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VILLA M. - MARSEILLE I FRANCE

19èmes journées françaises pratiques de rythmologie & de stimulation cardiaque

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Le CRT, c'est fini ?

Hugo Marchand

04/12/2025

ARNAULT TZANCK
SAINT-LAURENT DU VAR

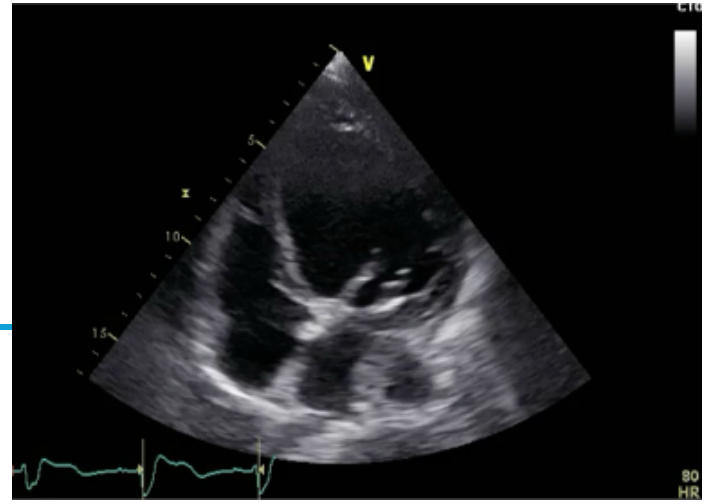
Conflits d’intérêts

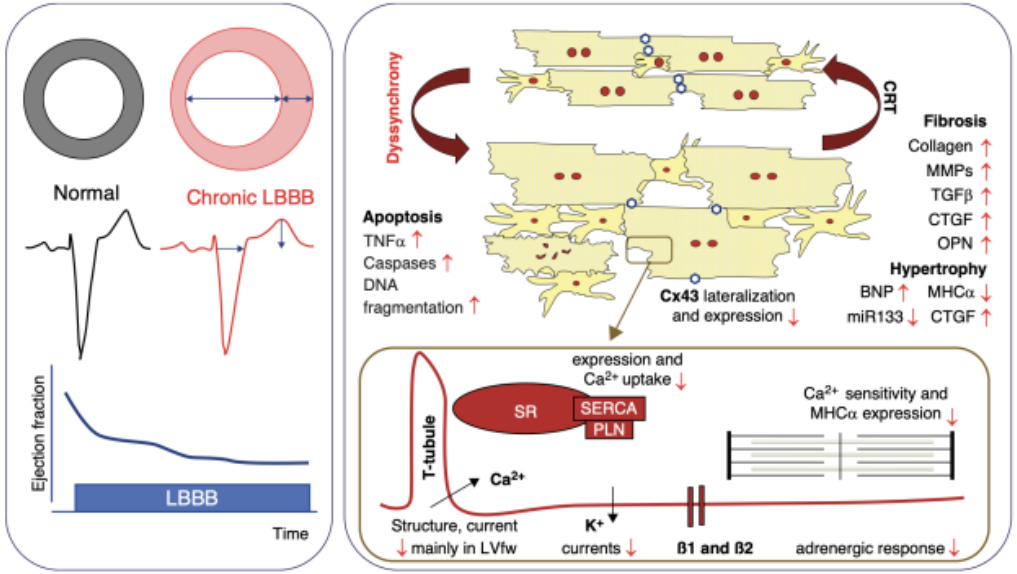
- Lecture fees : Biotronik, Medtronic, Abbott

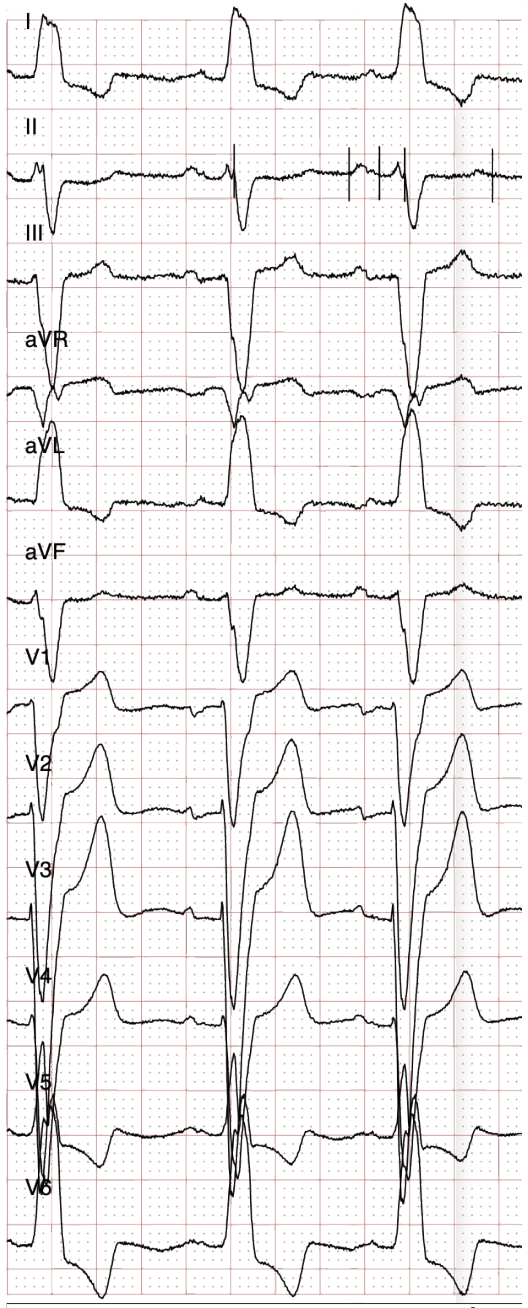
ARNAULT
TZANCK
SAINT-LAURENT DU VAR

Epidémiologie

- HF 1-2% de la population
- La moitié à FEVG altérée
- 20% de candidats à la CRT
- Mortalité à 1 an 6-20%



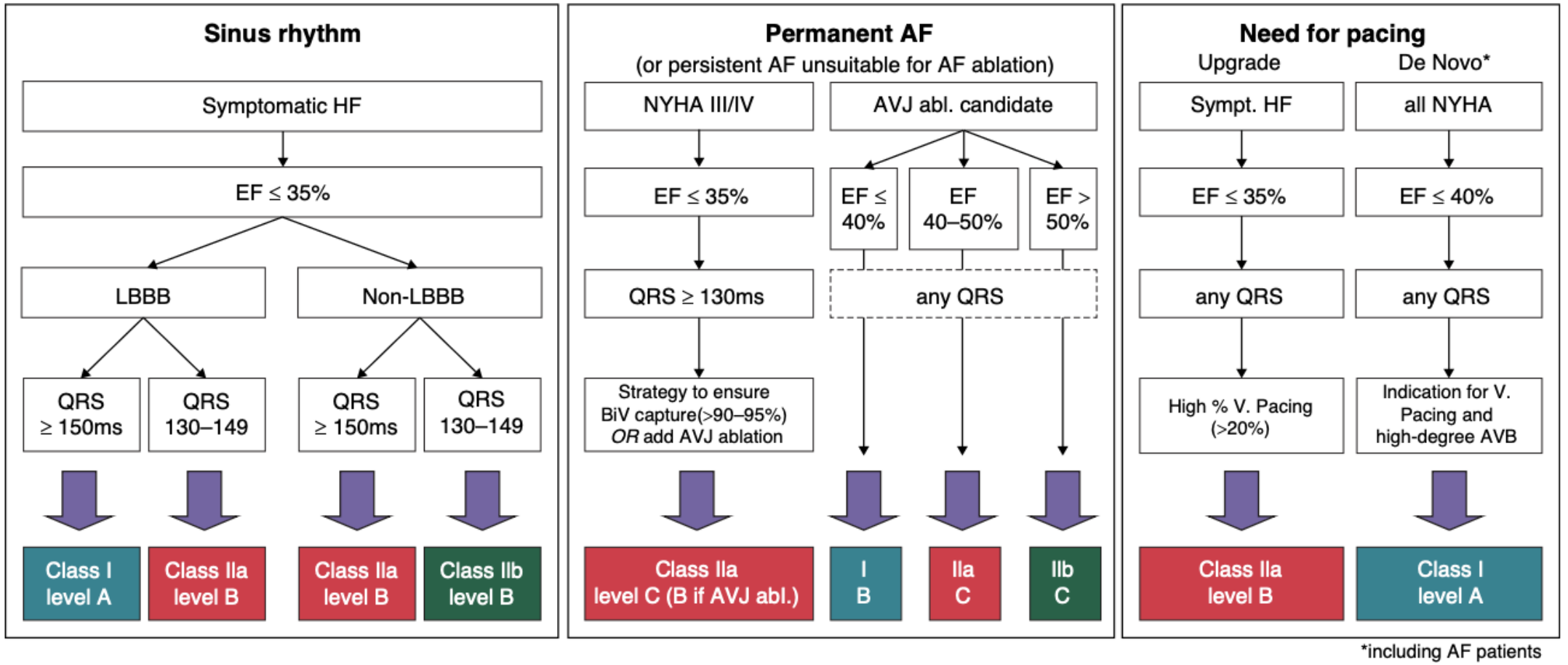




Ellenbogen et al. Europace 2023

Indications de CRT

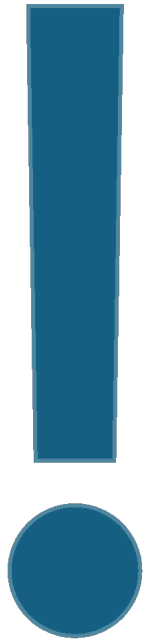
K. A. Ellenbogen et al.
Europace 2023



Preuves solides

Year	Study	Number	Design	Inclusion criteria	Comparison	Effect of CRT	Ref
2001	MUSTIC-SR	67	Single-blind, cross-over RCT	NYHA III, LVEF < 35%, QRS ≥ 150 ms, LVEDD > 60 mm, 6MWD < 450 m	CRT vs. VVI (no pacing indications)	CRT improved QoL, walking distance, peak VO_2; reduced hospitalizations	14
2002	MUSTIC-AF	43	Single-blind, cross-over RCT	NYHA III, LVEF < 35%, RV-paced QRS ≥ 200 ms, LVEDD > 60 mm, 6MWD < 450 m	VVIR vs. BiV	CRT improved 6MWD, peak VO_2, QoL, and NYHA class; reduced hospitalizations (but no difference on intention-to-treat analysis)	64
	PATH-CHF	42	Single-blind, cross-over RCT	NYHA II–IV, LVEF < 35%, PR ≥ 150 ms, QRS > 120 ms	RV vs. LV vs. BiV	CRT improved NYHA class, QoL, and walking distance	65
	MIRACLE	453	Double-blind RCT	NYHA III–IV, LVEF < 35%, QRS ≥ 130 ms, LVEDD > 55 mm	CRT-on vs. CRT-off	CRT improved NYHA class, QoL, walking distance, LVEF, peak VO_2, mitral regurgitation; reduced hospitalizations	16
2003	MIRACLE-ICD I	369	Double-blind RCT	NYHA III–IV, LVEF < 35%, QRS ≥ 130 ms, LVEDD > 55 mm	CRT-D vs. ICD	CRT improved NYHA class, QoL, and walking distance, and reduced hospitalization	19
	CONTAK-CD	490	Double-blind, cross-over RCT	NYHA II–IV, LVEF < 35%, QRS ≥ 120 ms, ICD indications	CRT-on vs. CRT-off	CRT improved peak VO_2 and walking distance, not NYHA or QoL; reduced LV volumes and improved LVEF; no effect on HF progression	23
	COMPANION	1520	Unblinded RCT (1:2:2)	NYHA III–IV, LVEF < 35%, QRS > 120 ms	OMT vs. CRT-P or CRT-D	CRT-D and CRT-P reduced composite of all-cause mortality and hospitalization	20
2004	MIRACLE-ICD II	186	Double-blind RCT	NYHA II, LVEF < 35%, QRS ≥ 130 ms, ICD indications	CRT-on vs. CRT-off	CRT reduced LV volumes and LVEF and improved CCS; no effect on QoL, walking distance, or peak VO_2	66
2005	CARE-HF	813	Unblinded RCT	NYHA III–IV, LVEF < 35%, QRS > 120 ms	CRT-P vs. OPT	CRT reduced total mortality and HF hospitalizations	21
2006	HOBIPACE	30	Double-blind, cross-over RCT	Pacing indications, LVEF < 40%, LVEDD > 60 mm	CRT-P vs. RV pacing	CRT reduced LV volumes and improved QoL, LVEF, peak VO_2	67
2007	ReThinQ	172	Double-blind RCT	NYHA III, LVEF < 35%, QRS < 130 ms, echo dyssynchrony	CRT-on vs. CRT-off in CRT-D recipients	CRT improved NYHA class, but not walking distance, LVEF, or QoL	30
2008	PROSPECT	498	Prospective, observational	NYHA II–IV, LVEF < 35%, QRS > 130 ms, OMT	Echo dyssynchrony measures as predictor of CCS and LVRR	Echo dyssynchrony measures did not predict outcome after CRT	68
	REVERSE	610	Double-blind RCT (2:1)	NYHA I–II, LVEF < 40%, QRS > 120 ms	CRT-on vs. CRT-off (ICD on)	CRT reduced HF hospitalization and improved LVEF and NYHA class; no effect on mortality	25
2009	MADIT-CRT	1820	Single-blind RCT	NYHA I–II, LVEF < 30%, QRS > 130 ms	CRT-D vs. ICD	CRT-D reduced HF events; no effect on mortality	27
2010	RAFT	1798	Double-blind RCT	NYHA II–III, LVEF < 30%, QRS > 120 ms	CRT-D vs. ICD	CRT reduced total mortality and HF hospitalization	28
2011	BLOCK-HF	691	Single-blind RCT	NYHA I–III, AV block, LVEF < 50%	CRT vs. RV pacing	CRT reduced composite of total mortality, HF event, or 15% increase in LVESVi	69
2013	Echo-CRT	809	Double-blind RCT	NYHA III–IV, LVEF < 35%, QRS < 130 ms, echo dyssynchrony	CRT-on vs. CRT-off	No effect on composite of total mortality or HF hospitalization; higher total mortality with CRT-on	32
	LESSER-EARTH	85	Double-blind RCT	NYHA III–IV, LVEF ≤ 35%, QRS < 120 ms	CRT-D vs. ICD	Stopped prematurely after recruiting 85 patients: CRT reduced walking distance and increased QRS duration; trend towards increased HF hospitalizations	31

K. A. Ellenbogen et al. Europace 2023

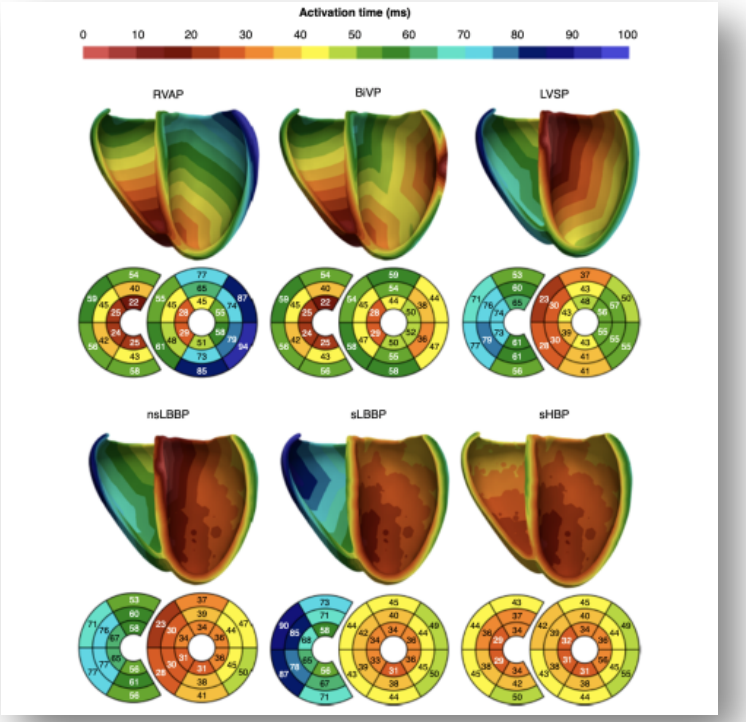


Limites CRT

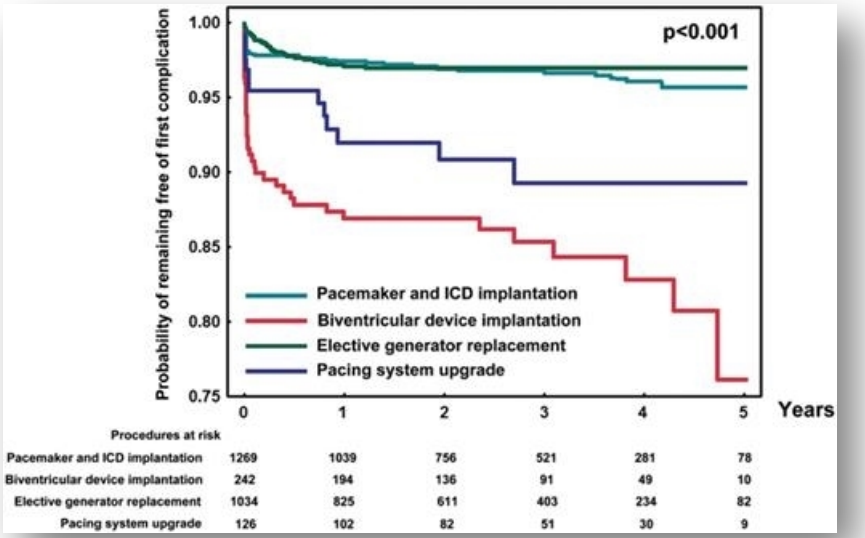
- Taux d’échec à 5-10 %
  - Difficultés anatomiques
  - Seuil élevé
  - Stimulation phrénique
- Taux de non répondeurs 30%
  - Sélection des patients
  - Position de la sonde
  - Taux de CRT < 90%

Promesses de la CSP

- Activation physiologique
  - Meilleure réponse
  - Moins de non répondeurs
- Technique simple
  - Deux sondes
  - Moins de complications



Meiburg et al.2023

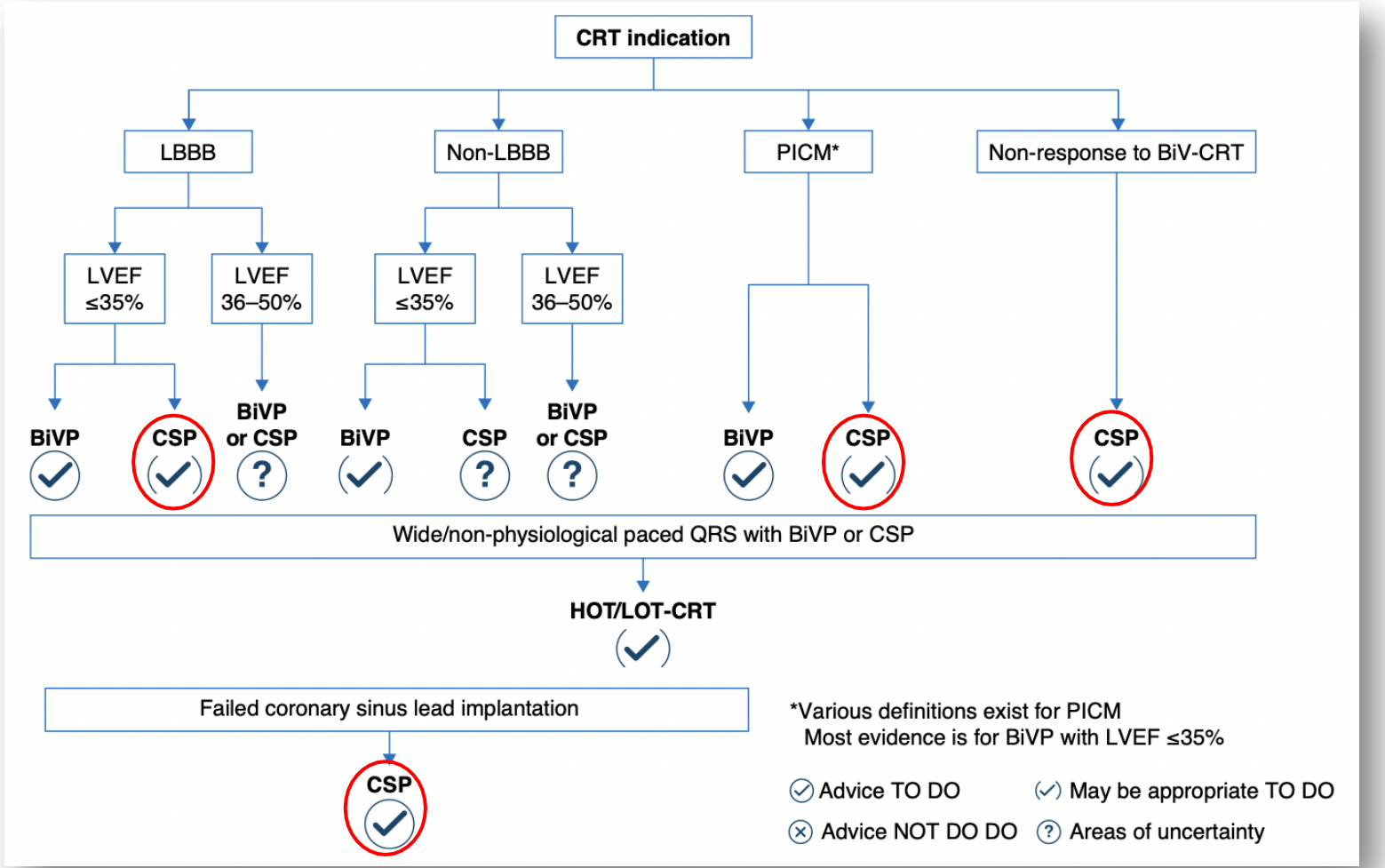


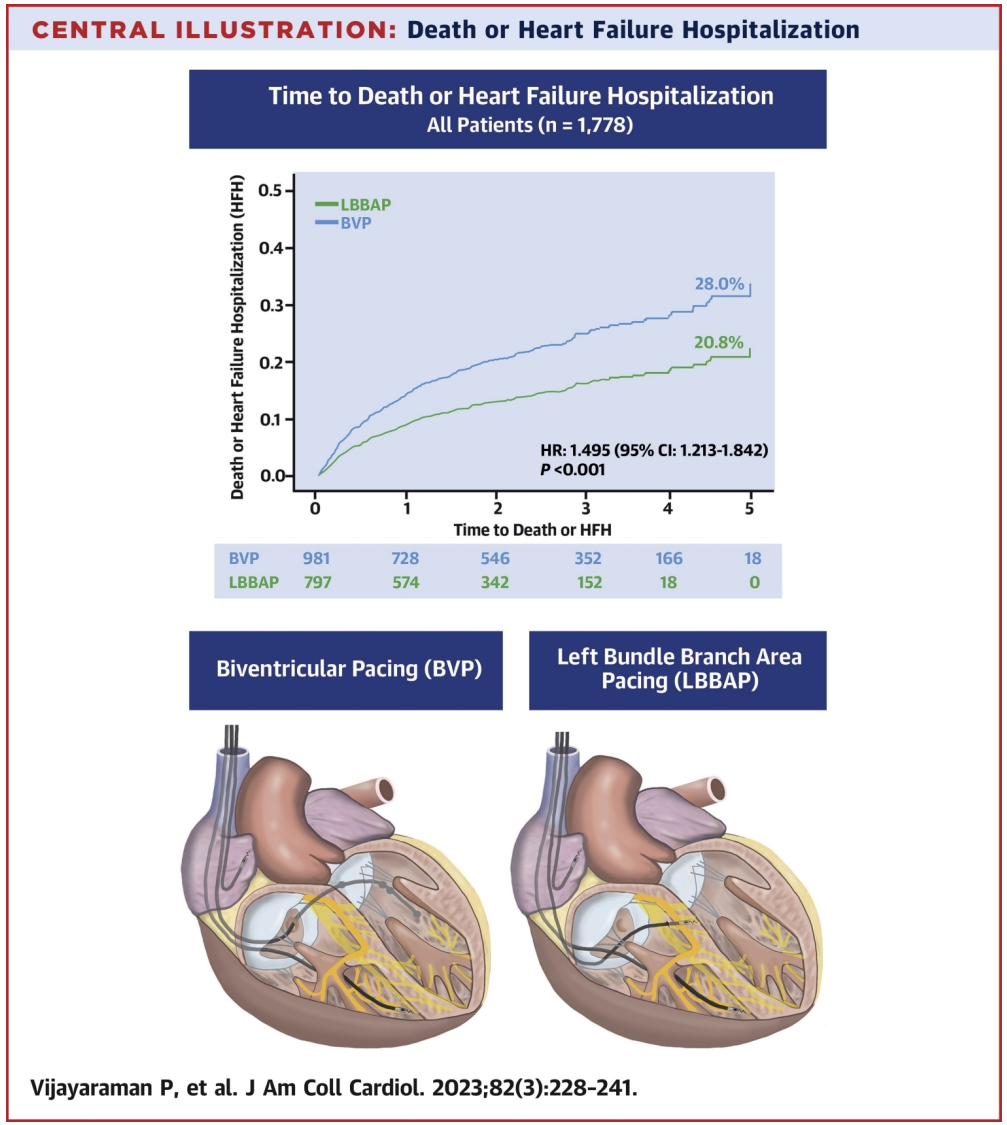
Palmisano et al. EP Europace 2013

Indications de LBBAP

In CRT candidates in whom coronary sinus lead implantation is unsuccessful, HBP should be considered as a treatment option along with other techniques such as surgical epicardial lead.[318,424,440,443]	IIa	B

Advice: CSP-CRT	Strength of evidence
Advice TO DO	
In candidates for BiVP in whom coronary sinus lead implantation is unsuccessful, CSP is advised as rescue therapy.[139,201]	
May be appropriate TO DO	
For patients with LVEF ≤ 35%, LBBB with QRS ≥130 ms, and Class II–IV HF symptoms despite GDMT, CSP may be appropriate as an alternative to BiVP to improve LVEF, exercise capacity, and symptoms and to reduce HFH[9,68,123,134,209,210]	
In non-responders to BiV-CRT, it may be appropriate to implant CSP to improve HF symptoms and LVEF[139,220]	>90% agree
In the presence of specific patient populations where a simpler device is desired (e.g. frail patients, patients with limited life expectancy, or those requiring a smaller device), it may be appropriate to choose CSP instead of BiVP as a primary strategy, taking into account operator experience	>90% agree
Areas of uncertainty	
For patients with a CRT indication and non-LBBB, the clinical impact of CSP is uncertain[66,67,208]	>90% agree
For patients with HF and LVEF >35% without an indication for ventricular pacing, the clinical impact of CSP is uncertain	>90% agree

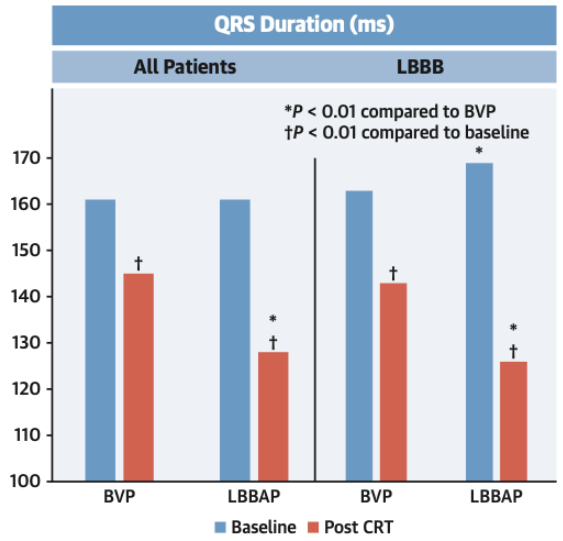




Etude rétrospective

- Patients implantés pour FEVG < 35% et indication de CRT ou VP >40%

FIGURE 4 QRS Duration and NYHA Functional Class



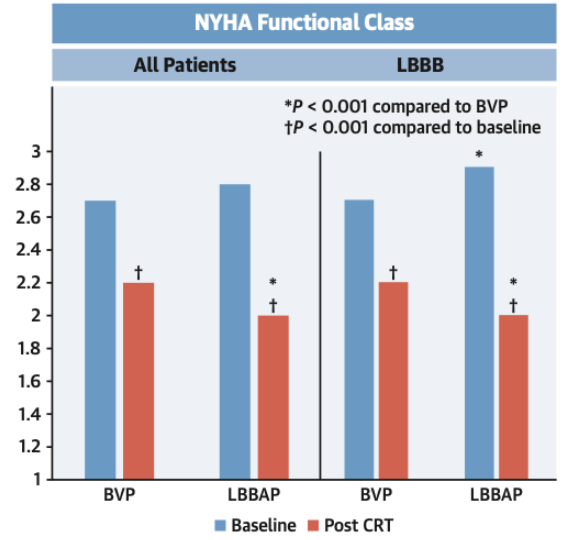
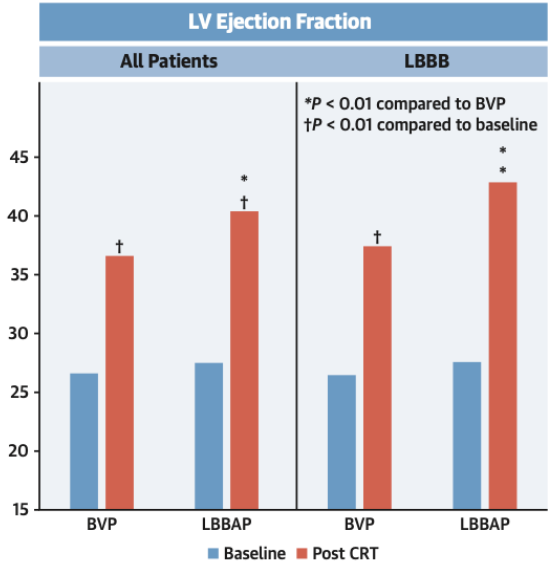
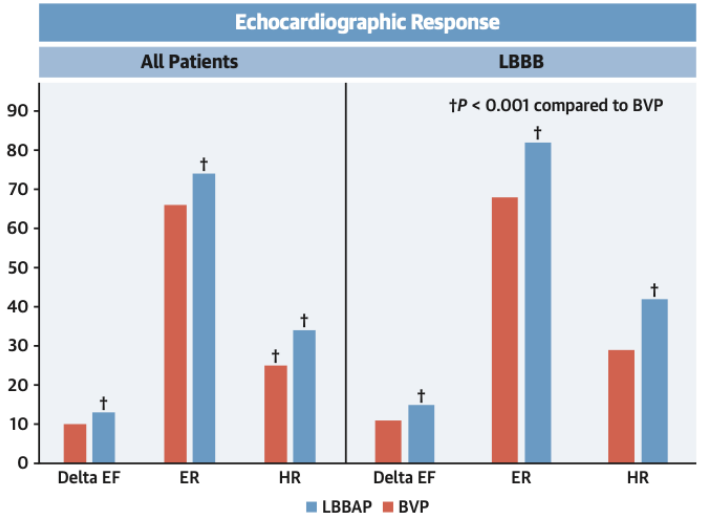


FIGURE 5 Echocardiographic Outcomes

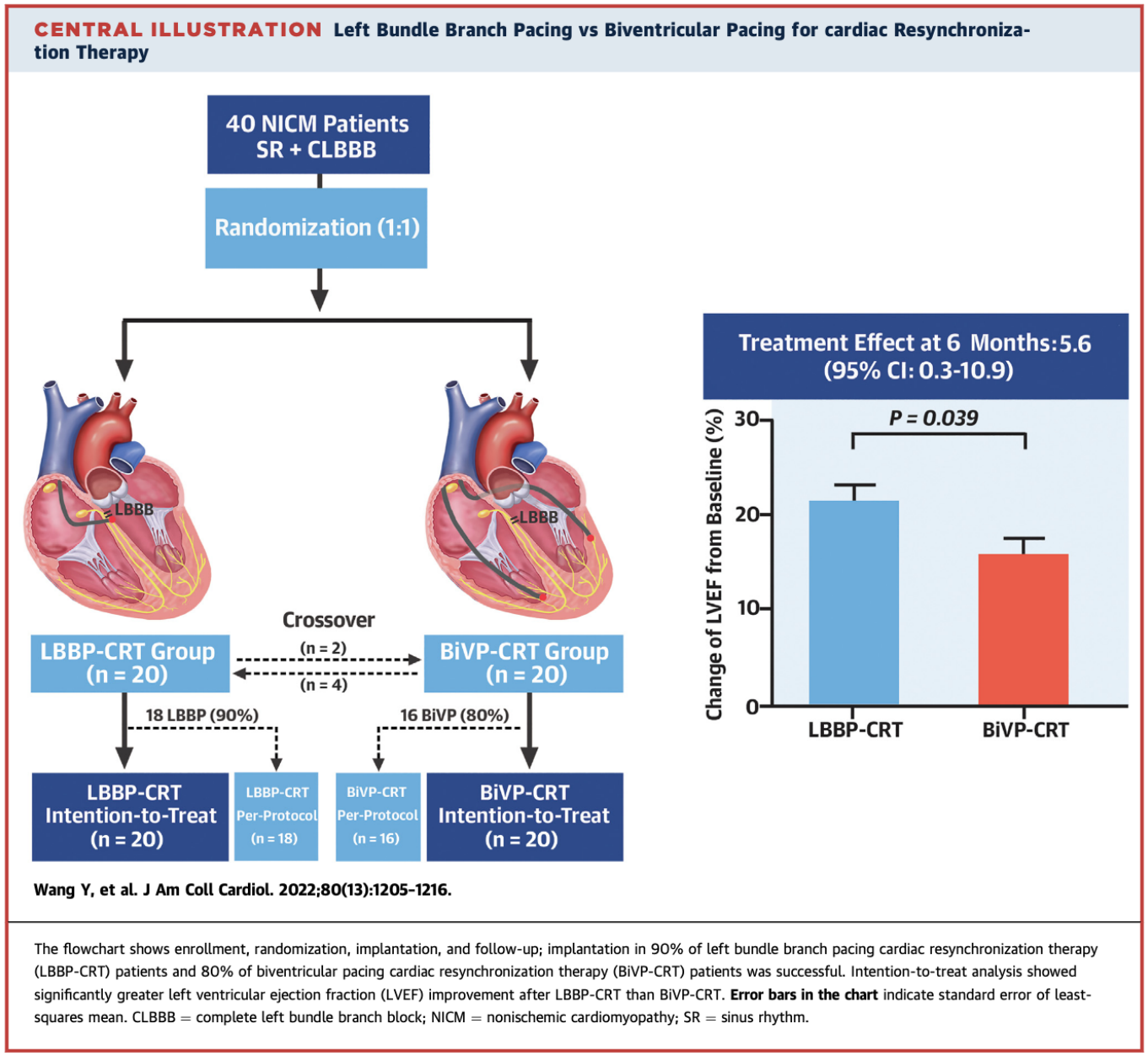


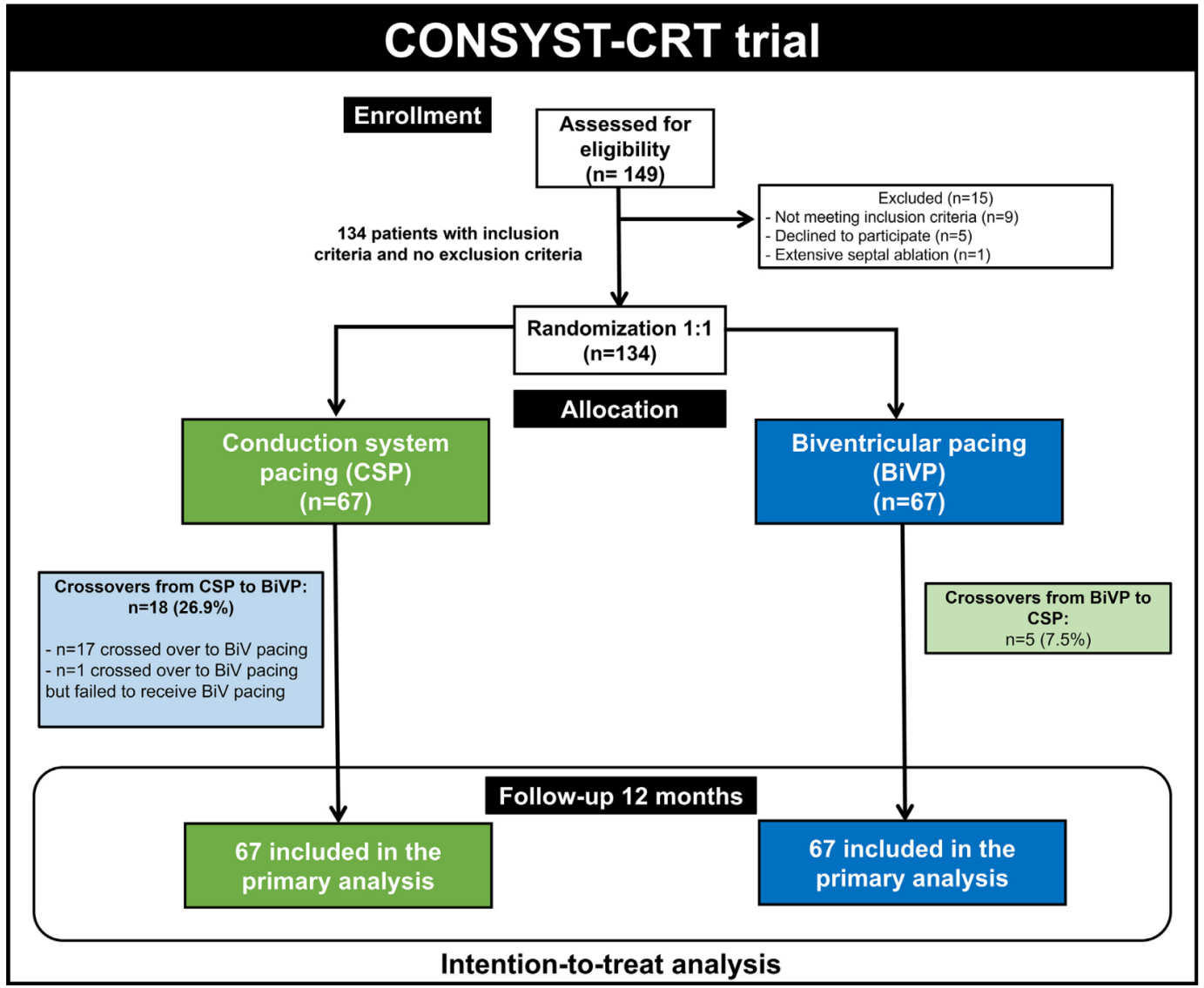


Vijayaraman P, et al. J Am Coll Cardiol. 2023;82(3):228-241.

LBBP-RESYNC

- Etude randomisée 2022
- Petits effectifs
- Crossover (10% et 20%)





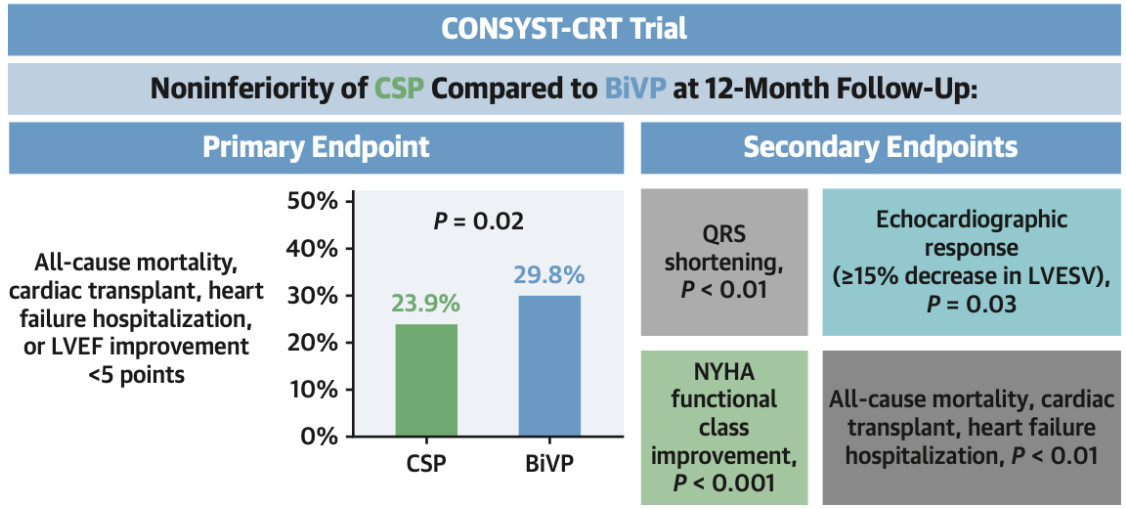
CONSYST-CRT

- Etude de non infériorité
- Inclusions
  - Symptomatic HF
  - LVEF < 35%
  - wide QRS [LBBB >130 ms or QRS >150 ms in non-LBBB)
  - indication for CRT due to AV block and LVEF <40%
- 26,9% crossover CSP /BiVP

Pujol-López M et al. JACC Clin Electrophysiol. 2025

CONSYST-CRT

CENTRAL ILLUSTRATION Primary and Secondary Endpoints of the CONSYST-CRT Trial (Intention-to-Treat)



Pujol-López M, et al. JACC Clin Electrophysiol. 2025;11(8):1820-1831.

BiVP = biventricular pacing; CONSYST-CRT = Conduction System Pacing vs Biventricular Resynchronization Therapy in Systolic Dysfunction and Wide QRS trial; CSP = conduction system pacing; LVEF = left ventricular ejection fraction; LVESV = left ventricular end-systolic volume.

TABLE 2 Endpoints for Intention-to-Treat

	Intention-to-Treat 12-mo Follow-Up (N = 134)			*P* Value	
	CSP (n = 67)	BiVP (n = 67)	Mean Difference (95% CI)	Noninferiority	Superiority
Primary endpoint					
All-cause mortality, cardiac transplant, heart failure hospitalization, or LVEF improvement <5 points	23.9 (16)	29.8 (20)	−5.9 (−21.2 to 9.2)	0.02	0.44
Secondary endpoints					
Delta LVEF at 12 mo, %[a]	14.1 ± 10.5	14.4 ± 9.9	−0.3 (−3.8 to 3.3)	0.06	0.87
Delta LVESV at 12 mo, %[a]	−27.9 ± 27	−27.9 ± 28.1	−0.1 (−9.9 to 9.7)	0.27	0.99
Echocardiographic response, ≥15% decrease in LVESV[b]	66.6 (44/66[b])	59.7 (37/62[b])	7 (−9.9 to 23.9)	0.03	0.42
All-cause mortality, cardiac transplant, heart failure hospitalization	11.9 (8/67)	17.9 (12/67)	−6.0 (−18.2 to 6.3)	<0.01	0.33
Delta QRS, ms					
From fast deflection	−49 ± 24	−45 ± 23	−4.0 (−11.9 to 3.9)	<0.001	0.32
From spike	−20 ± 26	−19 ± 24	−1.0 (−9.6 to 7.6)	<0.01	0.82
Correction of septal flash, mm					
15 d	−2.0 ± 2.0	−2.3 ± 1.7	0.3 (−0.4 to 0.9)	0.26	0.38
12 mo	−2.2 ± 2.7	−2.7 ± 2.4	0.5 (−0.5 to 1.4)	0.45	0.33
Delta NYHA functional class at 12 mo	−0.6 ± 0.7	−0.5 ± 0.7	−0.1 (−0.4 to 0.1)	<0.001	0.36

Values are % (n), mean ± SD, or % (n/total N). [a]12 months - baseline. [b]For left ventricular end-systolic volume (LVESV) and echocardiographic response endpoints, 1 patient in the conduction system pacing (CSP) arm and 5 in the biventricular pacing (BiVP) arm did not have LV volumes due to a poor echocardiographic window.

LVEF = left ventricular ejection fraction.

Pujol-López M et al. JACC Clin Electrophysiol. 2025

CONSYST-CRT

TABLE 3 Procedural Data and Complications for the Intention-to-Treat Analysis

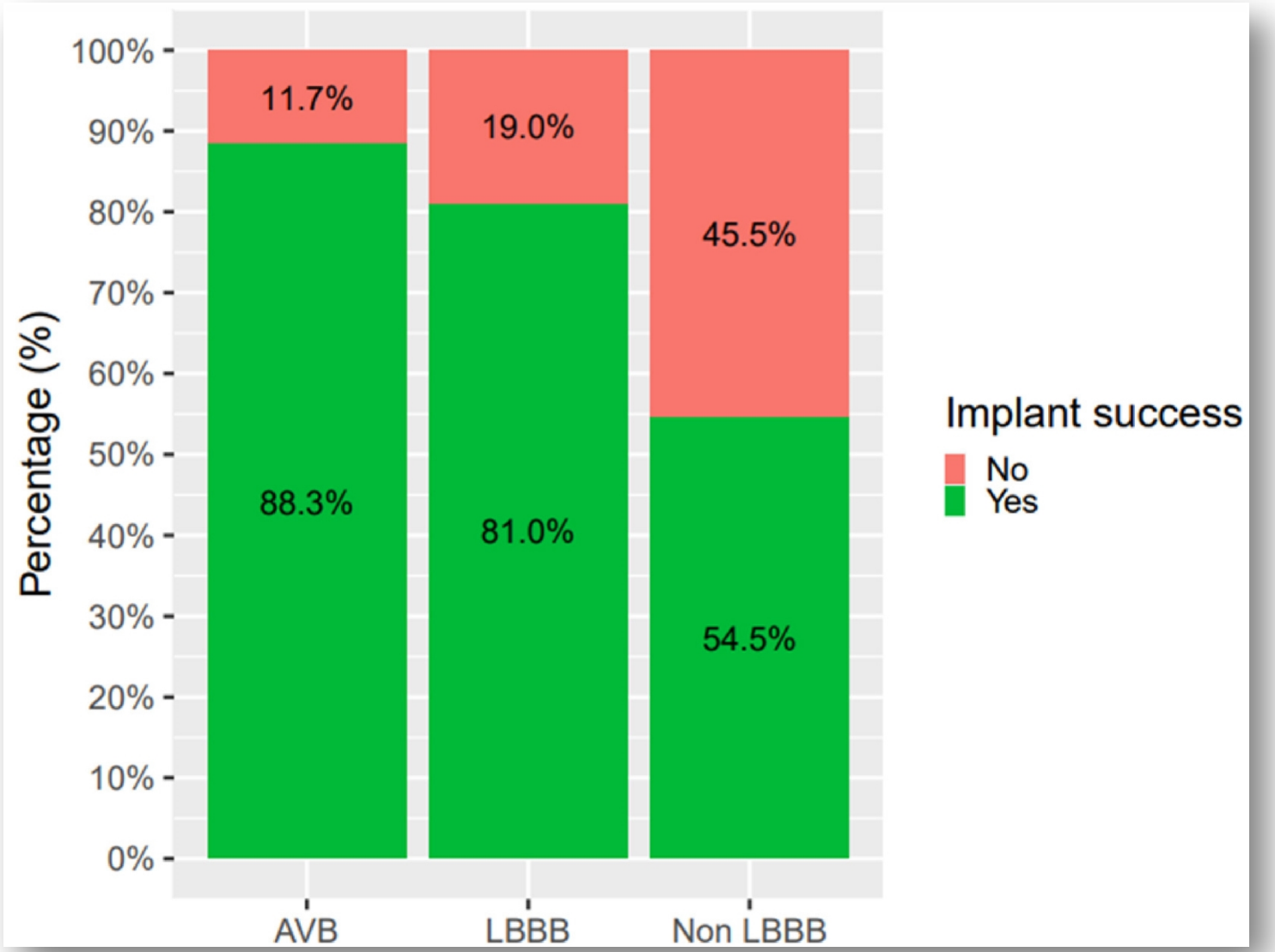
	Conduction System Pacing (n = 67)	Biventricular Pacing (n = 67)	*P* Value, Superiority
Total procedure time, min	123 ± 34	119 ± 37	0.53
Conduction system/coronary sinus lead implantation time, min	40 ± 24	34 ± 22	0.11
Threshold, V	1.0 ± 0.4	1.1 ± 0.5	0.09
Pulse width, ms	0.6 ± 0.3	0.5 ± 0.2	0.001
Fluoroscopy time, min	28 ± 14	21 ± 11	0.001
Fluoroscopy dose, milligray	206 ± 191	180 ± 167	0.41
Complications requiring reintervention	10.4 (7)	11.9 (8)	0.8
Requirement for intervention			
Lead dislodgement	4 (2 atrial, 2 coronary sinus; crossover)	4 (3 atrial, 1 coronary sinus)	
Lead disconnection	1 (coronary sinus; crossover)	0	
Infection	1	1	
Perforation	0	1	
Hematoma	0	1	
VF during implantation, 5 shocks	1 (during ICD lead implantation)	0	
Phrenic stimulation	0	1	

TABLE 1 Baseline Characteristics

	Conduction System Pacing (n = 67)	Biventricular Pacing (n = 67)
Female	28.3 (19)	25.4 (17)
Age, y	69 ± 9	69 ± 9
Ischemic	34.3 (23)	34.3 (23)
Hypertension	59.7 (40)	70.1 (47)
Diabetes	40.3 (27)	38.8 (26)
Glomerular filtration <45 mL/min	20.9 (14)	19.4 (13)
Permanent atrial fibrillation	22.4 (15)	17.9 (12)
QRS width, ms	175 ± 22	175 ± 23
Baseline QRS		
LBBB	55.2 (37)	56.7 (38)
Non-LBBB with QRS ≥150, IVCD	16.4 (11)	14.9 (10)
Atrioventricular block, no upgrade	10.4 (7)	16.4 (11)
Paced, upgrades	17.9 (12)	11.9 (8)
NYHA functional class	2.3 ± 0.6	2.4 ± 0.7
II	59.7 (40)	47.8 (32)
III-IV	34.3 (23)	44.8 (30)
LVEF, %	28 ± 6	27 ± 7
LV end-diastolic volume, mL	193 ± 88	183 ± 56
LV end-systolic volume, mL	131 ± 77	125 ± 49
Atrial diameter, mm	46 ± 8	44 ± 9
ICD implanted	70.1 (47)	70.1 (47)
Guideline-directed medical therapy	86.6 (58)[a]	86.6 (58)[a]

Pujol-López M et al. JACC Clin Electrophysiol. 2025

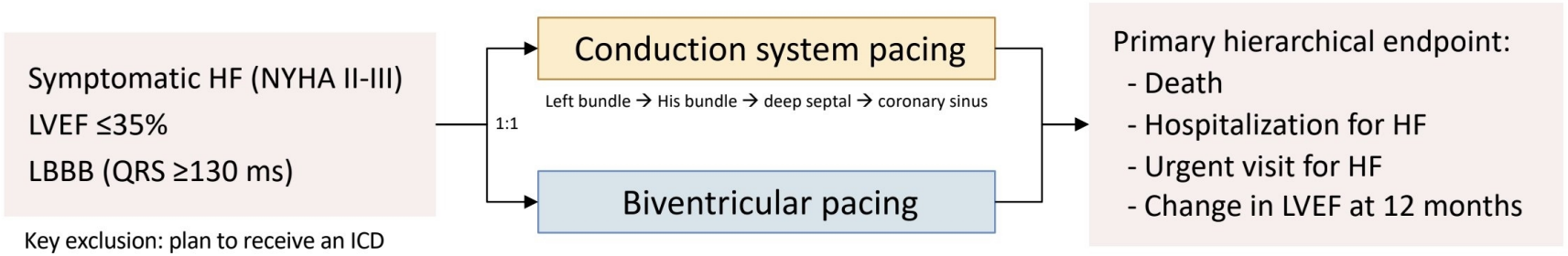
Limites : Sélection du patient



Graterol et al. Heart Rhythm 2024

Trial design

Clinicaltrials.gov: NCT05572736



Key exclusion: plan to receive an ICD

Treatment assignment was blinded to patients and non-electrophysiology personnel.
Endpoints were independently adjudicated by blinded committees.

Zimerman A et al., *Am Heart J* 2025;290:38–45

Baseline characteristics (1)

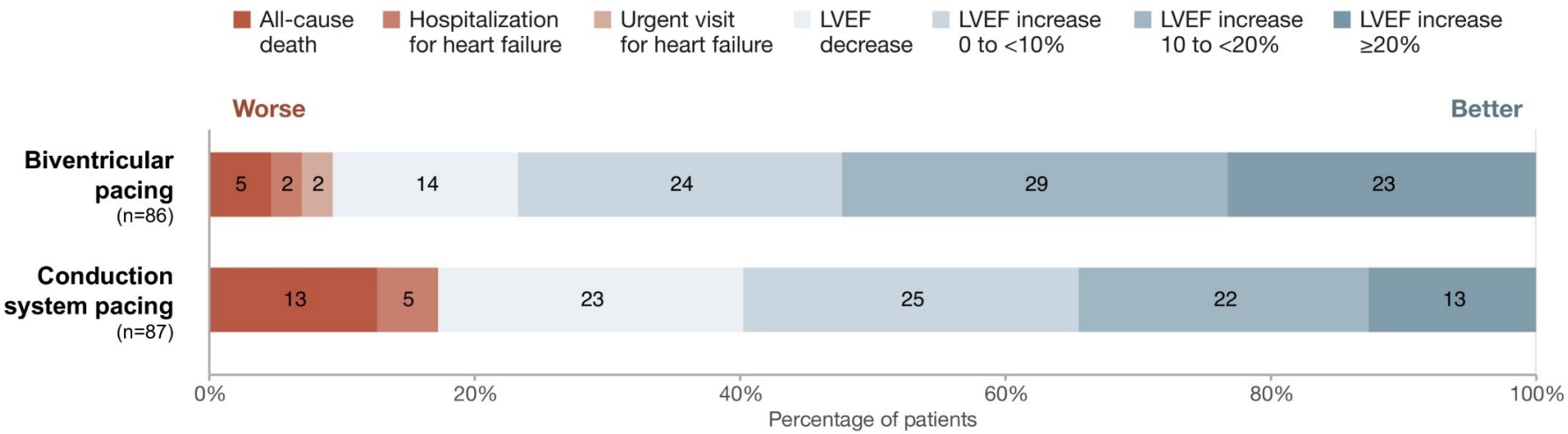
Characteristic	Conduction system pacing (n=87)	Biventricular pacing (n=86)
Age, years	61 (55, 67)	63 (57, 70)
Female sex	52	48
Non-white race	57	62
BMI, kg/m^2	28 (25, 30)	27 (23, 32)
Dilated cardiomyopathy	61	72
Ischemic	15	10
NYHA class		
NYHA II	54	52
NYHA III	45	48
KCCQ-OSS	39 (25, 52)	35 (22, 51)
6-minute walk distance, m	350 (234, 412)	320 (242, 413)

Baseline characteristics (2)

Characteristic	Conduction system pacing (n=87)	Biventricular pacing (n=86)
Baseline test values		
LVEF, %	26 (23, 31)	27 (22, 32)
QRS duration, ms	180 (170, 200)	180 (170, 200)
Typical LBBB (Strauss' criteria)	97	94
BNP, pg/ml	315 (114, 616)	222 (77, 476)
NT-proBNP, pg/ml	1302 (682, 2522)	1056 (329, 2797)
Medical therapy		
ACEi or ARB or ARNI	93	90
Beta-blocker	91	88
Spironolactone	78	88
SGLT2 inhibitor	29	41

Variables are displayed as median (IQR) or %.

Primary endpoint



Odds ratio, 2.36 (95% CI 1.37–4.06)

p=0.99 for non-inferiority of conduction system pacing
p=0.002 for between-group difference favoring biventricular pacing

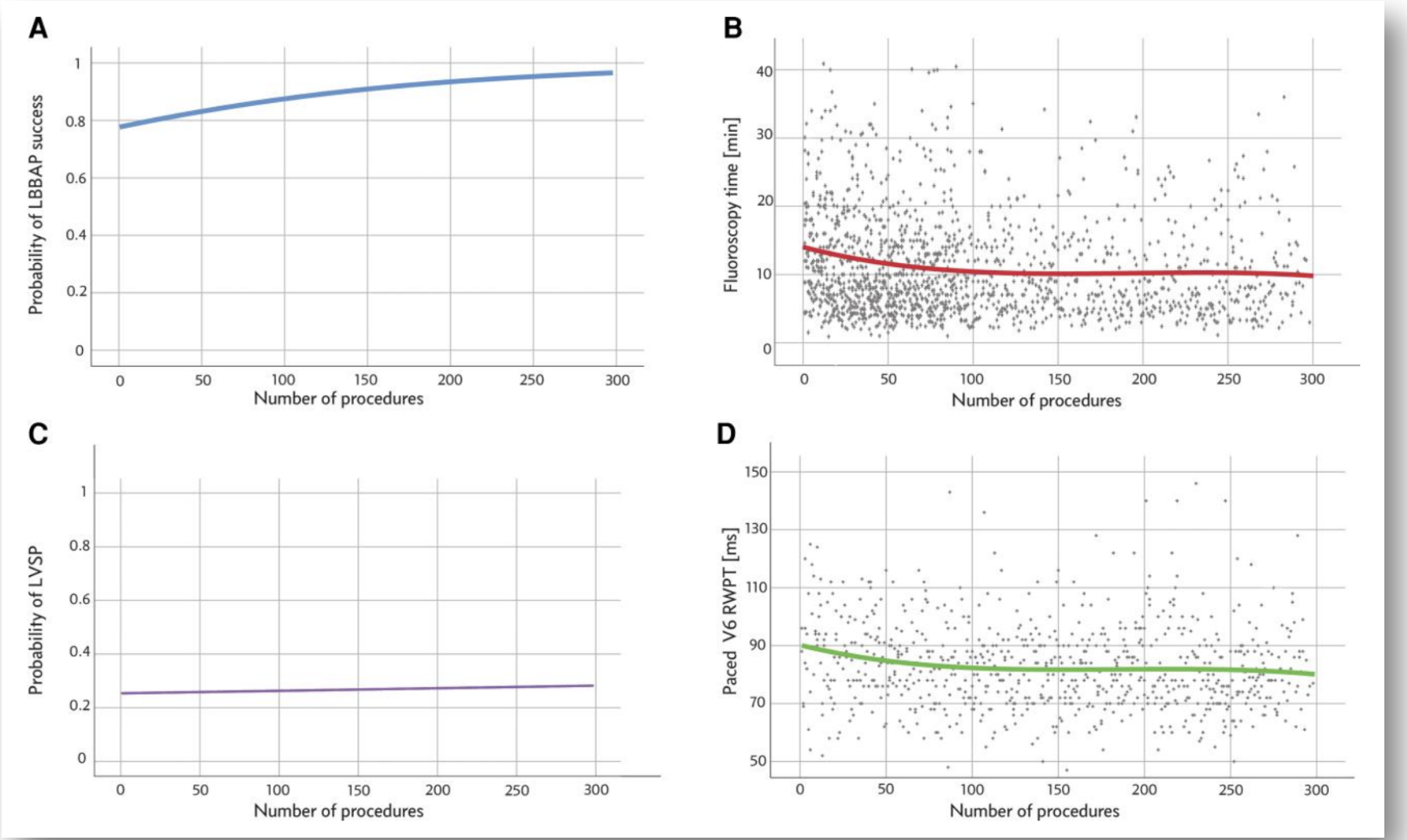
Assessed at 12 months.

Procedure

Characteristic	Conduction system pacing (n=87)	Biventricular pacing (n=86)
Procedure duration, min	120 (80, 165)	120 (80, 162)
CRT lead location	63% Left bundle branch area 2% His bundle 18% Deep septal 8% LBB area + coronary sinus	91% Coronary sinus
Crossover (index procedure)	7	8
Crossover (total)	10	8
R-wave peak time in lead V6	83 (70, 105)	-
V6-V1 interpeak interval, ms	42 (25, 63)	-
QLV, ms	-	121 (98, 150)
Final QRS duration, ms	120 (103, 133)	126 (118, 138)
Change from baseline, ms	-60 (-80, -45)	-55 (-71, -36)

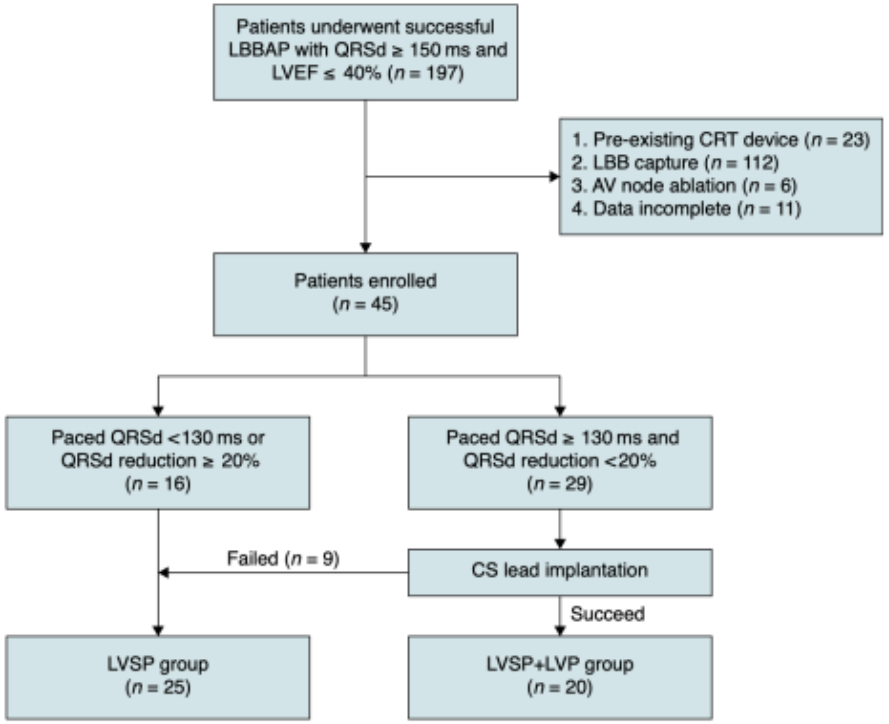
Variables are displayed as median (IQR) or %. Lead location was determined by the local operator; additional ECG parameters were independently evaluated by a blinded committee.

Limite LBBAP : Taux de succès



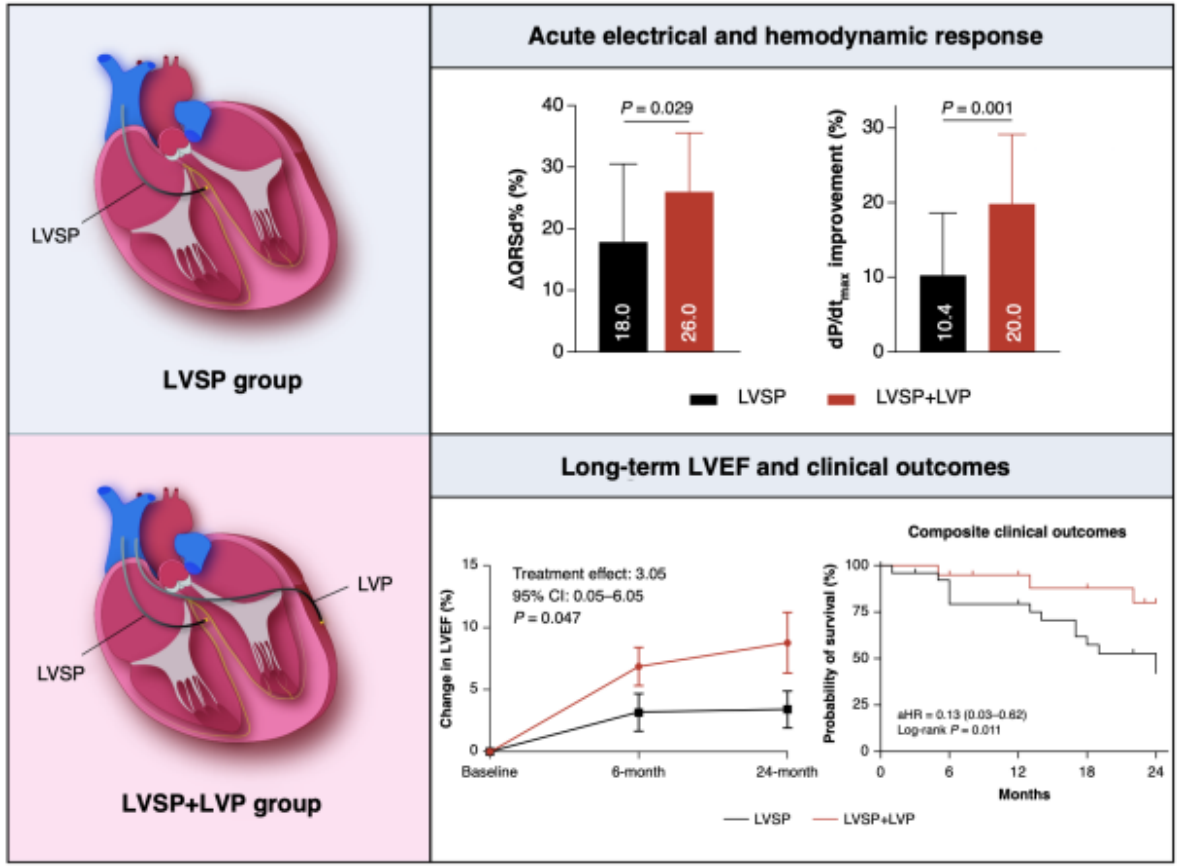
MELOS. Jastrzębski et al. EHJ 2022

SPORT- Study
LVS vs LVS +LVP



- Patients avec indications de CRT et échec de LBBAP : stimulation septale gauche

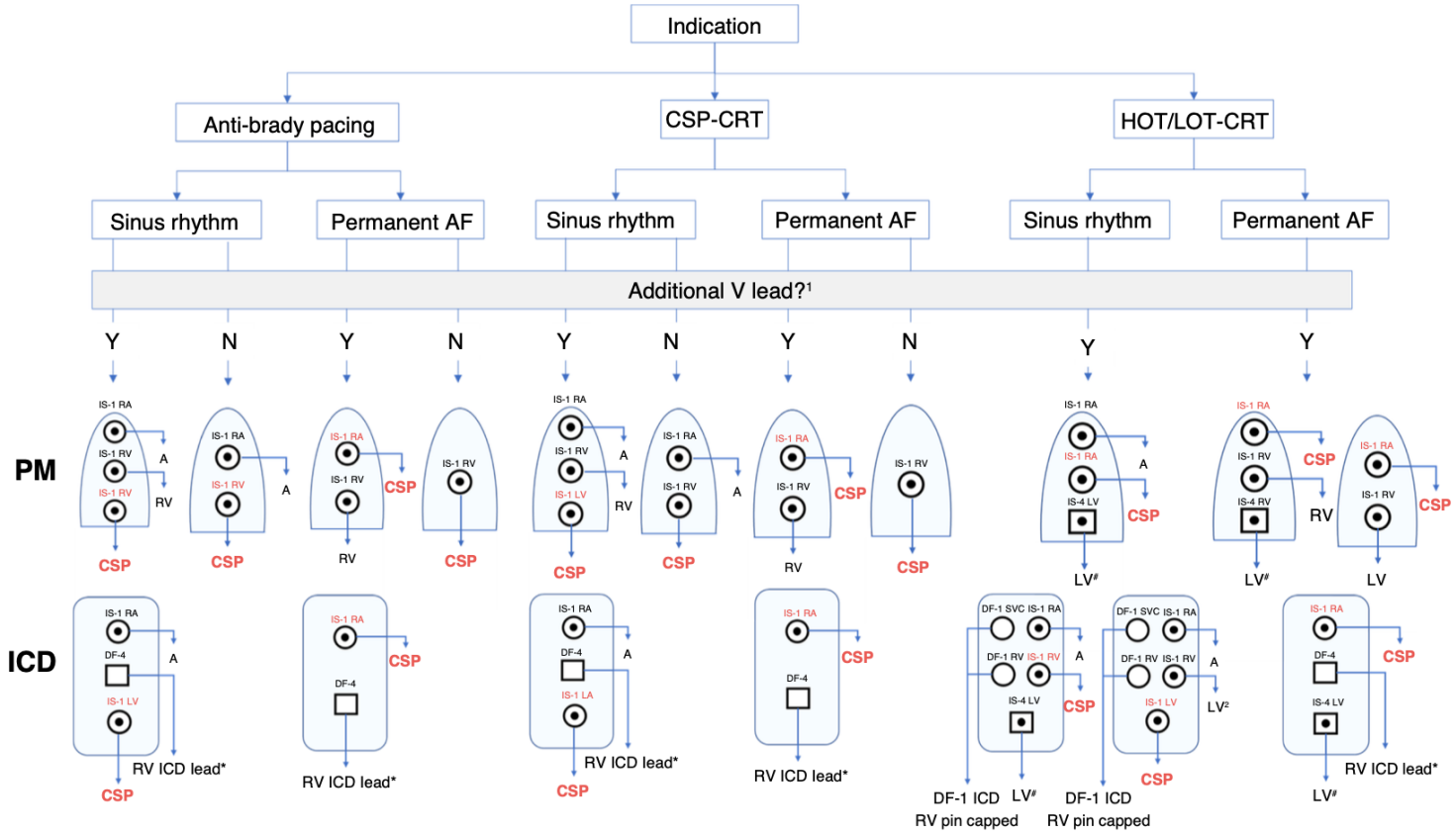
Siyuan Xue et al. Europace 2025



- Meilleure réponse si ajout de sonde CS quand LVS

Siyuan Xue et al. Europace 2025

La CRT c’est fini, place à la LOT-CRT ?



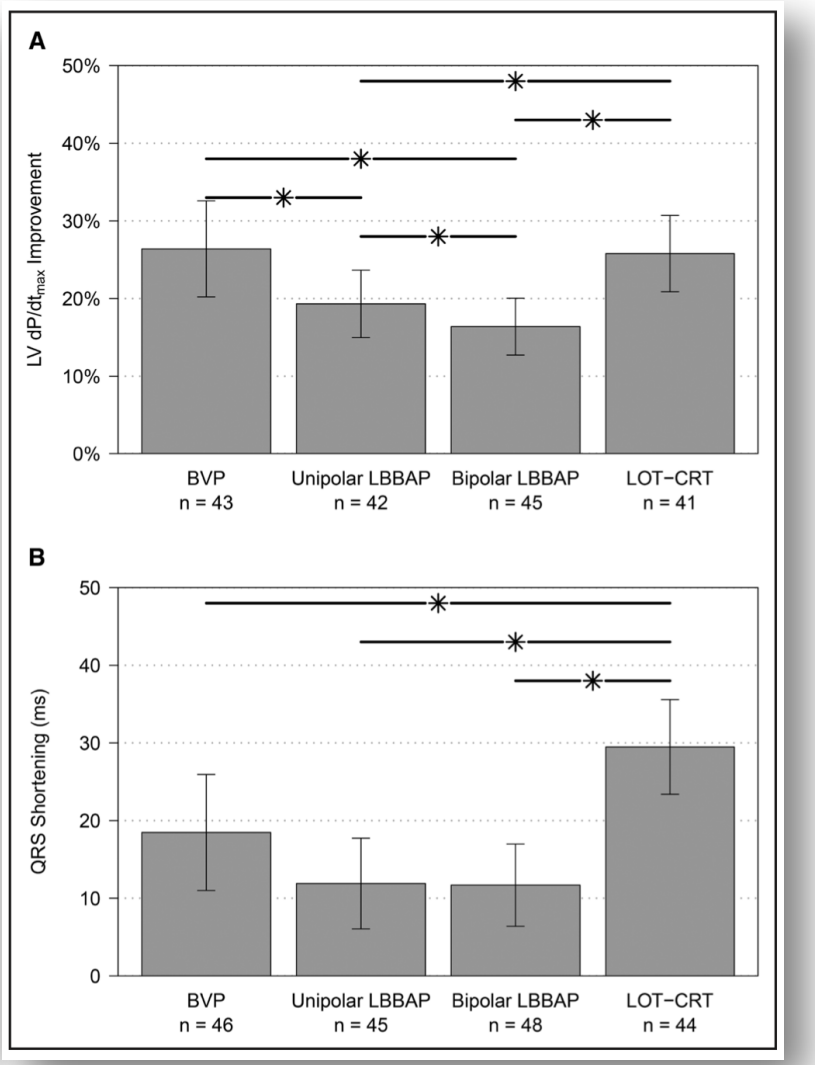
Intérêt du LOT-CRT

48 patients
Pose PM/DAI-CRT + sonde LBBAP

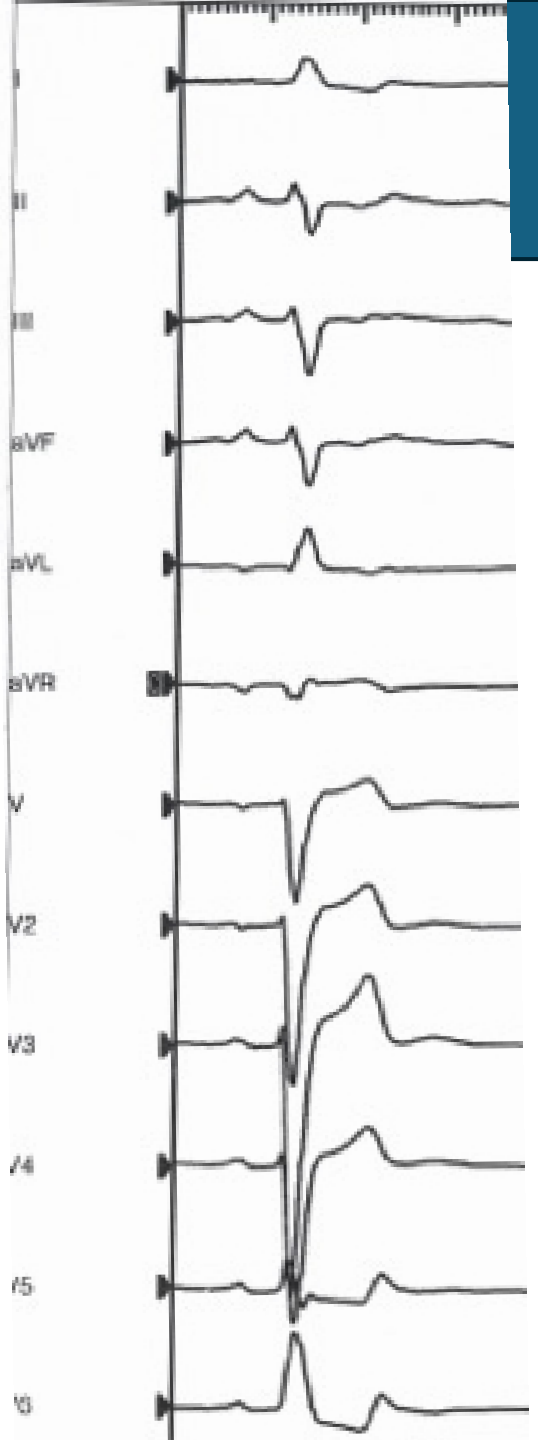
Comparaison des 3 modalités chez un même patient

Délai AV 70% du spontané
Délai VV 0ms

Characteristic	Mean±SD or n (%)
Age, y	65.3±10.3
Male sex	32 (67)
BMI, kg/m^2	30.1±4.8
Ischemic cardiomyopathy	14 (29)
ECG	
PR interval, ms	200±53
Blood pressure, mm Hg	
Systolic	120.6±18.7
Diastolic	70±11
NYHA classification	
I	3 (6)
II	26 (54)
III	17 (35)
IV	1 (2)
Conduction disease	
LBBB	19 (40)
IVCD	29 (60)
Echocardiography	
LVEF, %	31±11
LVESV, mL	144±62
LVEDV, mL	203±68



Jastrzębski et al. Circ EP 2024



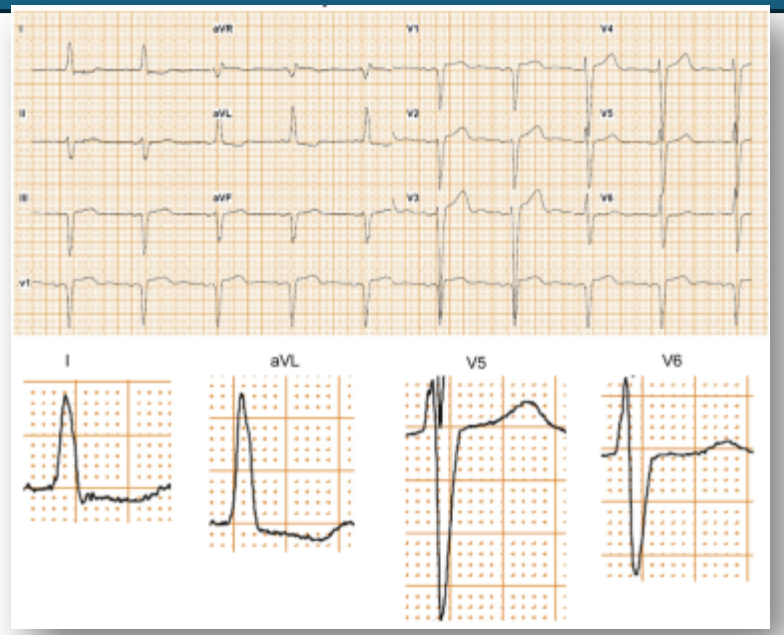
Defining Left Bundle Branch Block in the Era of Cardiac Resynchronization Therapy

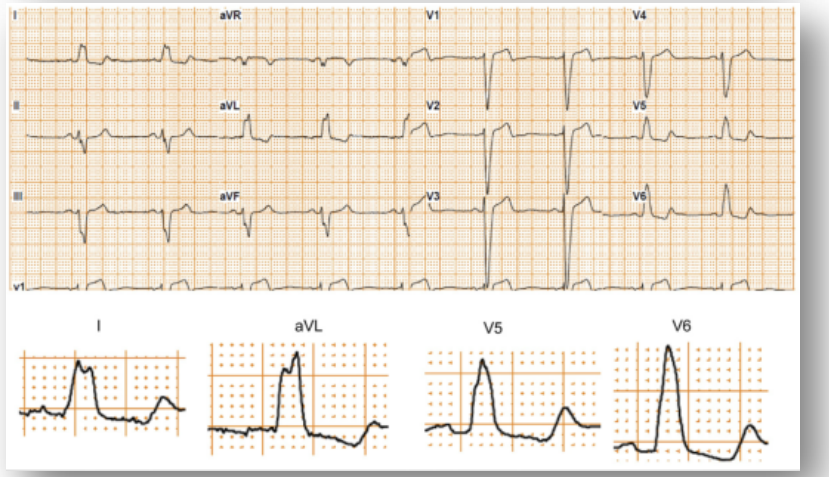
David G. Strauss, MD, PhD[a,b,*], Ronald H. Selvester, MD[c], and Galen S. Wagner, MD[d]

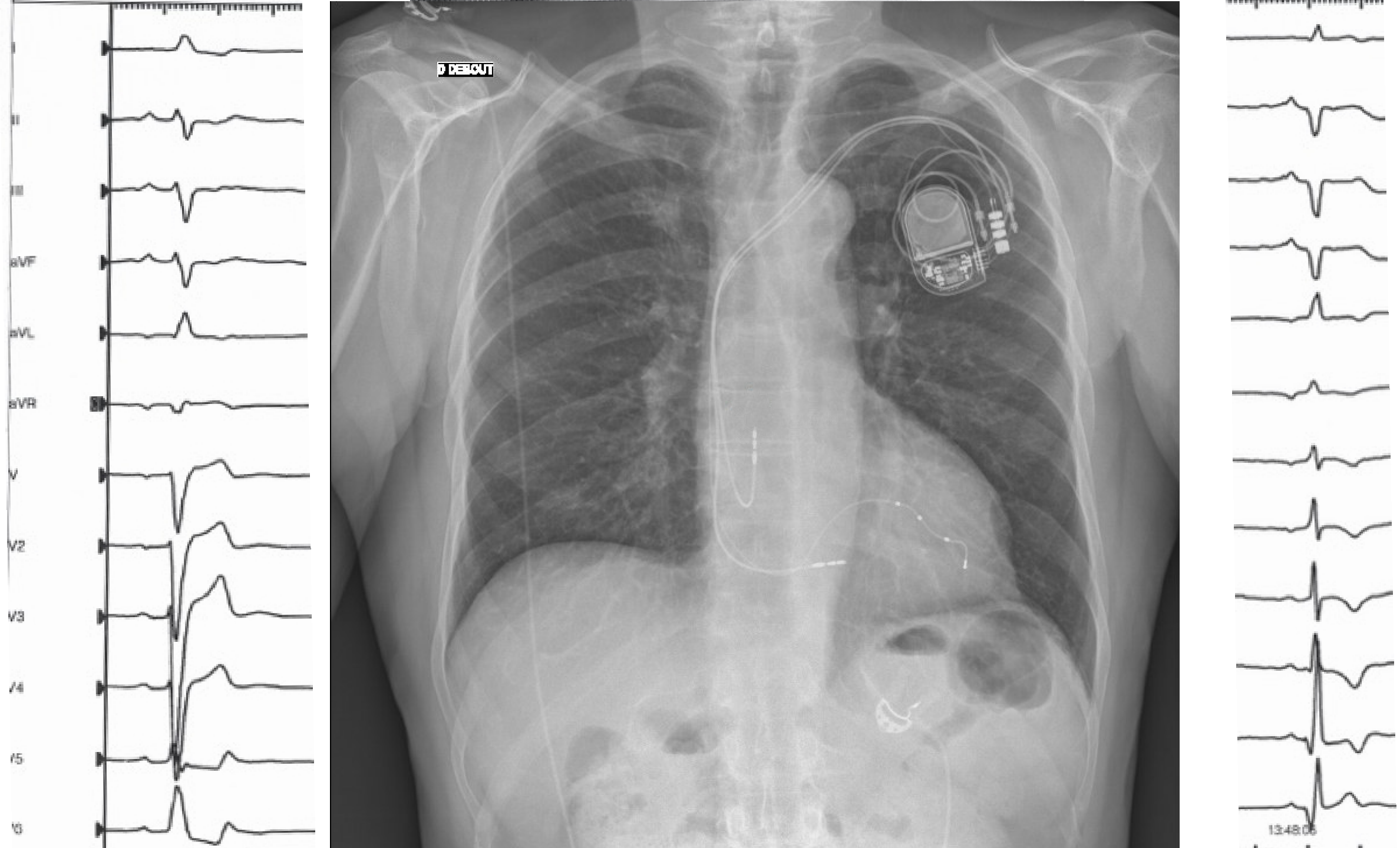
82 ans

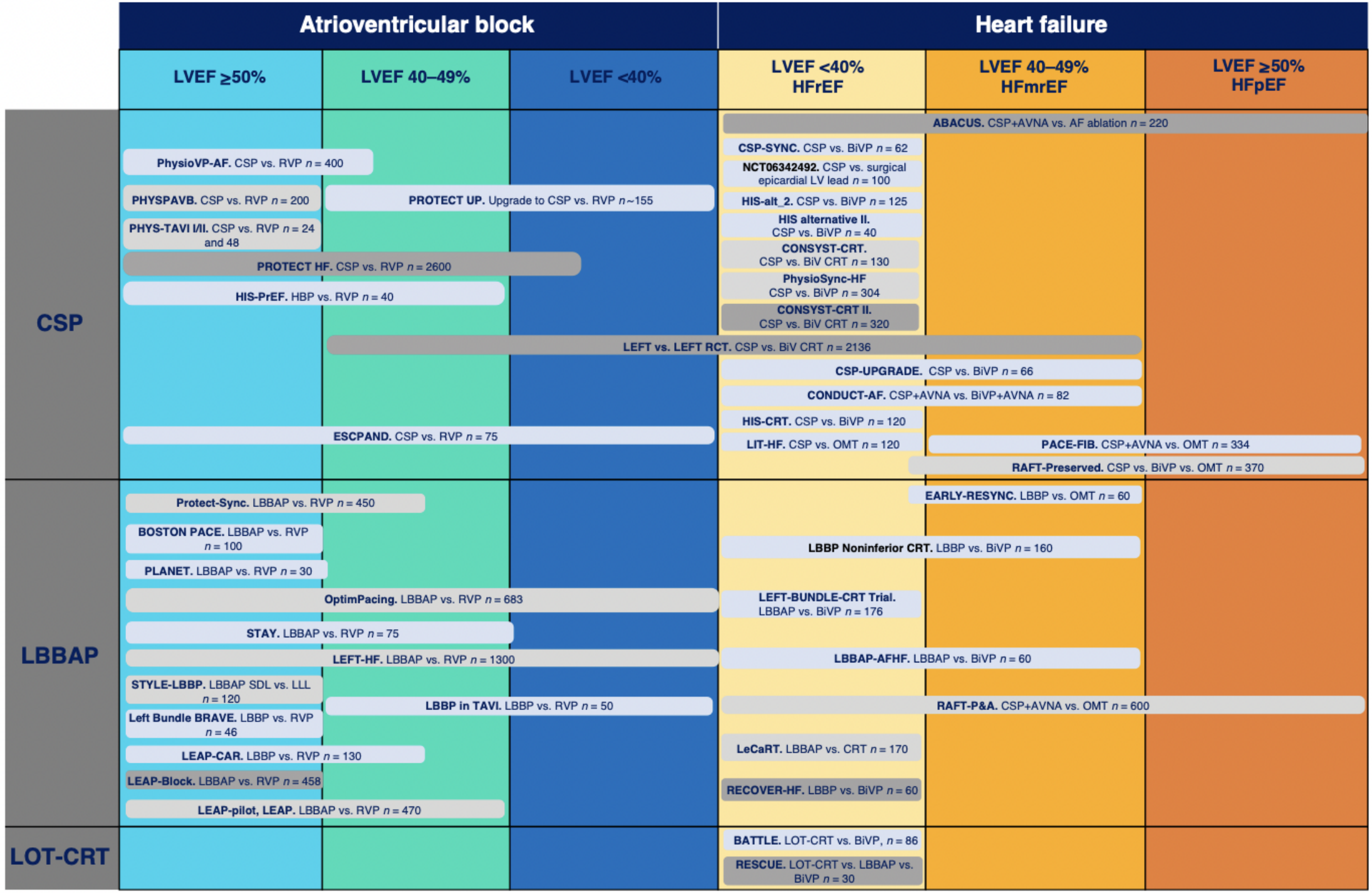
CMD FE 25%
Coronaires saines
IRM sans réhaussement

NYHA 3






aVF
aVL
aVR
V2
V3
13:48:05


Atrioventricular block
Heart failure
LVEF ≥50%
LVEF 40–49%
LVEF <40%
LVEF <40% HFrEF
LVEF 40–49% HFmrEF
LVEF ≥50% HFpEF
CSP
LBBAP
LOT-CRT
ABACUS. CSP+AVNA vs. AF ablation n = 220
CSP-SYNC. CSP vs. BiVP n = 62
NCT06342492. CSP vs. surgical epicardial LV lead n = 100
HIS-alt_2. CSP vs. BiVP n = 125
HIS alternative II. CSP vs. BiVP n = 40
CONSYST-CRT. CSP vs. BiV CRT n = 130
PhysioSync-HF CSP vs. BiVP n = 304
CONSYST-CRT II. CSP vs. BiV CRT n = 320
PhysioVP-AF. CSP vs. RVP n = 400
PHYSPAVB. CSP vs. RVP n = 200
PROTECT UP. Upgrade to CSP vs. RVP n~155
PHYS-TAVI I/II. CSP vs. RVP n = 24 and 48
PROTECT HF. CSP vs. RVP n = 2600
HIS-PrEF. HBP vs. RVP n = 40
LEFT vs. LEFT RCT. CSP vs. BiV CRT n = 2136
CSP-UPGRADE. CSP vs. BiVP n = 66
CONDUCT-AF. CSP+AVNA vs. BiVP+AVNA n = 82
HIS-CRT. CSP vs. BiVP n = 120
ESCPAND. CSP vs. RVP n = 75
LIT-HF. CSP vs. OMT n = 120
PACE-FIB. CSP+AVNA vs. OMT n = 334
RAFT-Preserved. CSP vs. BiVP vs. OMT n = 370
EARLY-RESYNC. LBBP vs. OMT n = 60
Protect-Sync. LBBAP vs. RVP n = 450
BOSTON PACE. LBBAP vs. RVP n = 100
LBBP Noninferior CRT. LBBP vs. BiVP n = 160
PLANET. LBBAP vs. RVP n = 30
OptimPacing. LBBAP vs. RVP n = 683
LEFT-BUNDLE-CRT Trial. LBBAP vs. BiVP n = 176
STAY. LBBAP vs. RVP n = 75
LEFT-HF. LBBAP vs. RVP n = 1300
LBBAP-AFHF. LBBAP vs. BiVP n = 60
STYLE-LBBP. LBBAP SDL vs. LLL n = 120
LBBP in TAVI. LBBP vs. RVP n = 50
RAFT-P&A. CSP+AVNA vs. OMT n = 600
Left Bundle BRAVE. LBBP vs. RVP n = 46
LeCaRT. LBBAP vs. CRT n = 170
LEAP-CAR. LBBP vs. RVP n = 130
LEAP-Block. LBBAP vs. RVP n = 458
RECOVER-HF. LBBP vs. BiVP n = 60
LEAP-pilot, LEAP. LBBAP vs. RVP n = 470
BATTLE. LOT-CRT vs. BiVP, n = 86
RESCUE. LOT-CRT vs. LBBAP vs. BiVP n = 30

Conclusion

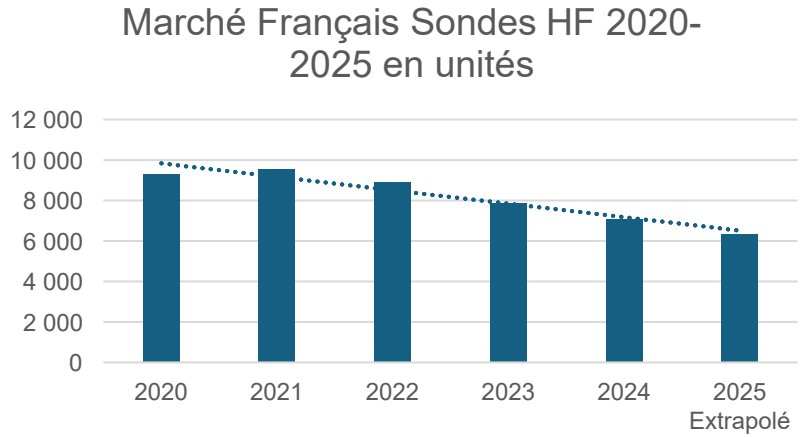
- LBBAP prometteur, études en cours
- Sélection du patient : LBBB +++
- Succès d'implantation ≠ 100%
- **Ne pas enterrer la CRT !**
  - Echec de LBBAP
  - Non-LBB : LOT-CRT

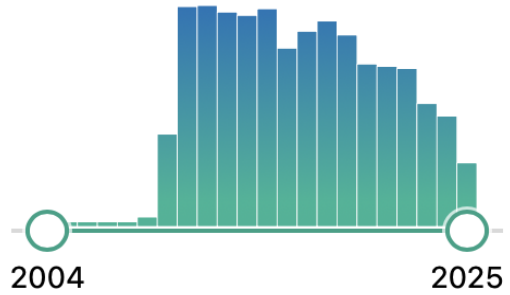
En pratique …

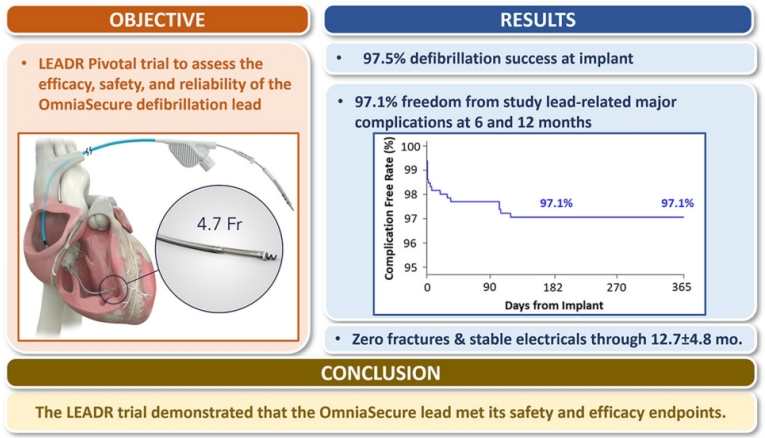
- Baisse d’activité
- Baisse des publications
- Innovations industrielles en LBBAP

- Formation à la CSP

Perte de compétences en CRT ?







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HOTEL VILLA M.
MARSEILLE I FRANCE

1Ç^{èmes} journées françaises pratiques de rythmologie & de stimulation cardiaque

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