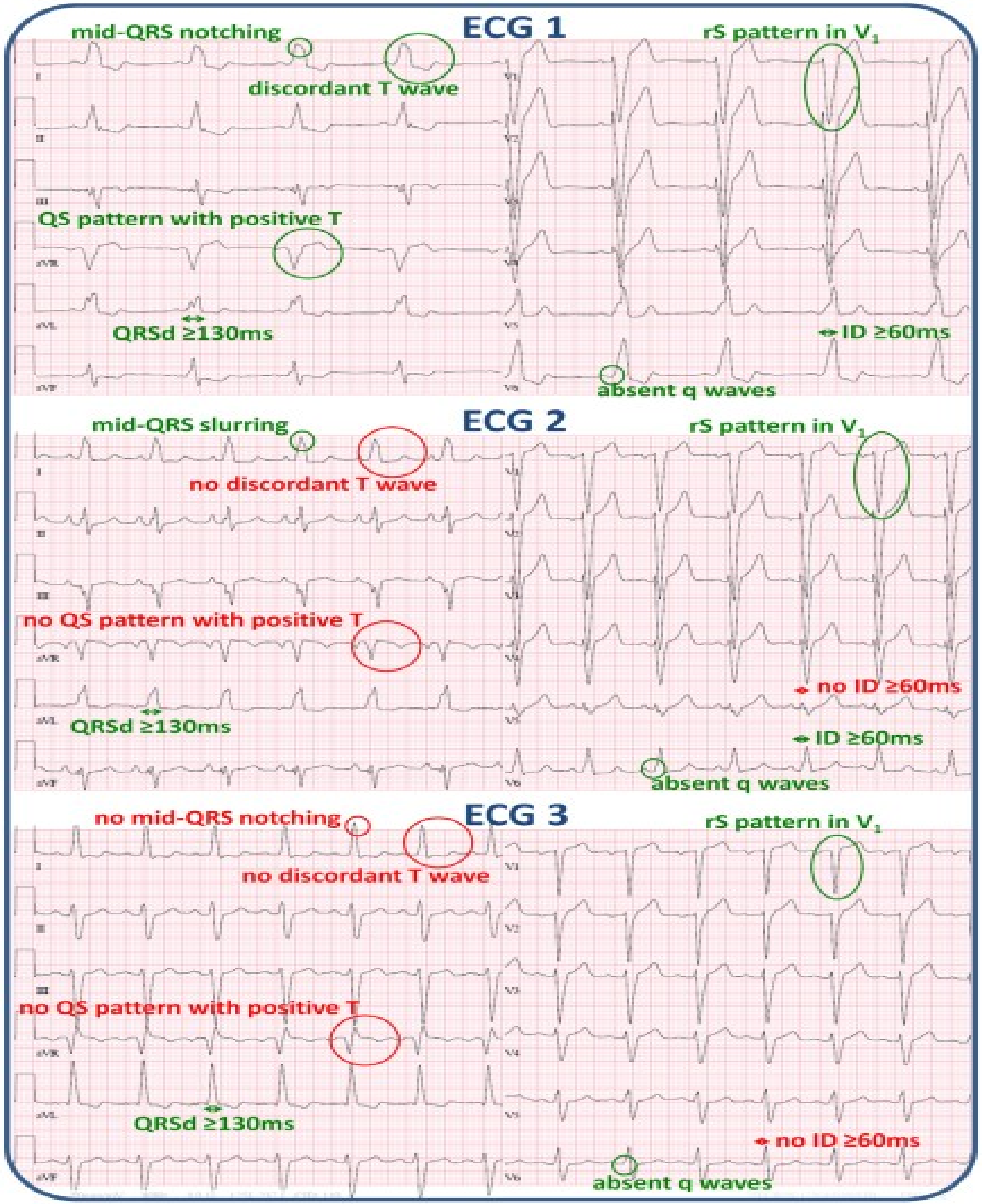
Adapted from Tomlinson S, Atherton JJ. Heart failure - The crucial role of the GP. MedicineToday 2018;19:19-27 with permission.



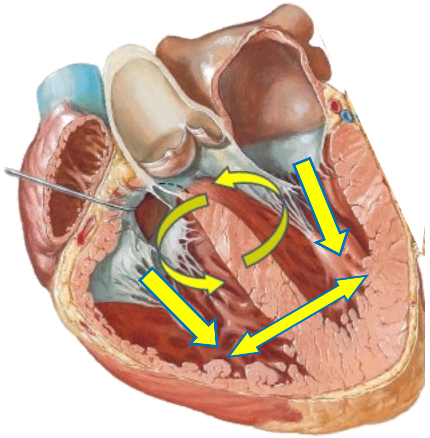
ECG – parameters LBBB.
(QRS duration and morphology)

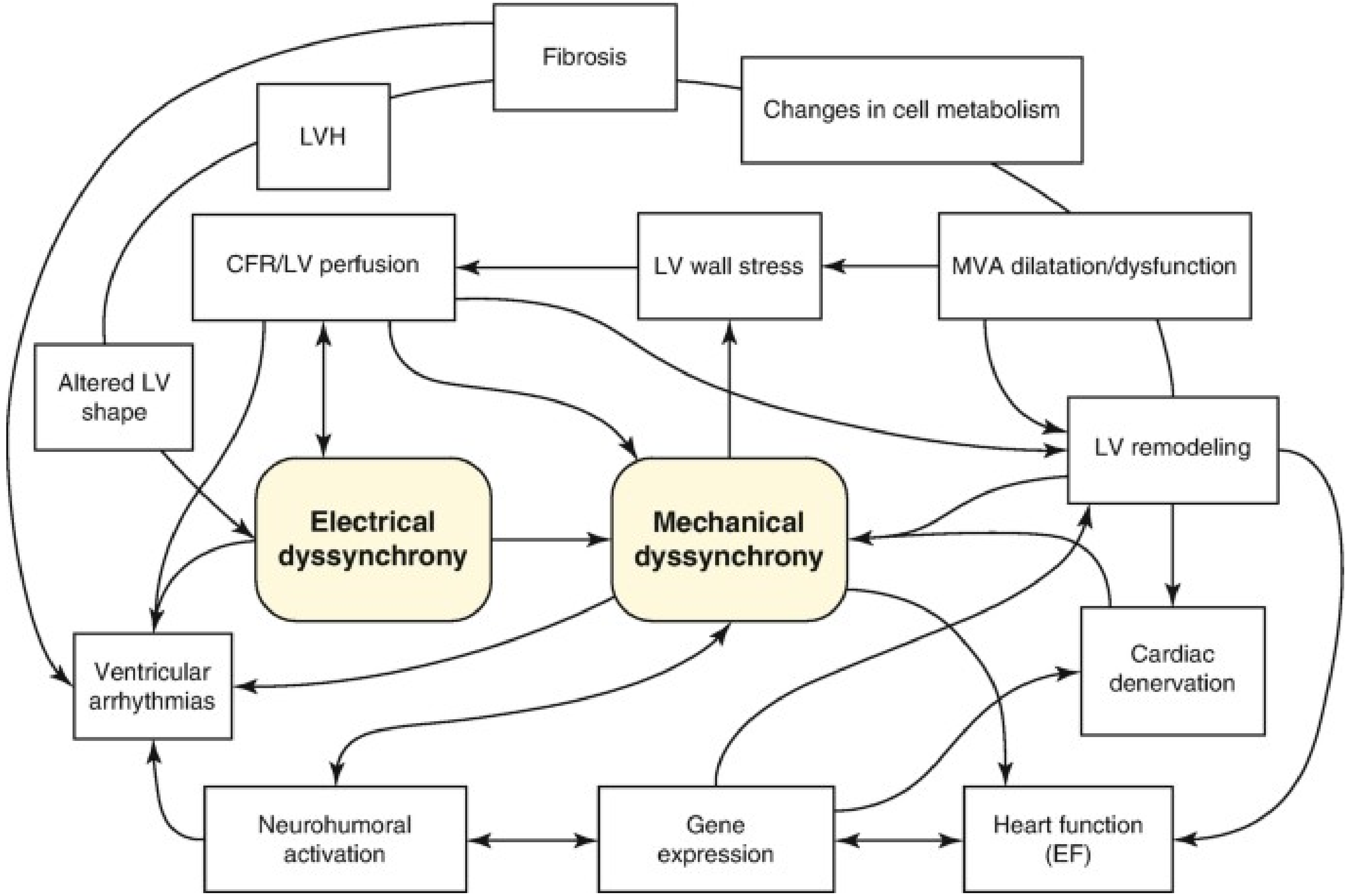
ECG parameter for complete LBBB	ESC	AHA	Strauss	MADIT	REVERSE
QRS duration (ms) ≥	120	120	♀130 ♂140	130	120
QS or rS in V_1	Yes	Yes	Yes	Yes	Yes
Positive T in V_1	Yes	No	No	No	No
Normal ID R in V_1–V_3	No	Yes	No	No	No
ID R in V_5 ≥60 ms	No	Yes	No	No	No
ID R in V_6 ≥60 ms	Yes	Yes	No	No	No
ID R in I ≥60 ms	Yes	No	No	No	No
Notch-/slurred R in I, aVL and V_5–V_6	No	Yes	No	No	No
Mid-QRS notch/slurring in ≥2 leads of V_1–V_2, V_5–V_6, I, aVL	No	No	Yes	No	No
RS pattern allowed in V_5–V_6	No	Yes	Yes	Yes	Yes
Absent q in V_5–V_6	No	Yes	No	Yes	Yes
Absent q in I	No	Yes	No	No	No
QS with positive T in aVR	Yes	No	No	No	No
Usually discordant T	Yes	Yes	No	No	No

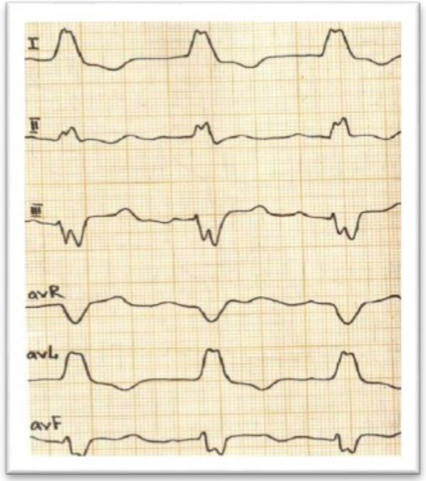
C.J.M. van Deursen et al. / Journal of Electrocardiology 47 (2014) 202–211

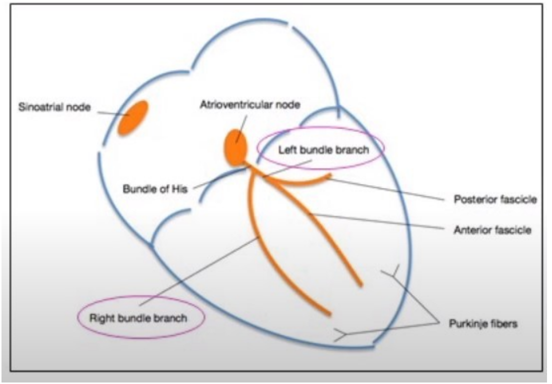


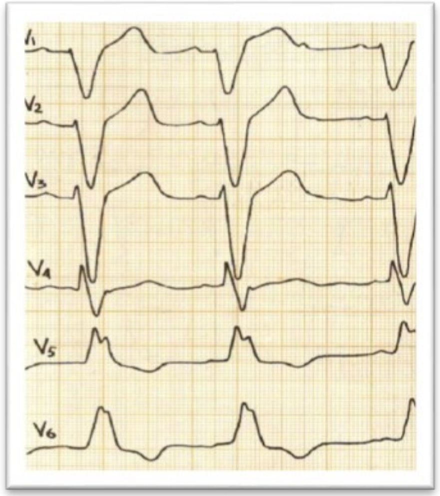
Dyssynchrony is a pathological dissociation of contraction or relaxation of individual chambers of the heart and segments of the myocardium as a result of disturbances in impulse conduction, which leads to a violation of the contractility of the heart and an increase in energy consumption by the myocardium.











Guideline-Directed Medical Therapy (GDMT)

	ACEi / ARB	β-Blocker	MRA	ARNi Transition	Repeat EF Assessment	Estimated Timeline to GDMT
Aggressive	4 wks	4 wks	4 wks	8 wks	4 wks	6 months
Practical	8 wks	8 wks	4 wks	12 wks	4 wks	9 months
Conservative	12 wks	12 wks	8 wks	12 wks	4 wks	12 months
	• 3 dosing changes to target doses • Double dose in at least 2-week intervals • Frequent laboratory monitoring	• 3 dosing changes to target doses • Double dose in at least 2-week intervals	• 1 dosing change to target dose • Dose uptitration in 4-8 weeks • Frequent laboratory monitoring	• Requires ACEi washout • 1-2 dosing changes to target dose • Dose uptitration every 2-4 weeks • Frequent laboratory monitoring	• After maximally-tolerated evidence-based doses of ACEi/ARB/ARNi, β-Blocker, and MRA achieved	

DeFilippis et al; Waiting Period Before ICD Implantation Circ Heart Fail. 2017

Surgical methods of treatment HF

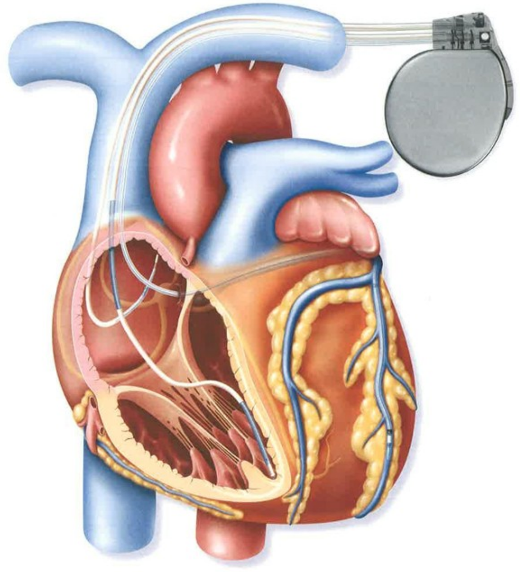
Cardiac Resynchronization Therapy (CRT)

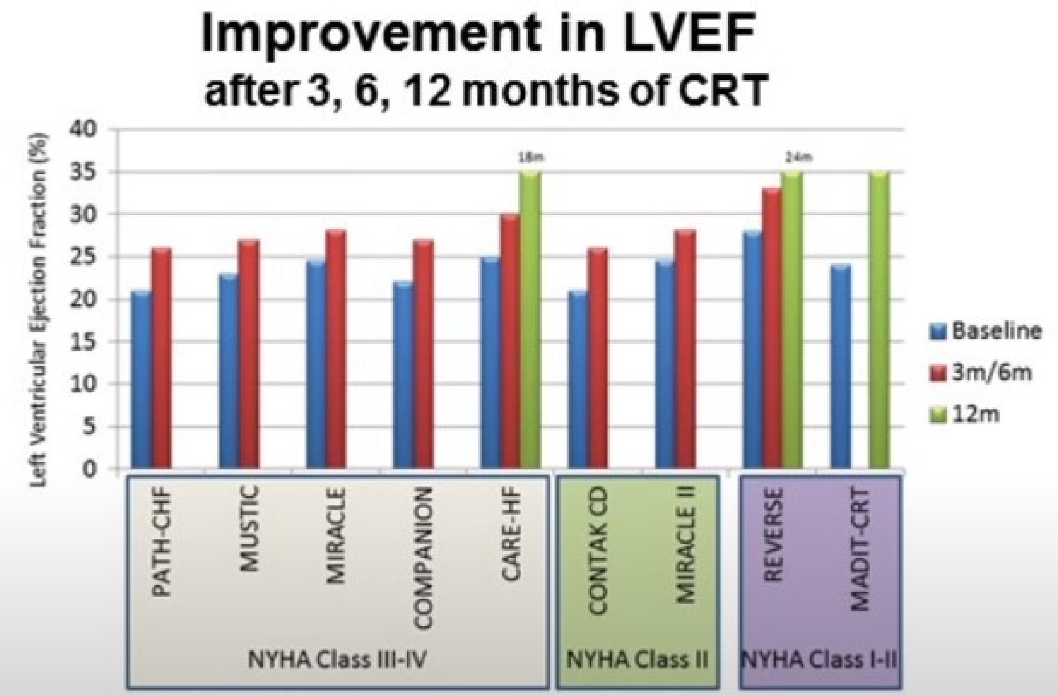
Cardiac Contractility Modulation (CCM)

Left Ventricular Assist Device (LVAD)

Orthotopic heart transplantation

Cardiac Resynchronization Therapy





Auricchio A. et al., Non-responders to cardiac resynchronization therapy – The Magnitude of the Problem and the Issues. Circ J 2011;75:521-7.

Reduction in overall mortality by 29%
Reduction in mortality due to progressive HF by 38%

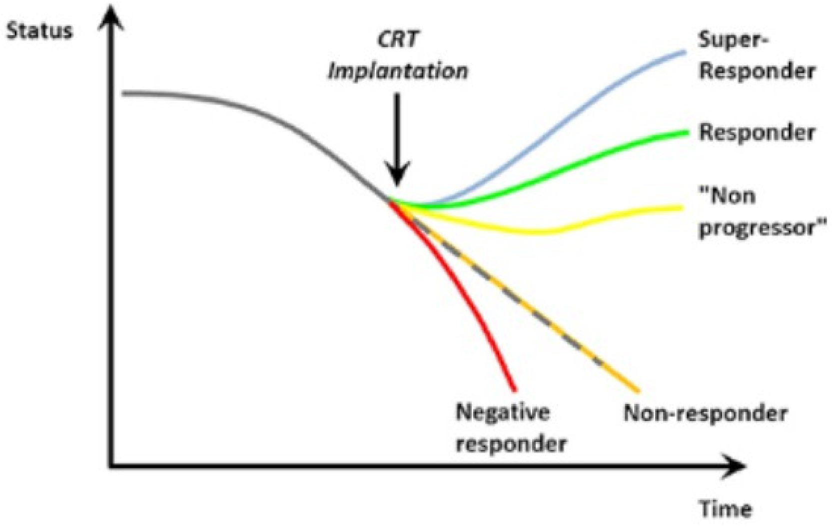
MIRACLE, COMPANION, CARE-HF, REVERSE, MADIT-CRT, RAFT.

Table 1 2022 AHA/ACC/HFSA guidelines for the management of heart failure

COR	RECOMMENDATIONS
1	For patients who have LVEF < 35%, sinus rhythm, left bundle branch block (LBBB) with a QRS duration ≥150 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT, CRT is indicated to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL. For patients who have LVEF≤ 35%, sinus rhythm, LBBB with a QRS duration of ≥ 150 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT, CRT implantation provides high economic value.
2A	For patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with a QRS duration ≥150 ms, and NYHA class II, III, or ambulatory class IV symptoms on GDMT, CRT can be useful to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL.
2A	In patients with high-degree or complete heart block and LVEF of 36% to 50%, CRT is reasonable to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL.
2A	For patients who have LVEF ≤35%, sinus rhythm, LBBB with a QRS duration of 120 to 149 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT, CRT can be useful to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL.
2A	In patients with AF and LVEF ≤35% on GDMT, CRT can be useful to reduce total mortality, improve symptoms and QOL, and increase LVEF, if: a) the patient requires ventricular pacing or otherwise meets CRT criteria and b) atrioventricular nodal ablation or pharmacological rate control will allow near 100% ventricular pacing with CRT.
2A	For patients on GDMT who have LVEF ≤35% and are undergoing placement of a new or replacement device implantation with anticipated requirement for significant (>40%) ventricular pacing, CRT can be useful to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL.
2B	For patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with QRS duration of 120 to 149 ms, and NYHA class III or ambulatory class IV on GDMT, CRT may be considered to reduce total mortality, reduce hospitalizations, and improve symptoms and QOL.
2B	For patients who have LVEF ≤30%, ischemic cause of HF, sinus rhythm, LBBB with a QRS duration ≥150 ms, and NYHA class I symptoms on GDMT, CRT may be considered to reduce hospitalizations and improve symptoms and QOL.
3	In patients with QRS duration <120 ms, CRT is not recommended.
3	For patients with NYHA class I or II symptoms and non-LBBB pattern with QRS duration < 150 ms, CRT is not recommended.
3	For patients whose comorbidities or frailty limit survival with good functional capacity to < 1 year, ICD and cardiac resynchronization therapy with defibrillation (CRT-D) are not indicated.

Who Responds to CRT?

Overall response rate 70%



- **Significant dyssynchrony**

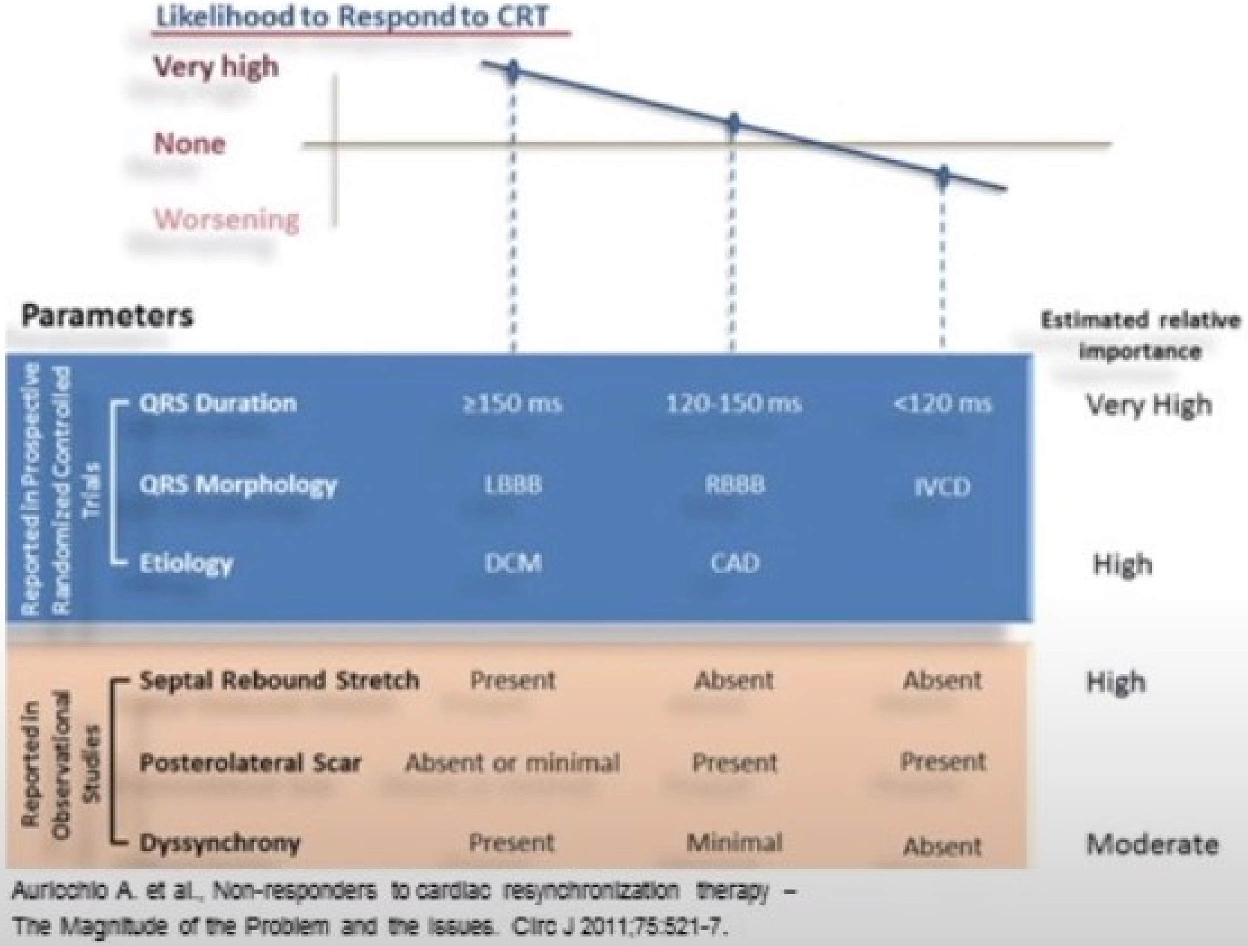
  LBBB, QRSD > 150 msec.
  3D ECHO IVD >40 msec.

- **Minimal lateral LV scar**

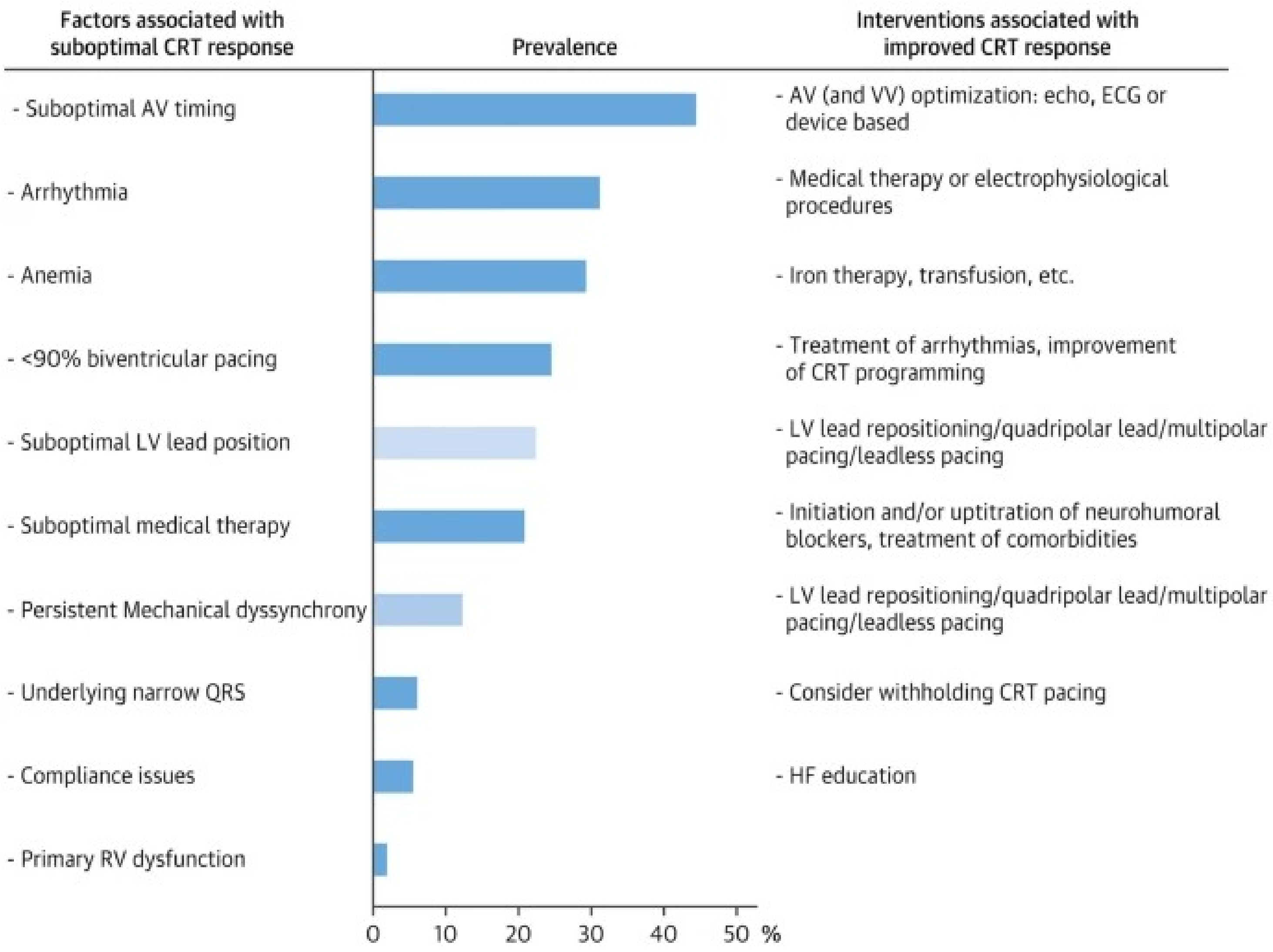
  MPI/SPECT/MRI ≤ 13-15%

- **Adequate CS anatomy**

  Lead placement
  Pace site of latest activation



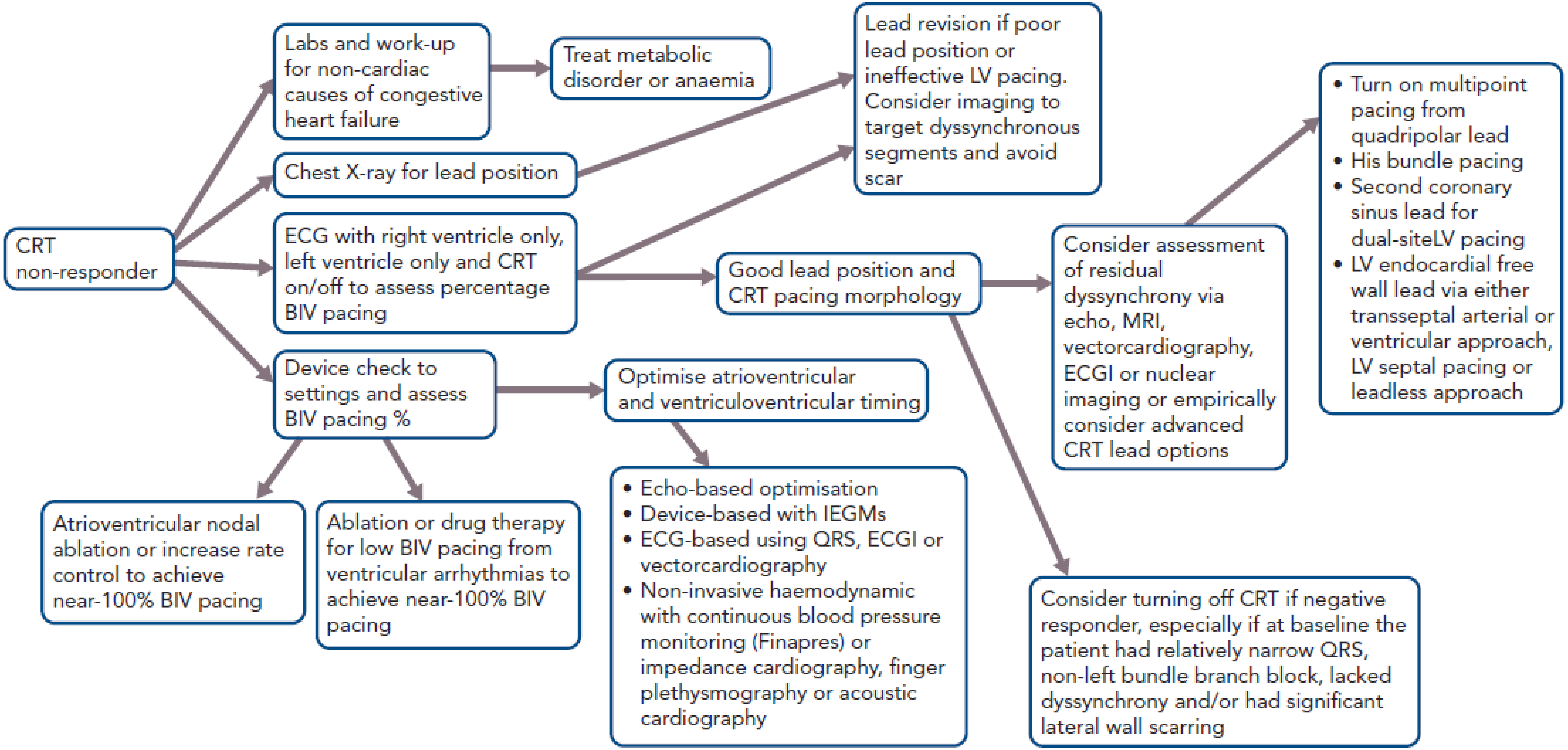
Understanding non -response to cardiac resynchronization therapy



Wilfried Mullens, Petra Nijst

Journal of the American College of Cardiology. 2017 69(17):2130–2133

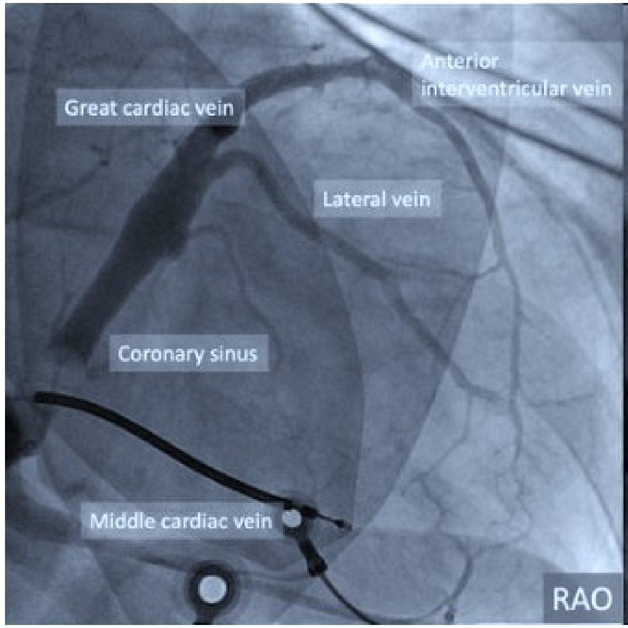
Decision Tree for CRT Non-responders

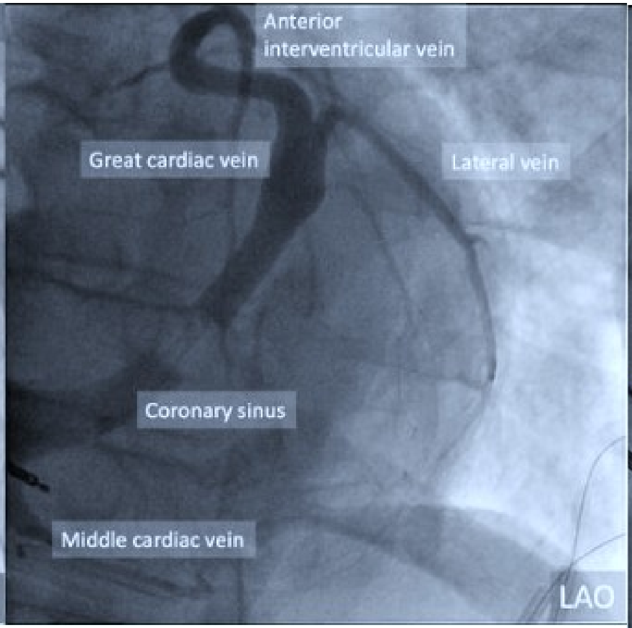


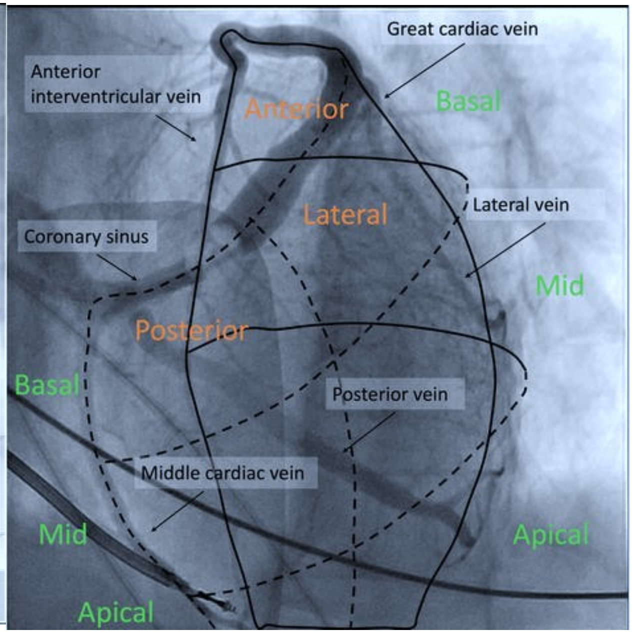
Improving Cardiac Resynchronisation Therapy
George Thomas, Jiwon Kim, Bruce B Lerman
Arrhythmia & Electrophysiology Review 2019;8(3):220–7.

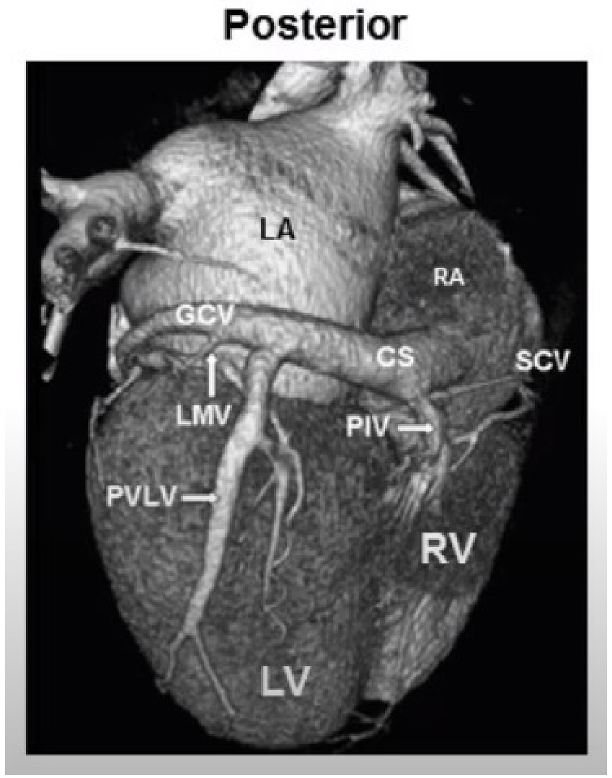
Coronary venous anatomy

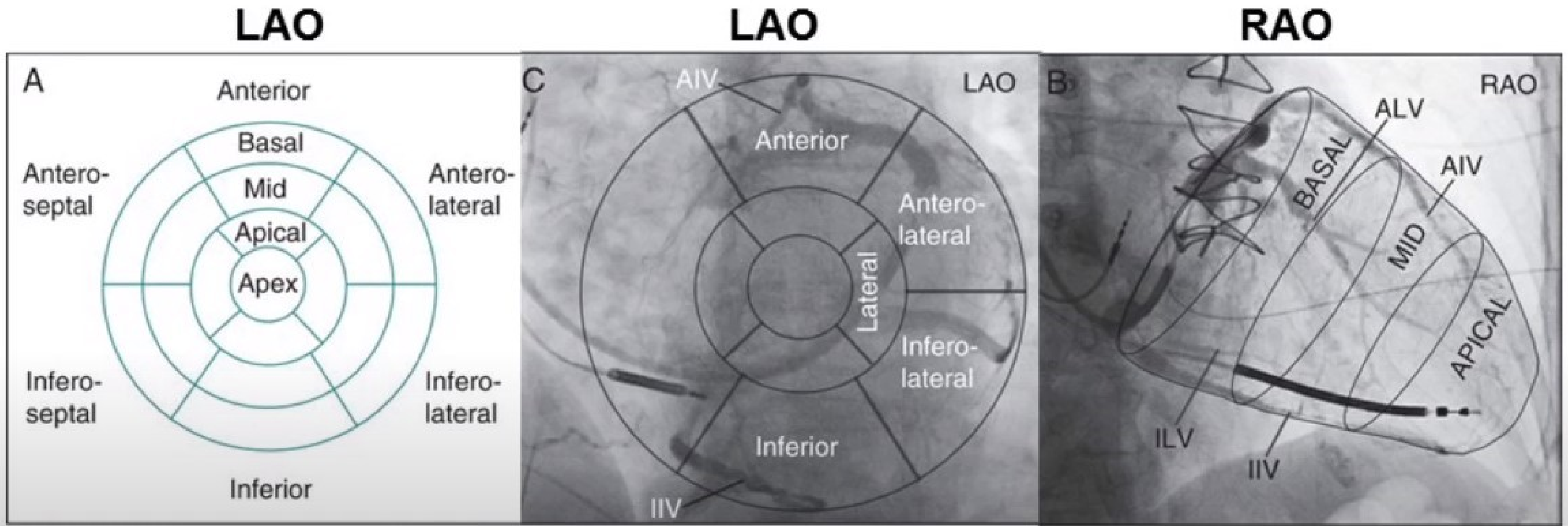
The coronary venous tree as seen on a rotational angiogram.



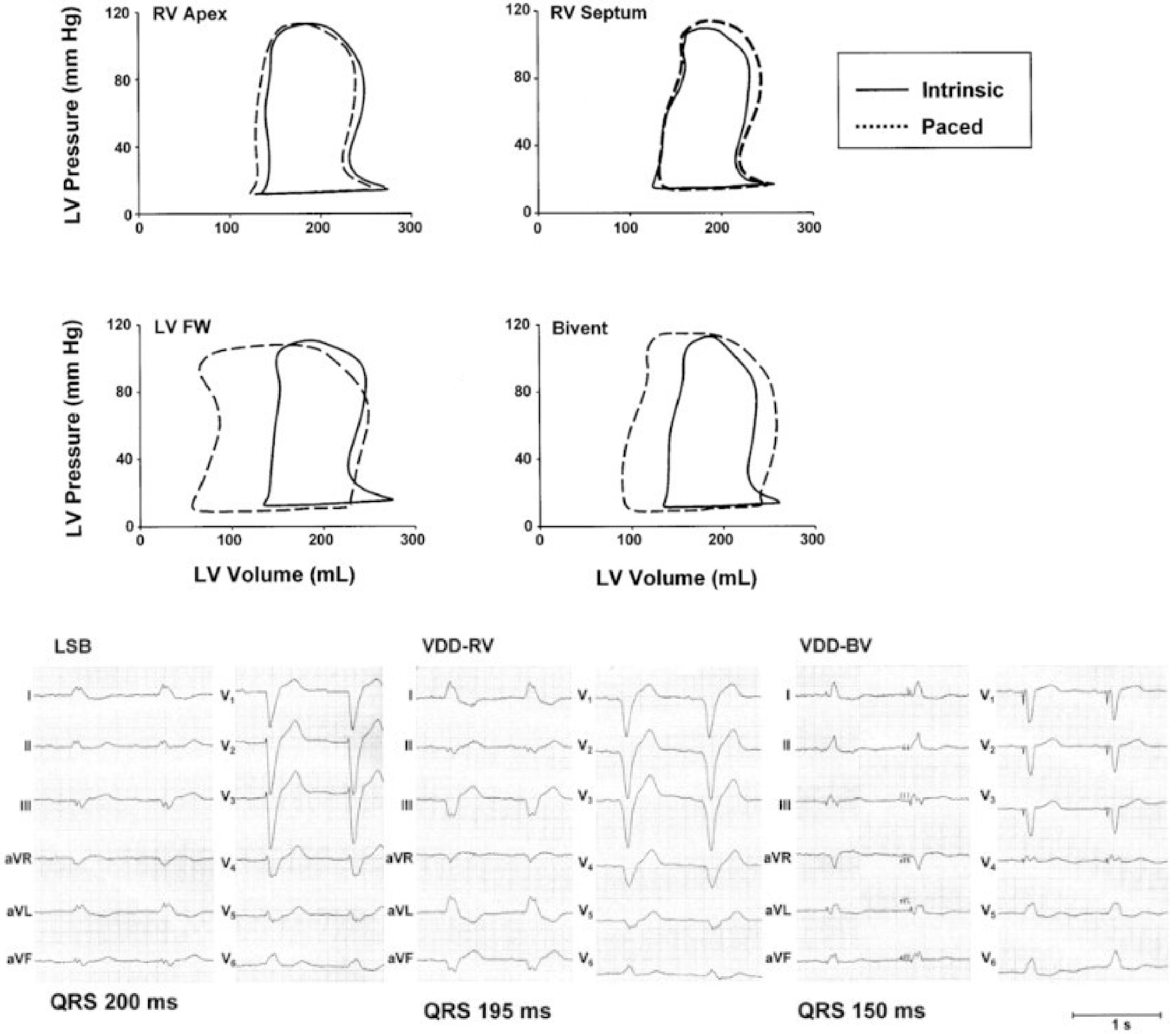






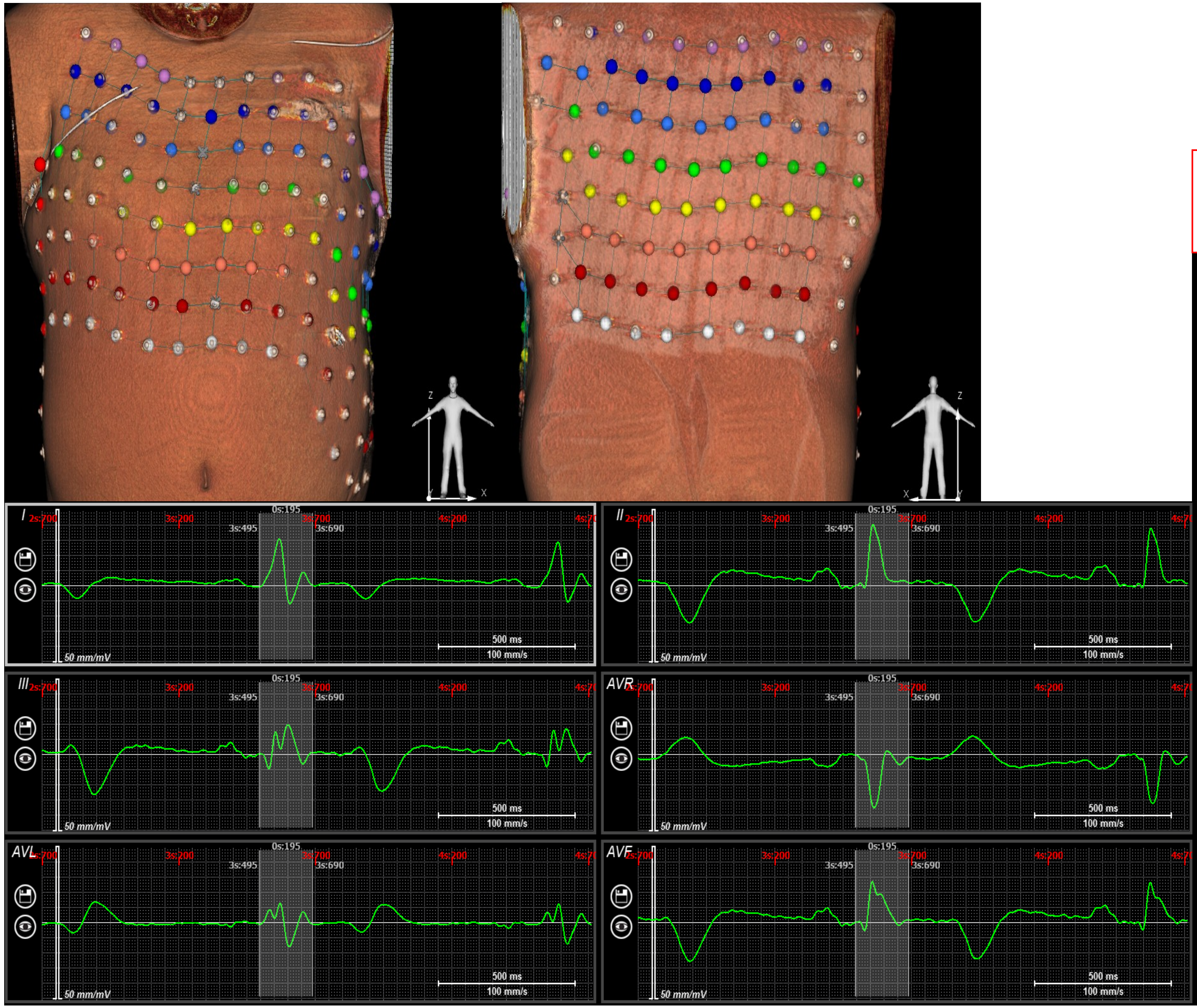


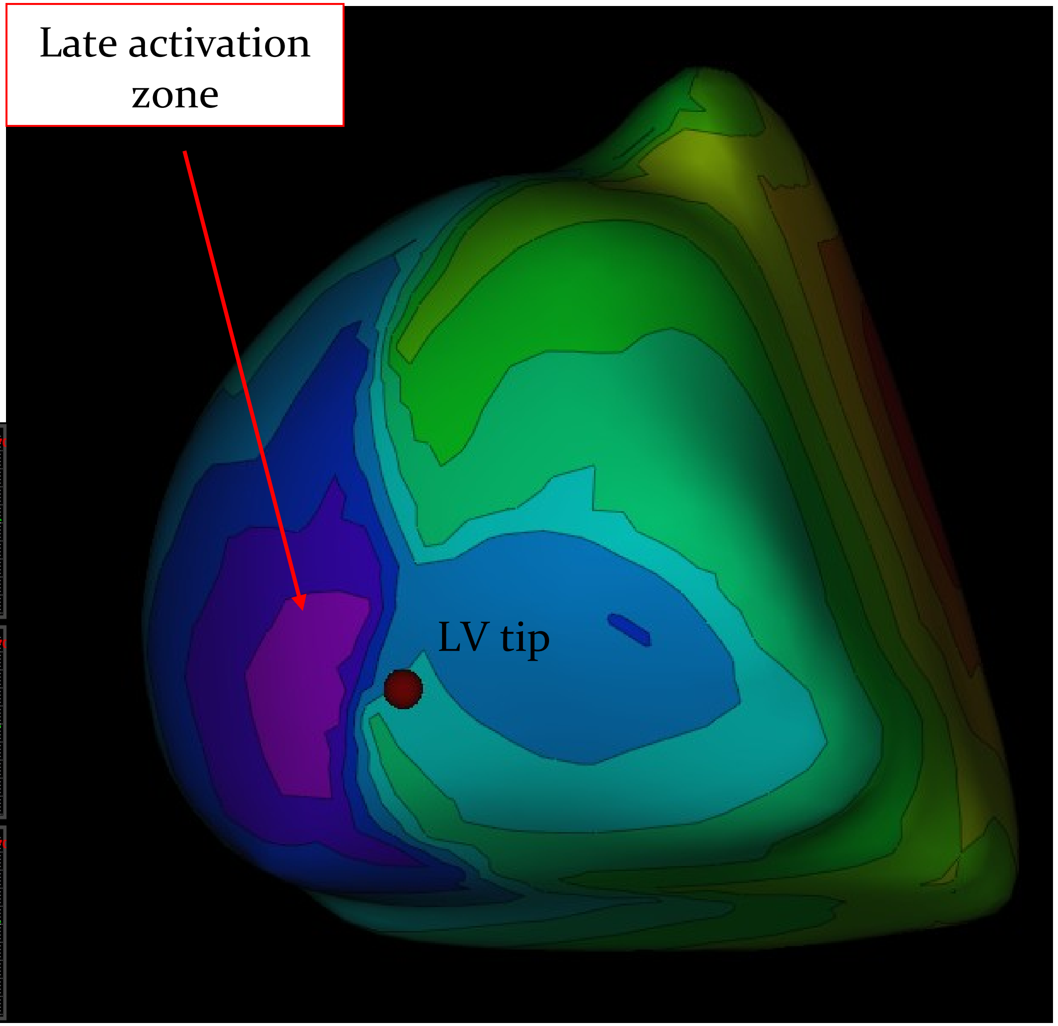
Pressure-volume (PV) loops from a patient with LBBB



O. A. Breithardt et al. Multisite pacing as a new treatment option in heart failure

Non-invasive Activation Mapping of the Heart

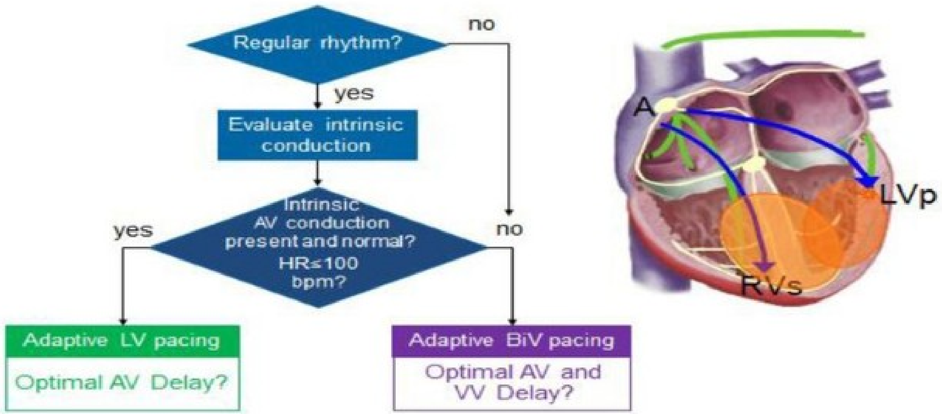


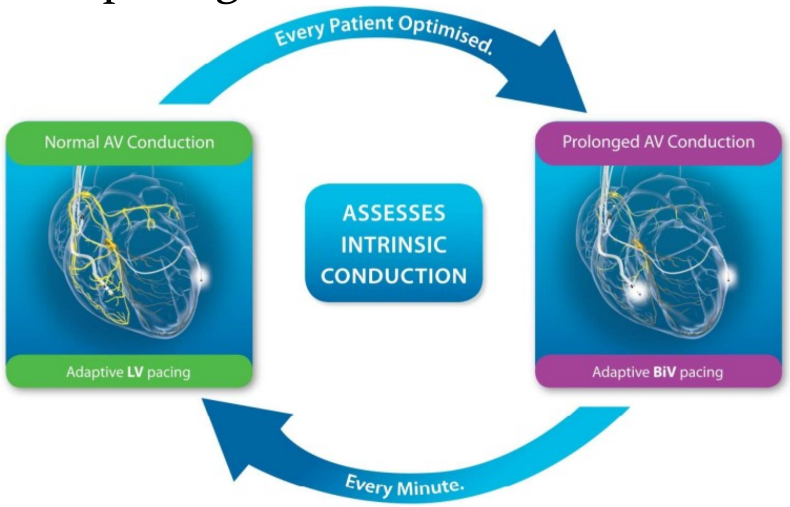


CRT – Optimization
Adaptiv CRT (Adaptiv BiV + LV)

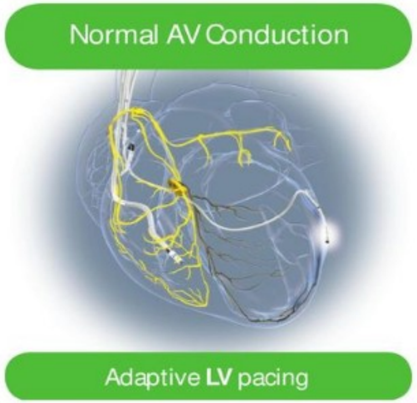
LV compared to BiV pacing: Do you really need RV pacing?

AdaptivCRT®: Operation





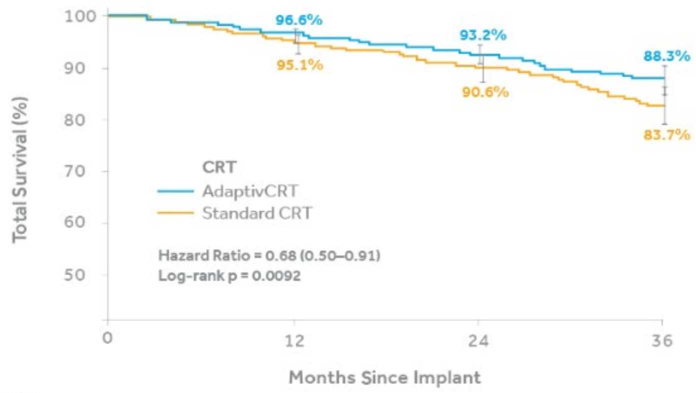
Adaptive LV Pacing



Adaptive LV pacing leverages intrinsic RV conduction by pre-pacing the LV to synchronize with intrinsic RV activation.

- AdaptivCRT® promotes physiologic pacing by reducing RV pacing by 44%[1]
- In addition to the potential for an increase in CRT response, reducing RV pacing increases device longevity[1,2]

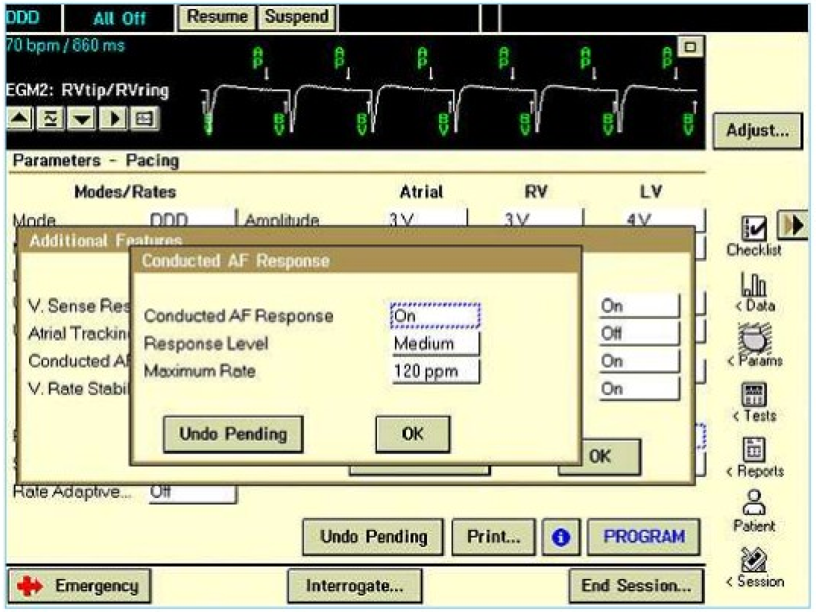
TOTAL SURVIVAL ADAPTIVCRT VERSUS STANDARD CRT



No. at Risk				
Number	1,162	856	548	242
Remaining	652	529	395	257

*Patients who received AdaptivCRT were associated with a 29% relative reduction in all-cause mortality versus conventional CRT (after adjusting for other potential risk factors including age, gender, LVEF, NYHA class, QRS duration, AF, CAD, hypertension, AV block, and LBBB).

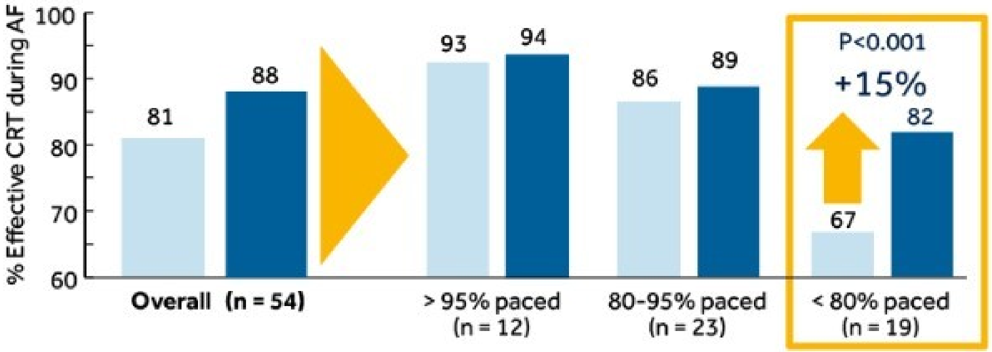
Effective CRT During AF Algorithm

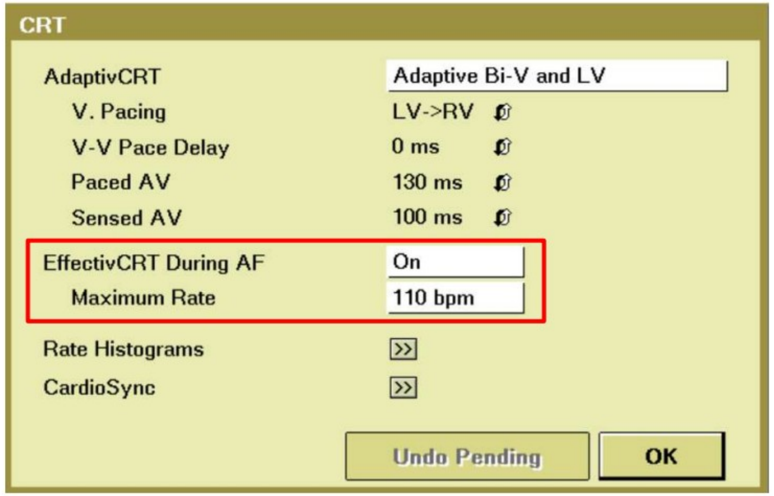


Conducted AF Response

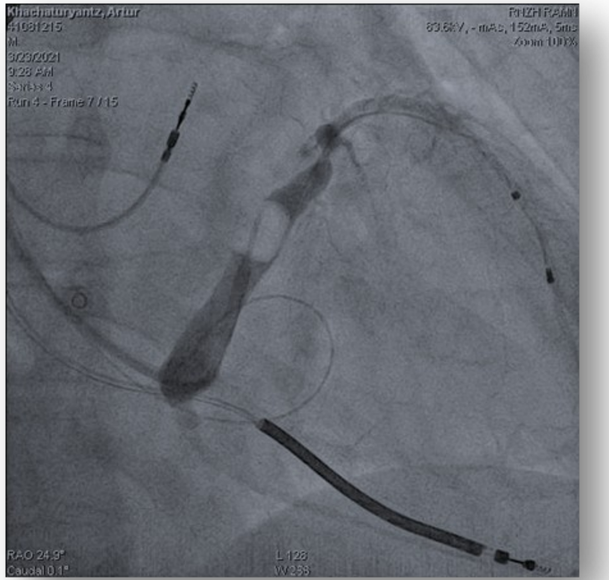
The EffectivCRT™ During AF Algorithm automatically changes the pacing rate to increase effective CRT delivery during AF by up to 15%[1]

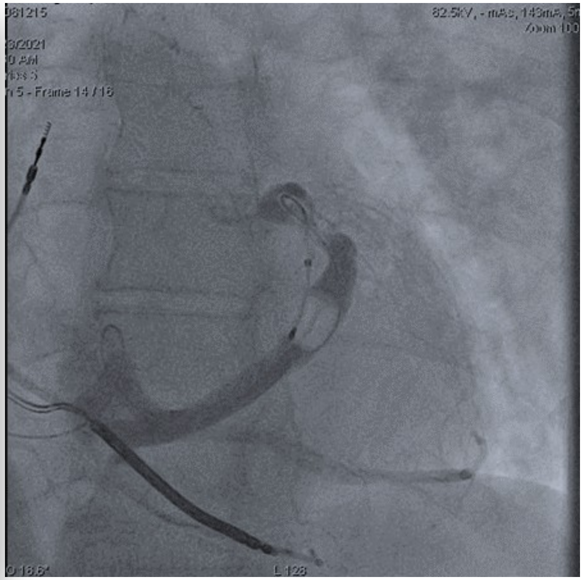
- EffectivCRT During AF increased effective pacing, from 81% to 88% ($p < 0.001$).
- Heart rate increased by 3 beats per minute, from 77 to 80 BPM ($p < 0.001$).
- Patients with baseline (< 80%) paced received the greatest benefit.

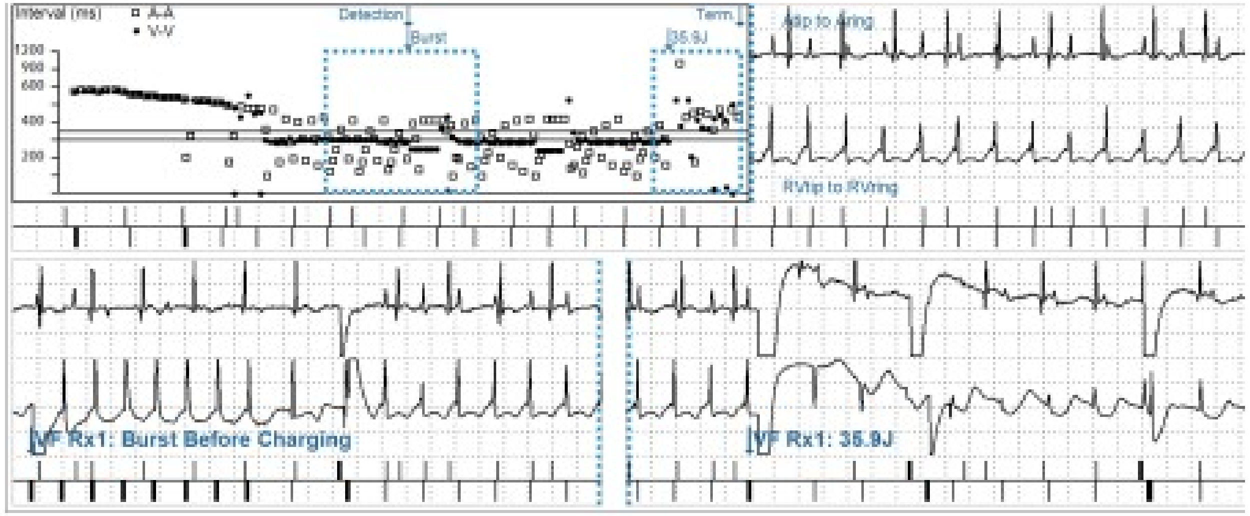


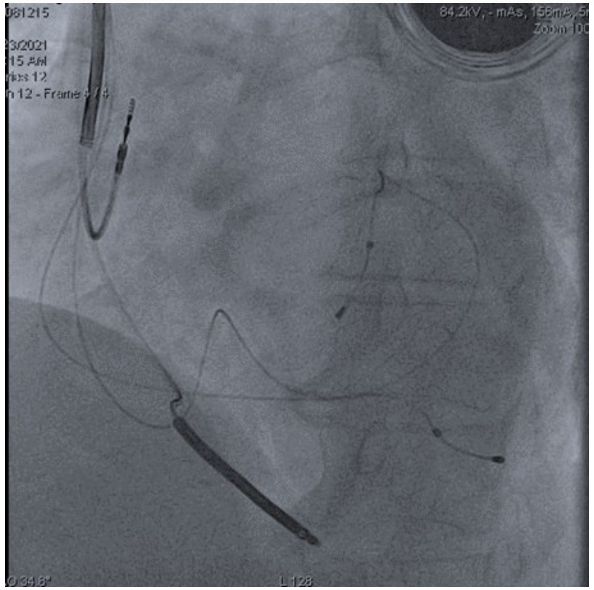


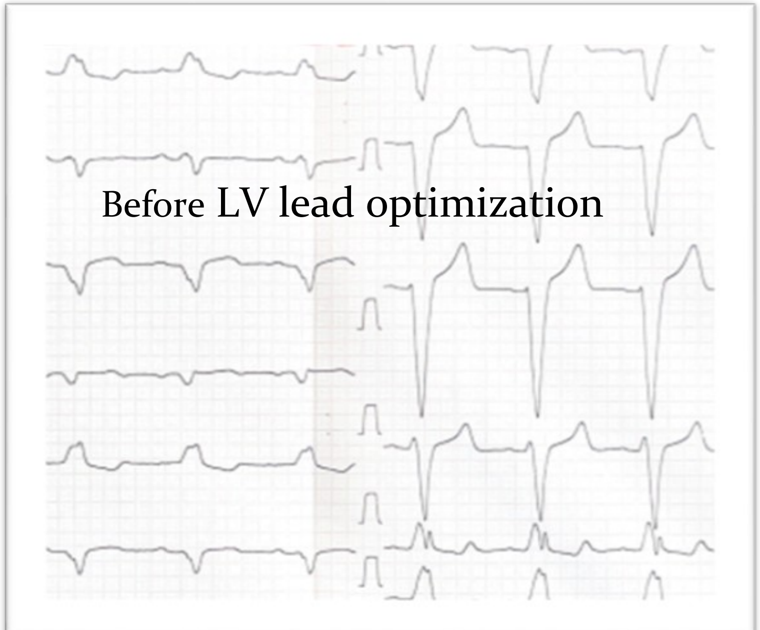
Case №1. Patient X, 63 y.o. DCM. Paroxysmal AF/AT. VT. LBBB. HF – II-III (NYHA). CRT-D – 2015, Ablation- VT- 2021г, Ablation AF/AT – 10.03. 2021г, re CRT-D + LV lead optimization 23.03.2021г.

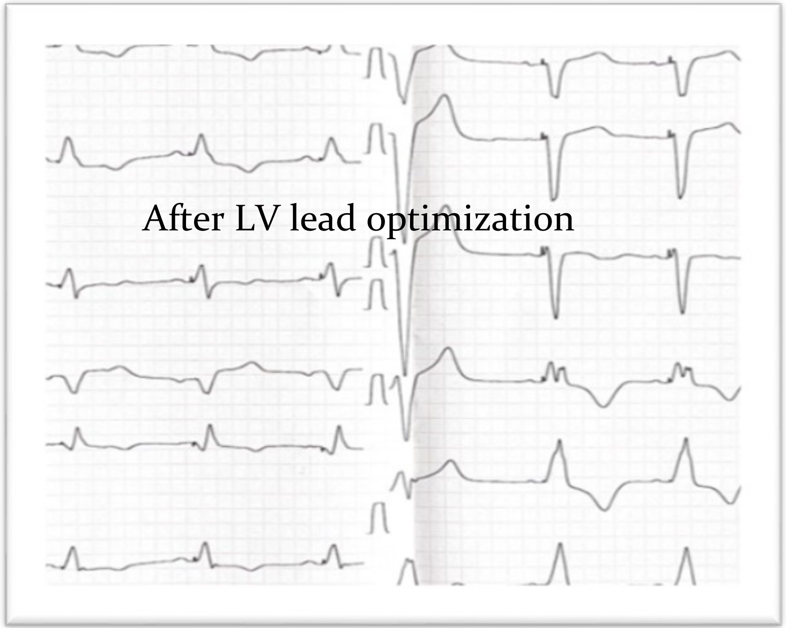




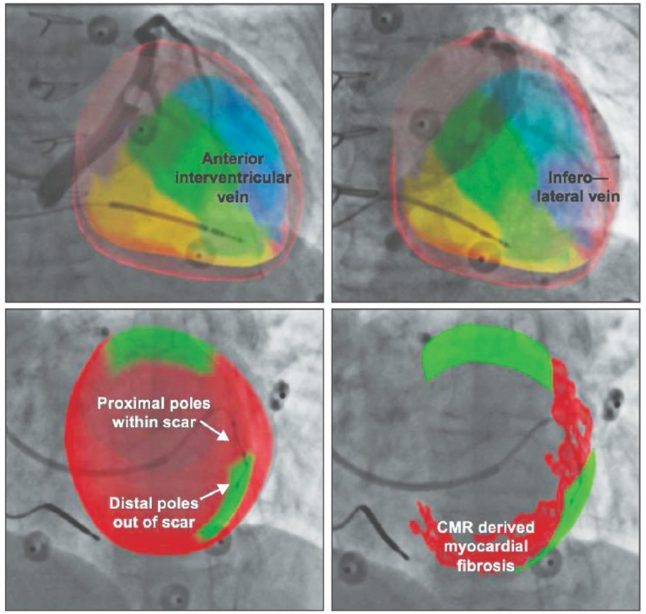


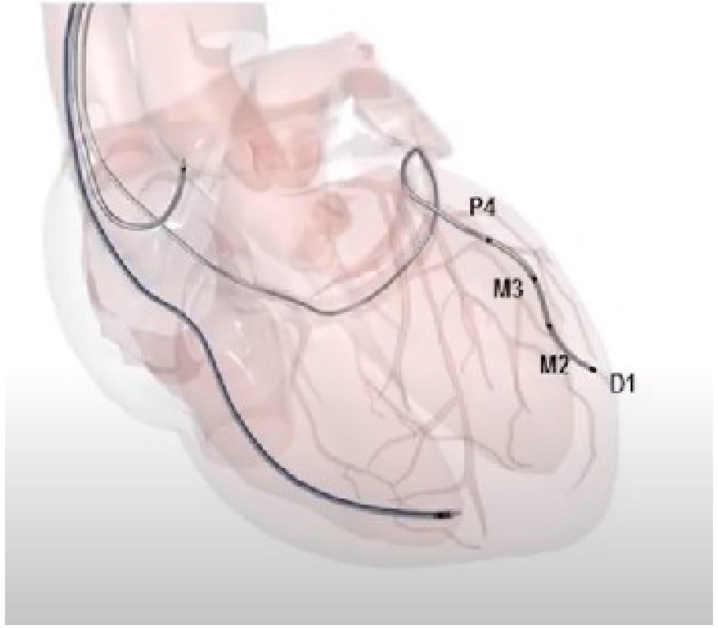






New approaches to LV stimulation to improve resynchronization therapy





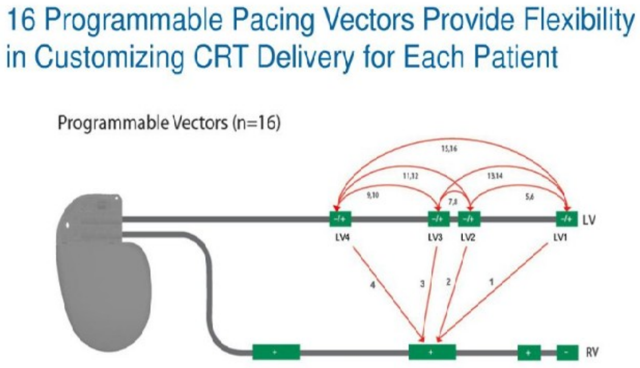
Benefits of using a quadripolar LV lead

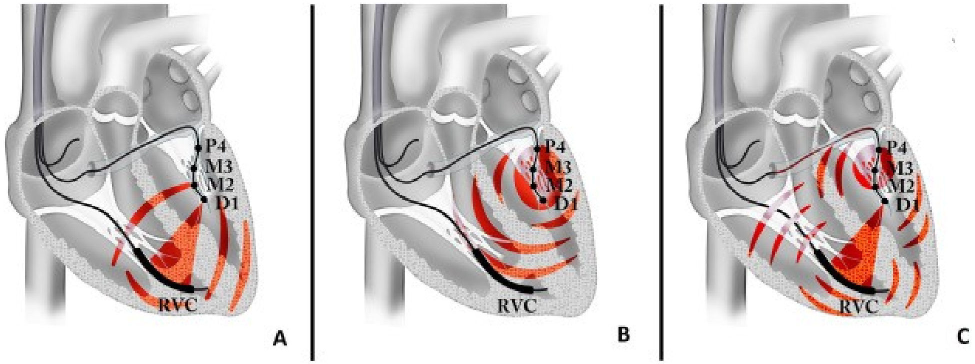
- **Better CRT**
- Implant at most stable location
- Pace at anatomically superior sites for CRT
- Lateral LV, Basal to Mid LV

- **Lead stability**
- Implant at most stable site
- Least chance of dislodgement
- Pace from available poles

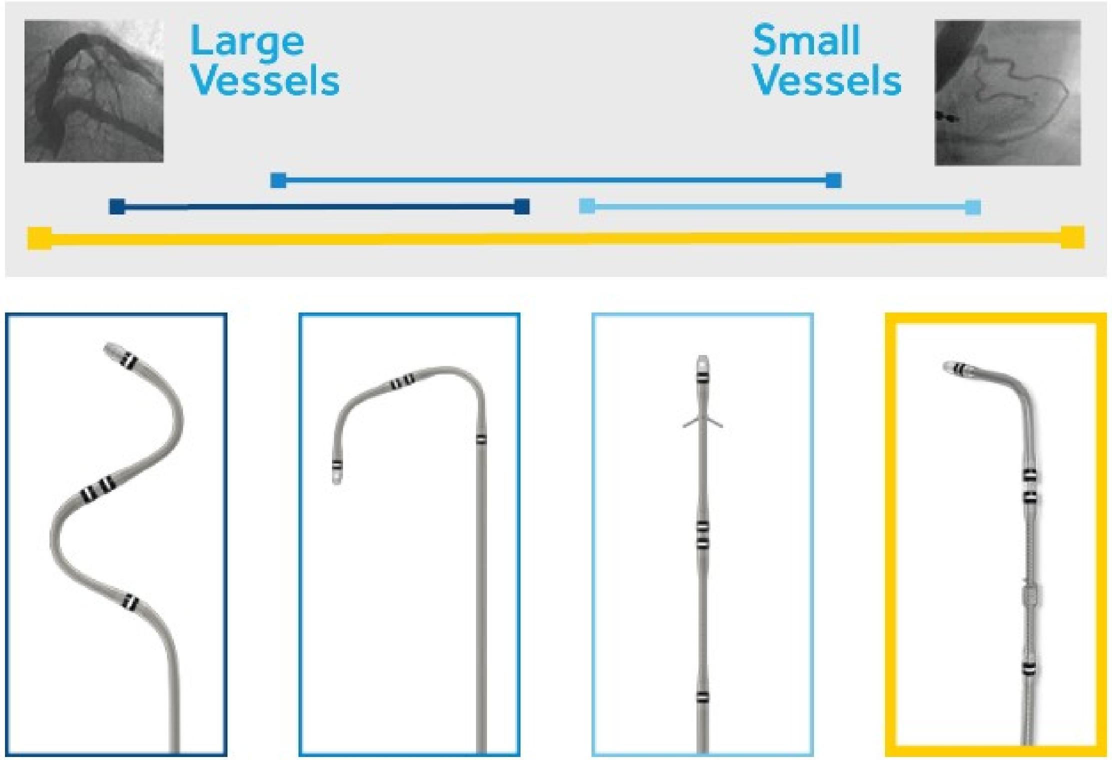
- **Phrenic Nerve Capture**
- Change pacing poles to eliminate phrenic capture without moving lead

- **Lowest Threshold**
- Multiple Pacing Vectors
- Superior vectors for CRT
- Best pacing threshold





The Family of quadripolar leads



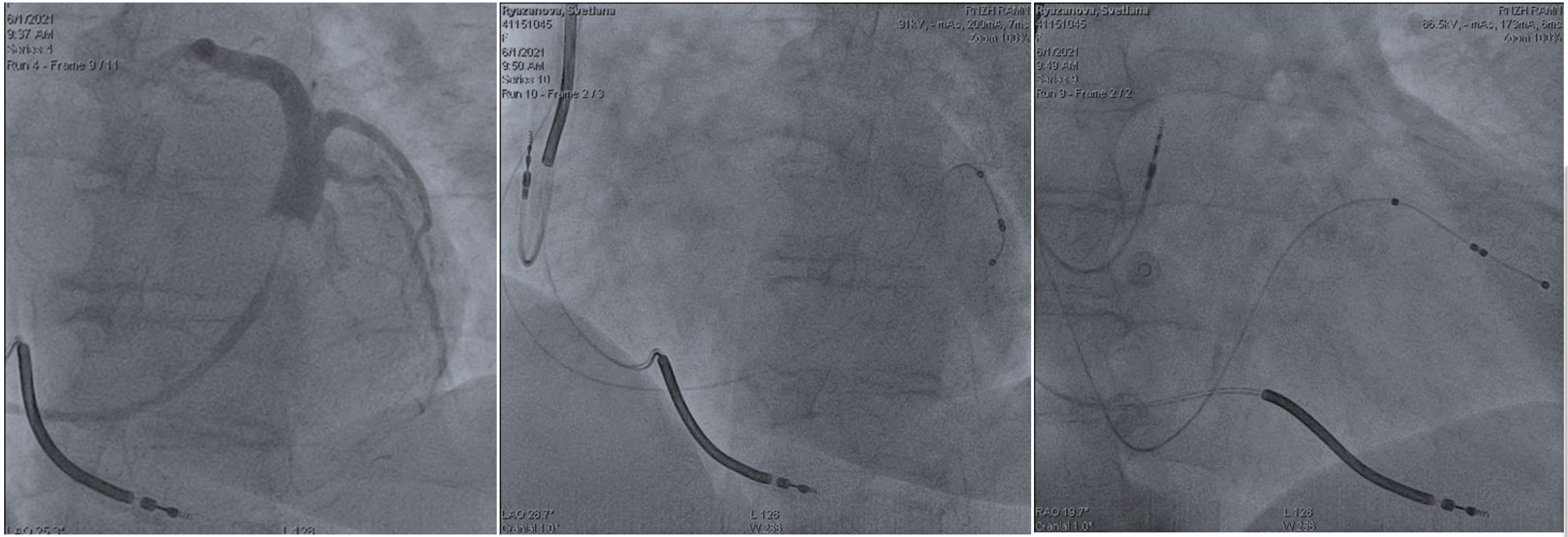
Attain Performa 4598
5.3 Fr; S-shape

Attain Performa 4298
5.3 Fr; double-canted

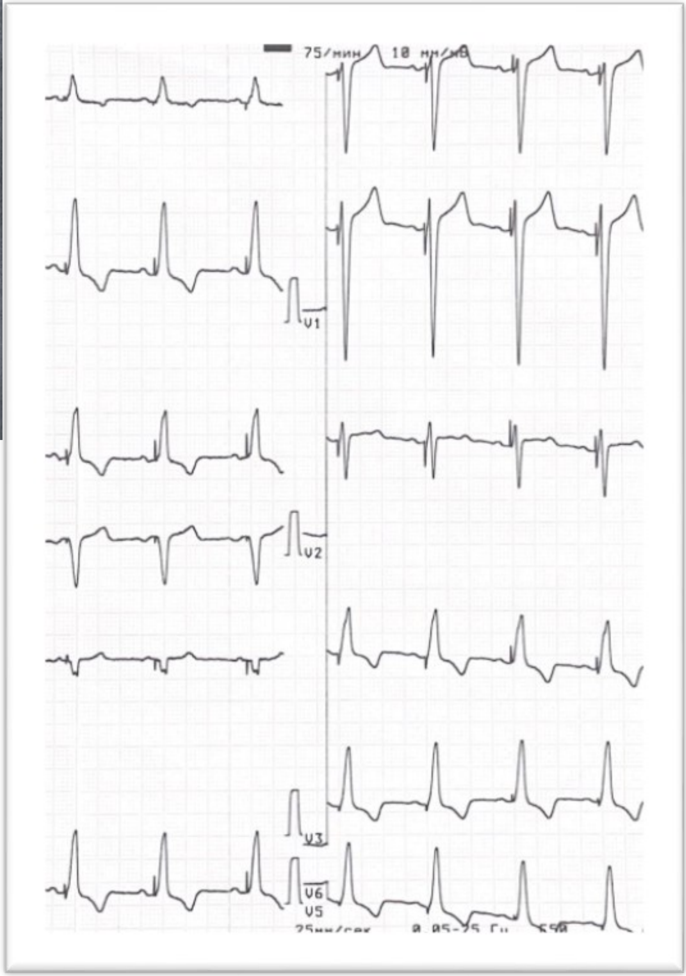
Attain Performa 4398
5.3 Fr; straight with tines

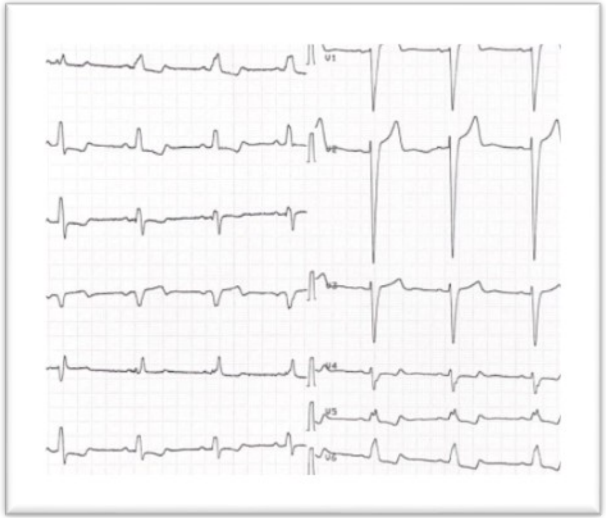
Attain Stability Quad 4798
4.4 Fr; single cant with active fixation side helix

Case №2. Patient R. women 72 y.o. Ds: DCM. OA – angioplastic (08.12.2018г). LBBB (I type). HF - III (NYHA).



After CRT-D, EF- 53%, QRS – 120ms.





ECHO – EF 27%. ECG – LBBB (QRS – 160 ms.)

Case № 3 Patient: X., man 57 y.o.

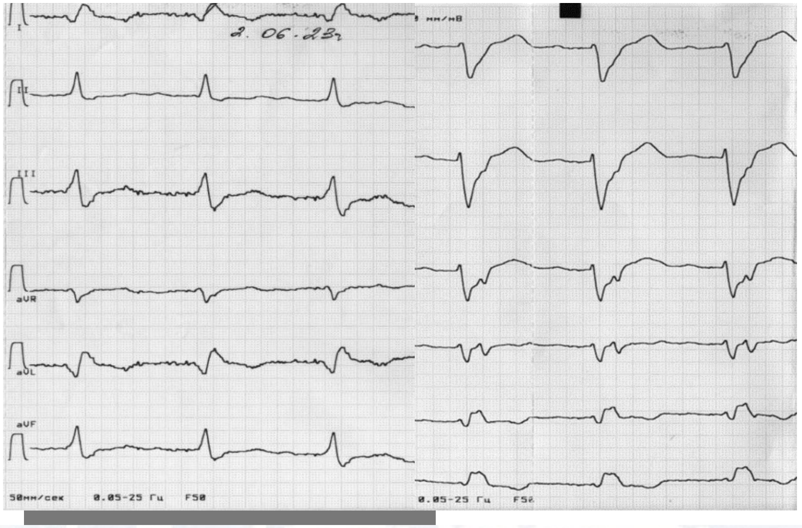
Ds: ICM 2006 г. LIMA - LAD, CABG-DA, DOR – procedure (2007 г.). LBBB. VT. HF - III (NYHA).

2006
- Myocardial infarction

2007
- Angiography: LAD – occlusion, aneurysm LV
- ECHO: - EF- 37%
- LIMA - LAD, CABG-DA, DOR - procedure

2022
- Covid - 19

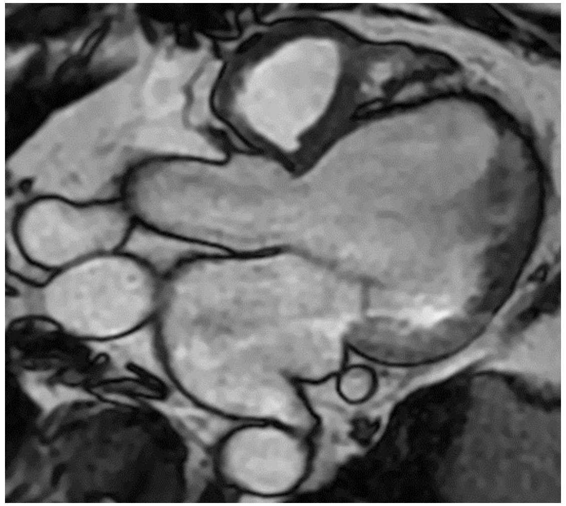
2023
- ECG - normal sinus rhythm, LBBB
- ECHO: EF – 24%, LVEDV – 263 ml

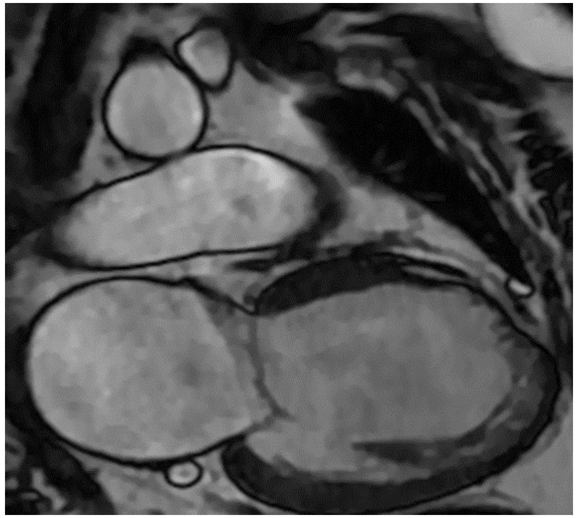


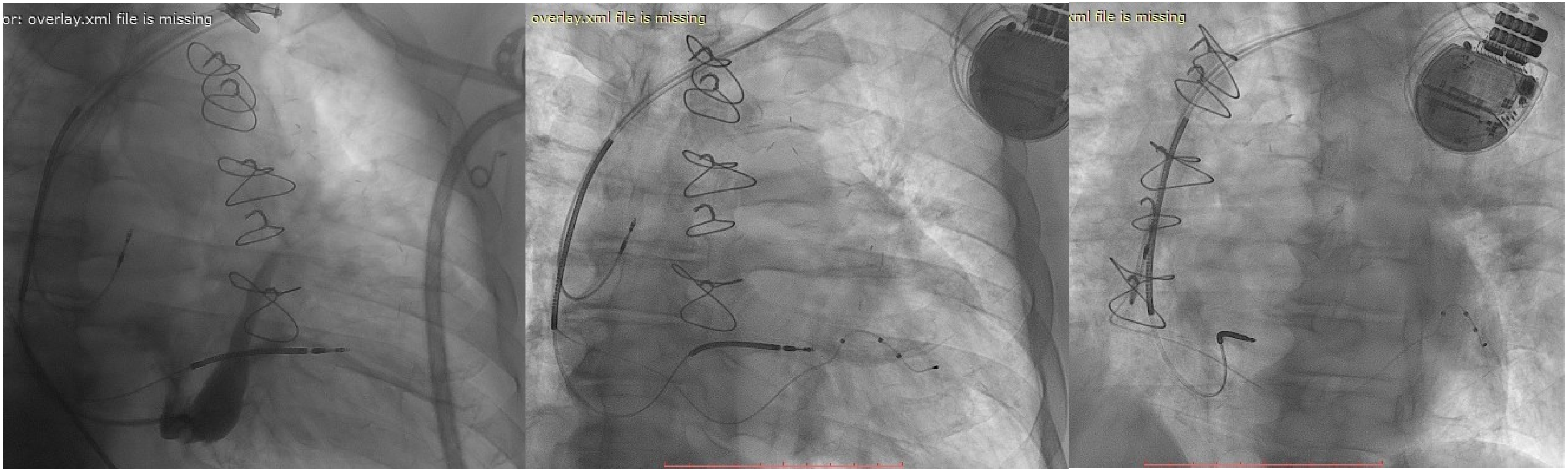
Левый желудочек
КДР- **8,1** см (N до 5,5см), КСР- **7,6** см, тМЖП- **1,0** см, тЗСЛЖ- **1,3** см, КДО- **263** мл, КСО- **193** мл, УО- **70** мл, КДОинд- **108,0** мл/м², КСОинд- **79,3** мл/м², ФИ- **27** % (по Симпсону).
VSфкмк-бок **5** см/с (N 7-11 см/с), VSфкмк-перег **3** см/с (N 6-8 см/с)

Локальная сократимость верхушка закруглена, перегородочно -верхушечные сегменты представлены рубцовой тканью, акинетичны, визуализируется тень от заплаты (пластика левого желудочка), нельзя исключить наличие тромба в области верхушки, размерами 1,4х2,6, неоднородной эхогенности, с включениями кальция, парадоксальное движение МЖП

СЕГМЕНТЫ:			
	Базальный	Средний	Верхушечный
Передний	нормокинез	гипокинез	акинез (рубец)
Передне-перегородочный	акинез (рубец)	акинез (рубец)	заплата
Перегородочный	акинез (рубец)	акинез (рубец)	заплата
Нижний	гипо-акинез	гипо-акинез	акинез (рубец)
Задний	нормокинез	гипокинез	акинез (рубец)
Боковой	нормокинез	гипокинез	акинез (рубец)



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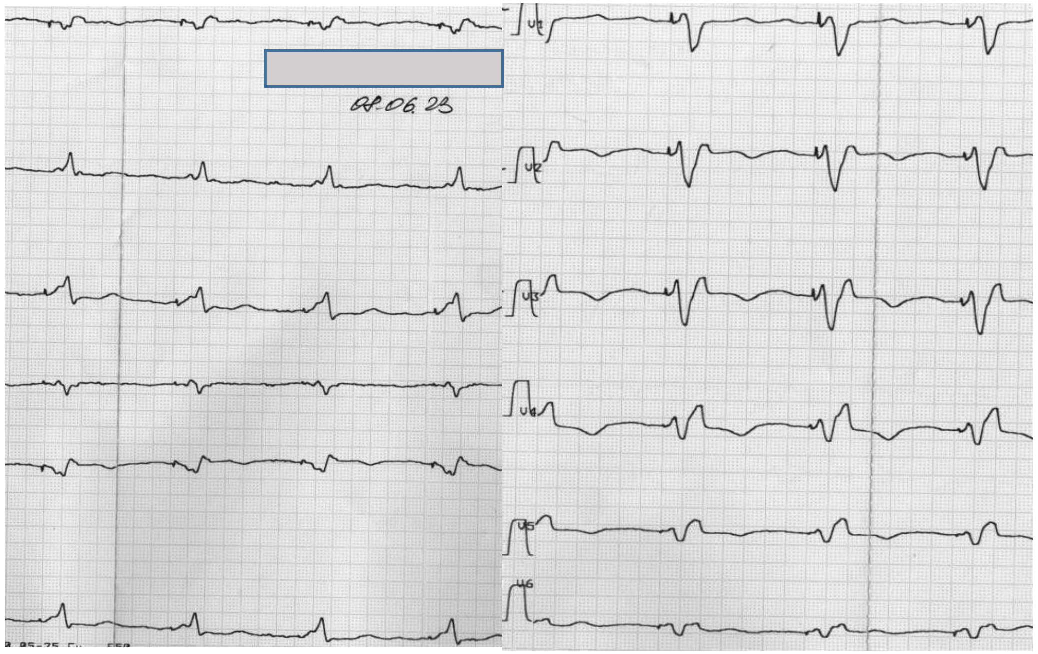
Abbott
Neutrino™ NxT HF




Abbott
Neutrino™ NxT HF

Case №4. Patient T. man, 45 y.o. Ds: AV Block - III. IPG (2015г). DCM. HF –II (NYHA). Muscular Dystrophy.

before 2015

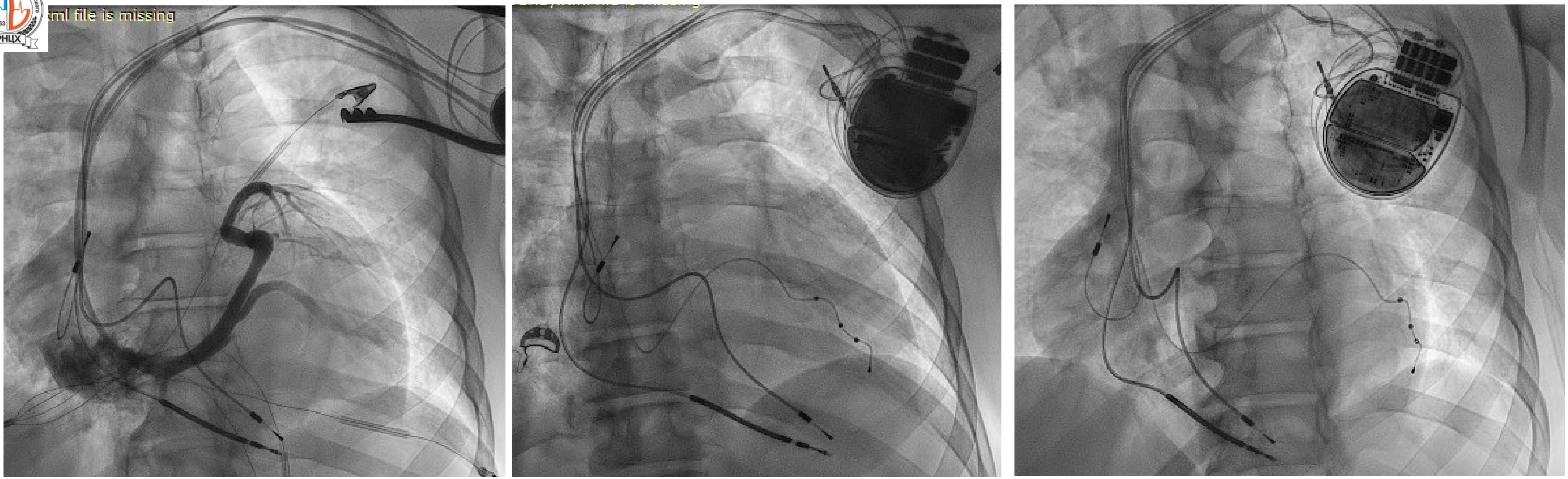
- At the age 25 years, the onset of muscular dystrophy was diagnosed.
- DCM, muscular dystrophy twin brother.

2015

- Syncope (MAS).
- ECG: AV Block III.
- ECHO: EF 66%.
- IPG 06.11.2015.

2023

- ECHO-04.04.2023: LVEDV- 343 ml, EF 21%.
- GDMT.



ECHO before CRTD:

Левый желудочек

КДР- **7,5** см (N до 5,5см), КСР- **6,7** см, тМЖП- **1,0** см, тЗСЛЖ- **0,9** см, КДО- **270** мл, КСО- **210** мл, УО- **60** мл, КДОинд- **179,9** мл/м^2, КСОинд- **139,9** мл/м^2, ФИ- **22** % (по Симпсону).

VSфкмк-бок **8** см/с (N 7-11 см/с), VSфкмк-перег **8** см/с (N 6-8 см/с)

повышенная трабекулярность стенок, в области верхушки лоцируется несколько поперечных и диагональных хорд

Локальная сократимость асинхронное сокращение перегородочно-верхушечных сегментов на фоне работы ЭКС, гипокинез базальных сегментов боковой, нижней, передней, задней стенок, остальные сегменты - диффузный гипо-акинез

Правый желудочек **2,1** см (N до 3,0 см) На уровне ВТПЖ **2,7** см (N 2,1-3,5 см), приточный отдел **3,4** см (N 2,5-4,2 см), средний отдел **1,4** см (N 1,9-3,5 см), длинник **8,0** см (N 5,9-8,6см).

VSфктк **11** см/с (N 9-14 см/с)

ECHO 1 day after CRTD:

Левый желудочек

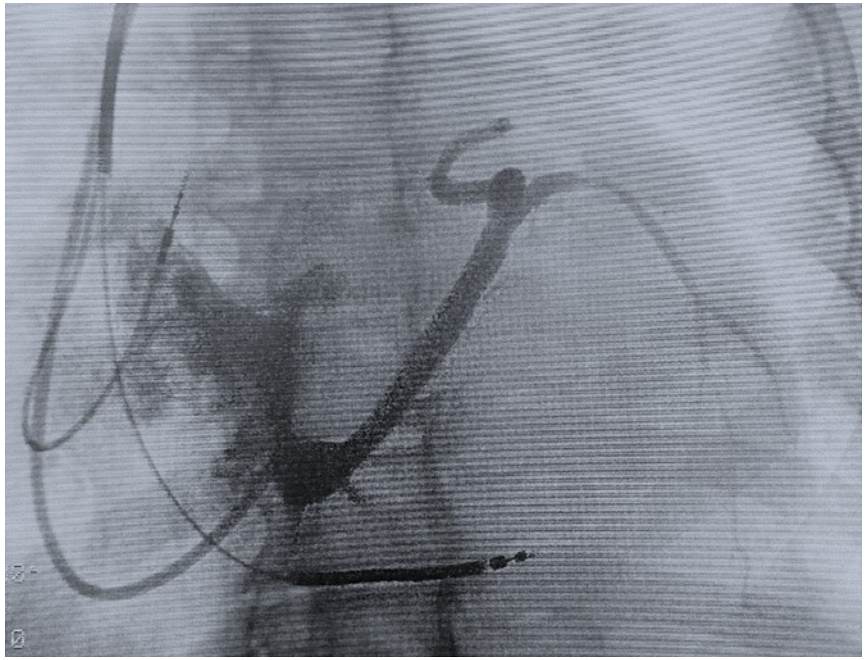
КДО- **245** мл, КСО- **180** мл, УО- **65** мл, КДОинд- мл/м^2, КСОинд- мл/м^2, ФИ- **27** % (по Симпсону).

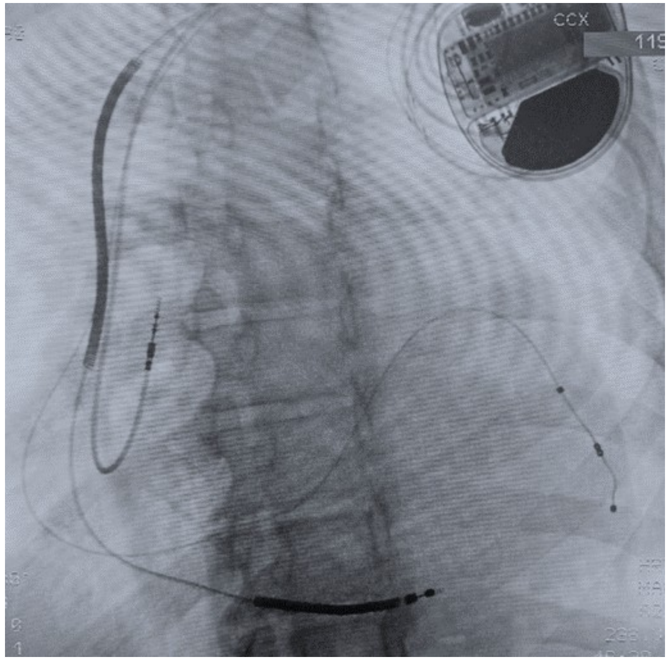
Локальная сократимость асинхронное сокращение перегородочно-верхушечных сегментов на фоне работы ЭКС, остальные сегменты - диффузный гипокинез

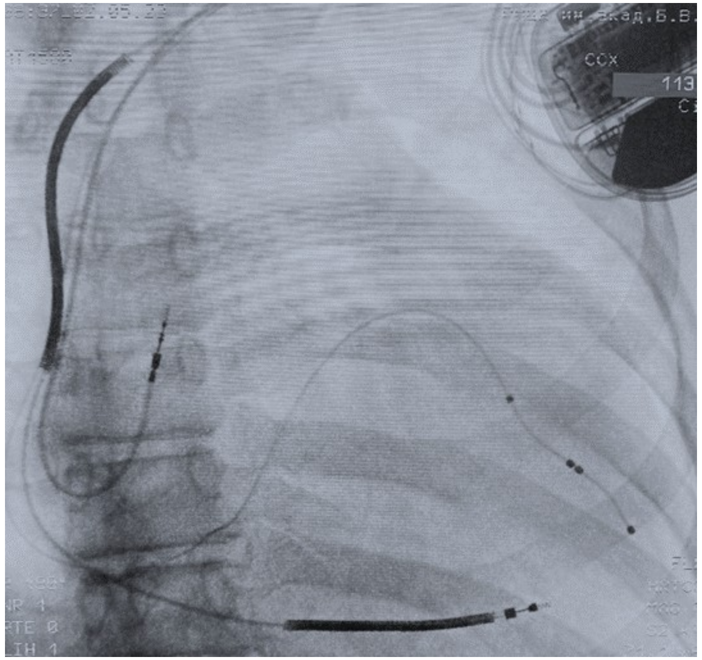
Оценка асинхронии:

Межжелудочковая (лево-правая) задержка: PEP (период предизгнания) Ао - ЛА = **170 - 140** = **30 мс** (N<40 мс).

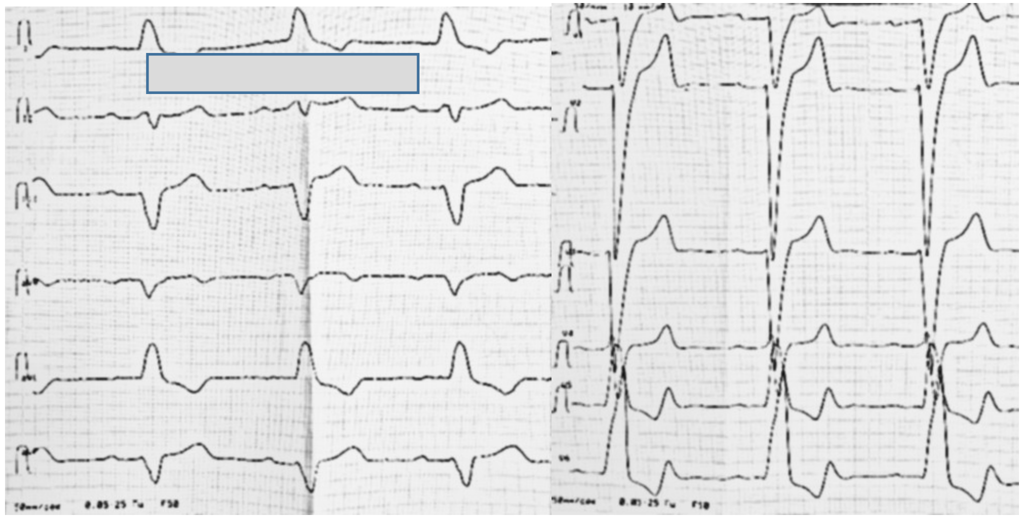
Case №5. Patient T. Sergey, man 45 y.o. Ds: DCM. HF –III (NYHA).
Muscular Dystrophy. CRT-D Viva Quad XT 02.05.2023г.







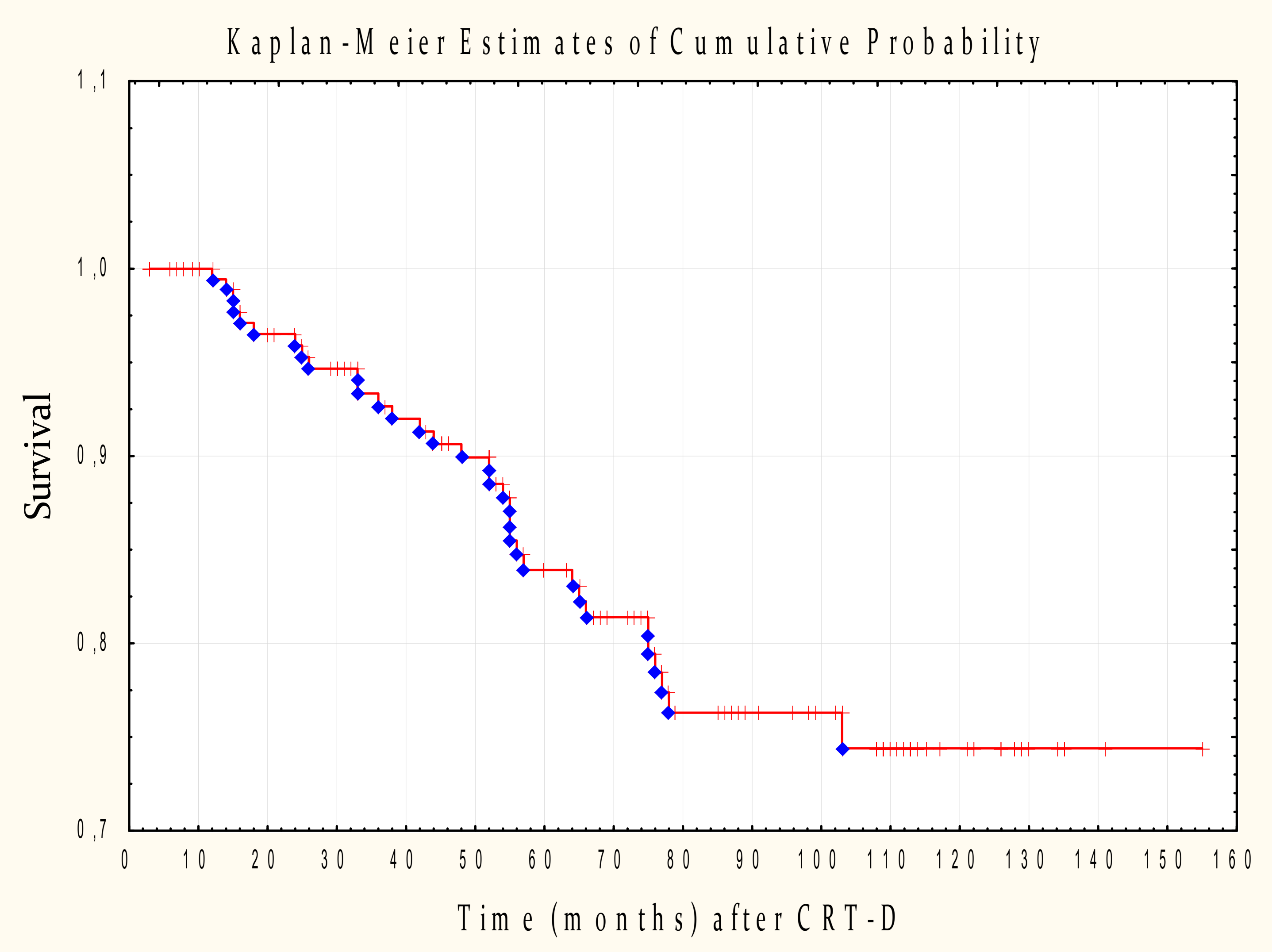
Attain Performa 4298
5.3 Fr; double-canted

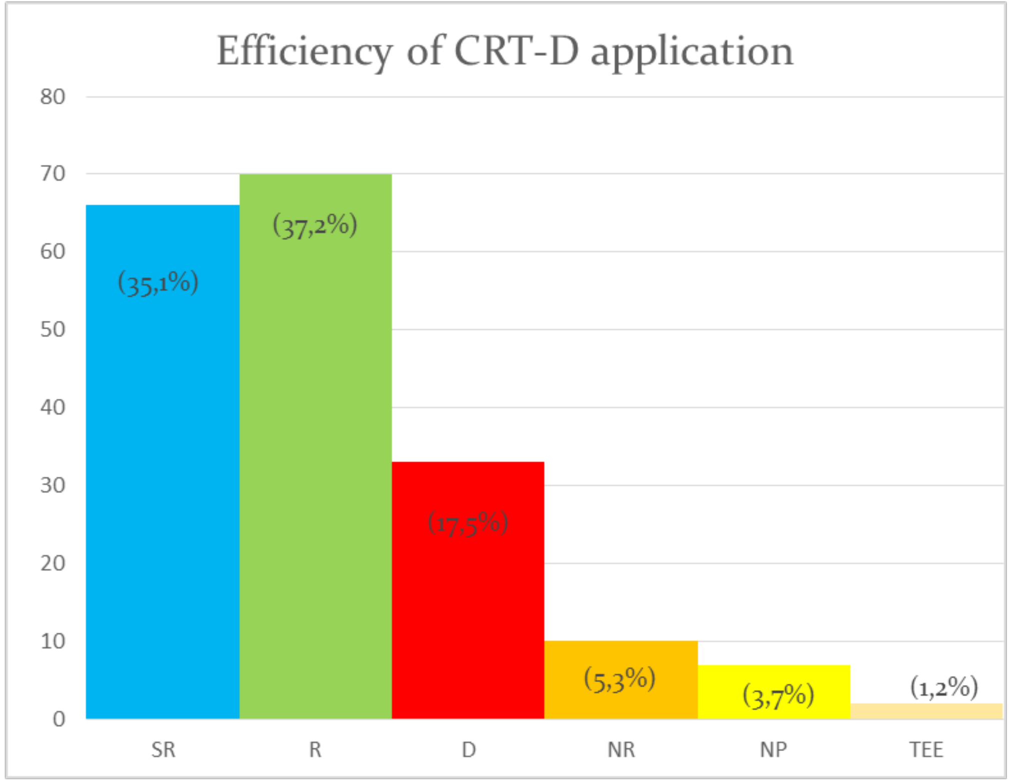


Левый желудочек
КДР- 7,8 см (N до 5,5см), КСР- 6,5 см, тМЖП- 0,7 см, тЗСЛЖ- 0,8 см, КДО- 353 мл, КСО- 259 мл, УО- 94 мл, КДОинд- 232,0 мл/м², КСОинд- 170,2 мл/м², ФИ- 27 % (по Симпсону).
VSфкмк-бок 5 см/с (N 7-11 см/с), VSфкмк-перег 4 см/с (N 6-8 см/с)
повышенная трабекулярность стенок ЛЖ
Локальная сократимость выраженное асинхронное сокращение перегородочно-верхушечных сегментов на фоне БЛНПГ, остальные сегменты - диффузный гипокинез

Оценка асинхронии:

Межжелудочковая (лево-правая) задержка: РЕР (период предизгнания) Ао - ЛА = 177 - 81 = 96 мс (N <40 мс).





5 – year survival rate was – 162 (87%)
10 – year survival rate was – 153 (82,3%)

RESULTS

The experience of surgical treatment of 188 patients with (HF) II-III (NYHA) and typical LBBB (during the observation period 67,4 ± 2,7 m (QRS 167.9 ± 1.5 ms), EF – before CRT-D 27.2% ± 0.5; after treatment 44,5% ± 0.9

Implantation of CRT-D/CRT-P with: quadripolar - 28, multipoint pace – 2, bipolar - 153,

epicardial leads – 5.

The 152 patients are currently being monitored; 33(17,7%) -died; heart transplantation -1; explantation CRTD - 2 (pocket infection).

- LV lead repositioning – 32 (5 - quadripolar LV lead);

- AV node ablation – 22;

-AF/AT/VT - ablation– 14;

5 – year survival rate was – 162 (87%).

10 – year survival rate was – 153 (82,3%).

Initially the number of non-responders was 29.7%.

After the treatment, the number of non-responders and non – progression decreased to 9%.

CONCLUSIONS

- CRT is an affordable and clinically effective treatment for patients with HF and typical left bundle branch block.

- The position of the LV lead is one of the main factors determining the response to CRT.

- Systematic optimization of CRT parameters, the use of a remote monitoring system, optimization of the position of the LV lead using multipoint pacing, AV node/ AF/AT/VT - ablation against the background of optimal drug therapy, can improve the quality and life expectancy of patients, as well as significantly reduce the number of non-responders.

Thank you for your attention!