

ELECTRA 

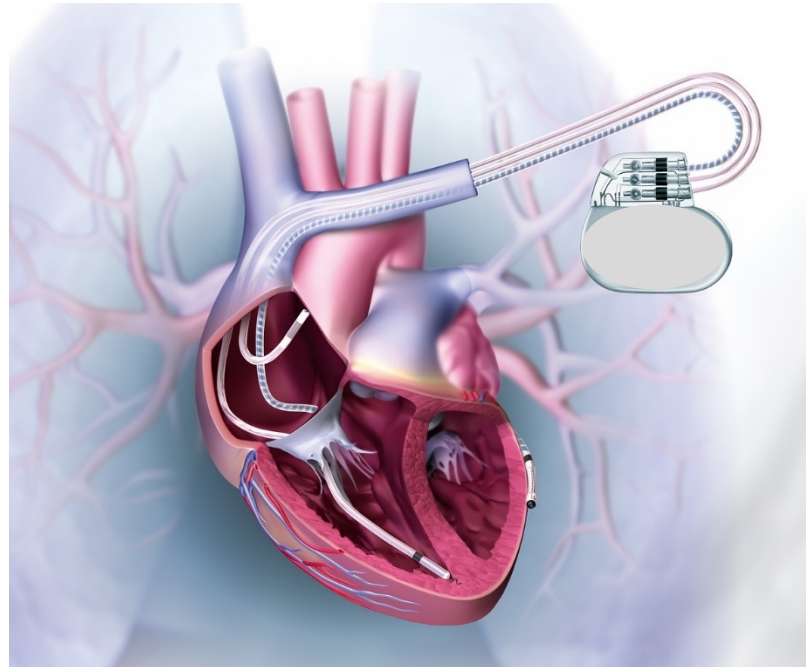
4-5 DÉCEMBRE 2025

VILLA M. - MARSEILLE | FRANCE

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

WWW.CONGRES-ELECTRA.COM

L'histoire de la resynchronisation



Philippe Mabo

Mes relations avec l'industrie

- **Consultant: Biosency, Medinthepocket**
- **Directeur médical: Implicity**
- **Actionnaire/fondateur: Oktoscience**

L'histoire de la resynchronisation commence à l'étage atrial

L'histoire de la resynchronisation commence à l'étage atrial

Le contexte à la fin des années 1980:

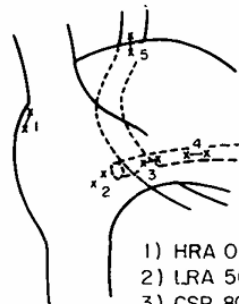
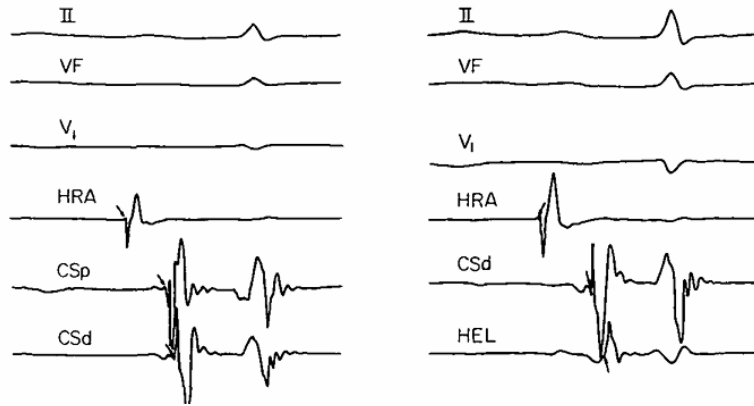
prévenir la FA par la stimulation atriale

des algorithmes dédiés

des résultats mitigés...

Interatrial conduction block and retrograde activation of the left atrium and paroxysmal supraventricular tachyarrhythmia

A. BAYÉS DE LUNA, M. CLADELLAS, R. OTER, P. TORNER, J. GUINDO, V. MARTÍ, I. RIVERA AND P. ITURRALDE



- 1) HRA 0 msec
- 2) LRA 50 msec
- 3) CSP 80 msec
- 4) CSD 100 msec
- 5) HEL 135 msec

Table 2 Characteristics of the sustained paroxysmal tachyarrhythmias.

Group with interatrial block
(16 patients; 15 with tachyarrhythmia during the follow-up) (93.7%)

Atrial flutter	7/15 cases
Atrial fibrillation	4/15 cases
Atrial flutter with fibrillation	4/15 cases
MVR	133 ± 42 beats min^{-1}

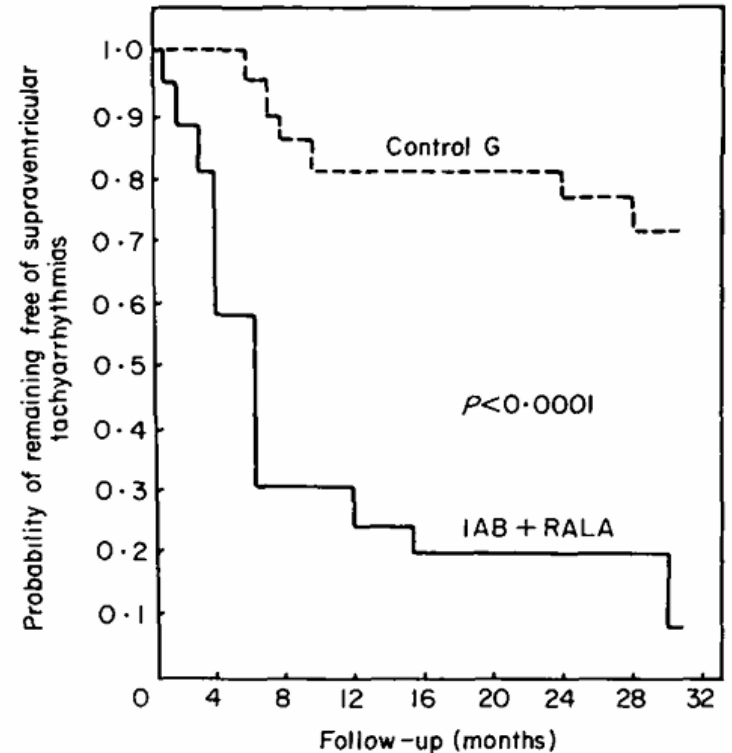
Characteristics of the atrial flutter
(11 cases)

Typical form (AR 276 ± 21 min^{-1})	2 cases
Atypical form (AR 252 ± 36 min^{-1})	7 cases
Two or more morphologies	2 cases

Control group

(22 patients; 6 with tachyarrhythmia at follow-up) (27.7%).

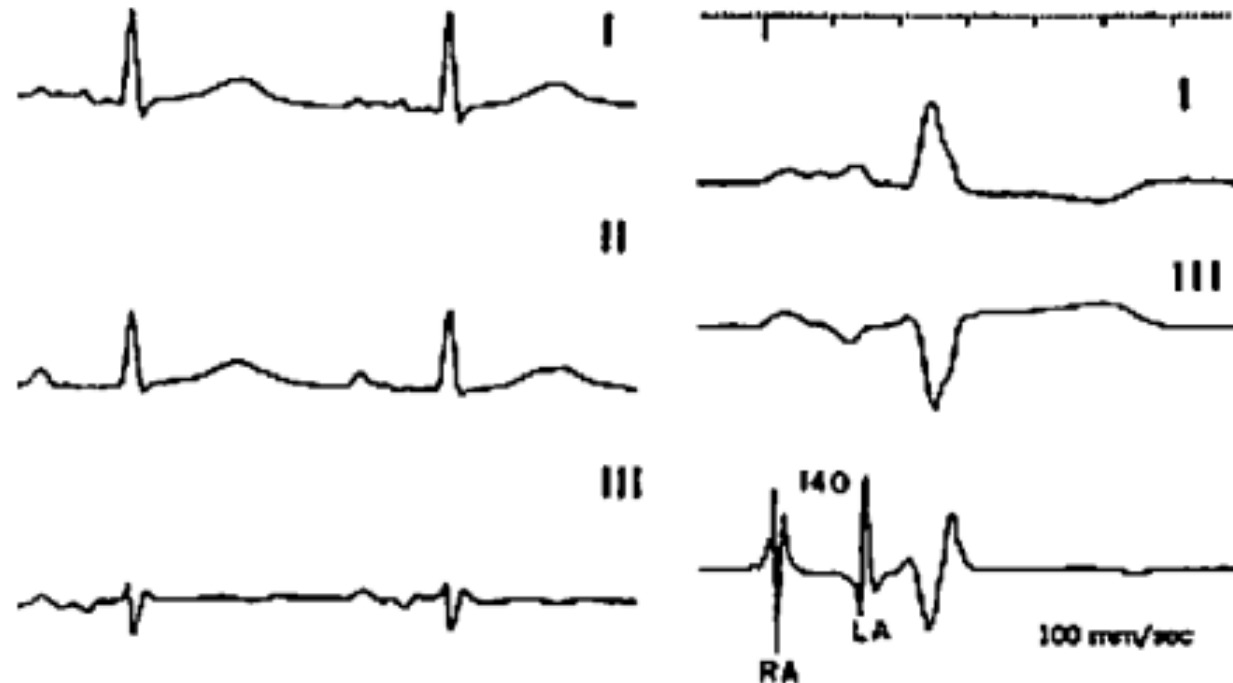
Typical atrial flutter (AR 270 min^{-1})	1 case
Atrial fibrillation	5 cases
MVR	127 ± 28 beats min^{-1}



Intra- and Interatrial Conduction Delay: Implications for Cardiac Pacing

JEAN-CLAUDE DAUBERT, DOMINIQUE PAVIN, GAËL JAUVERT, and PHILIPPE MABO

From the Département de Cardiologie et Maladies Vasculaires, Centre Cardio-Pneumologique, Hôpital Pontchaillou, CHU Rennes, France



Et si on resynchronisait les oreillettes...

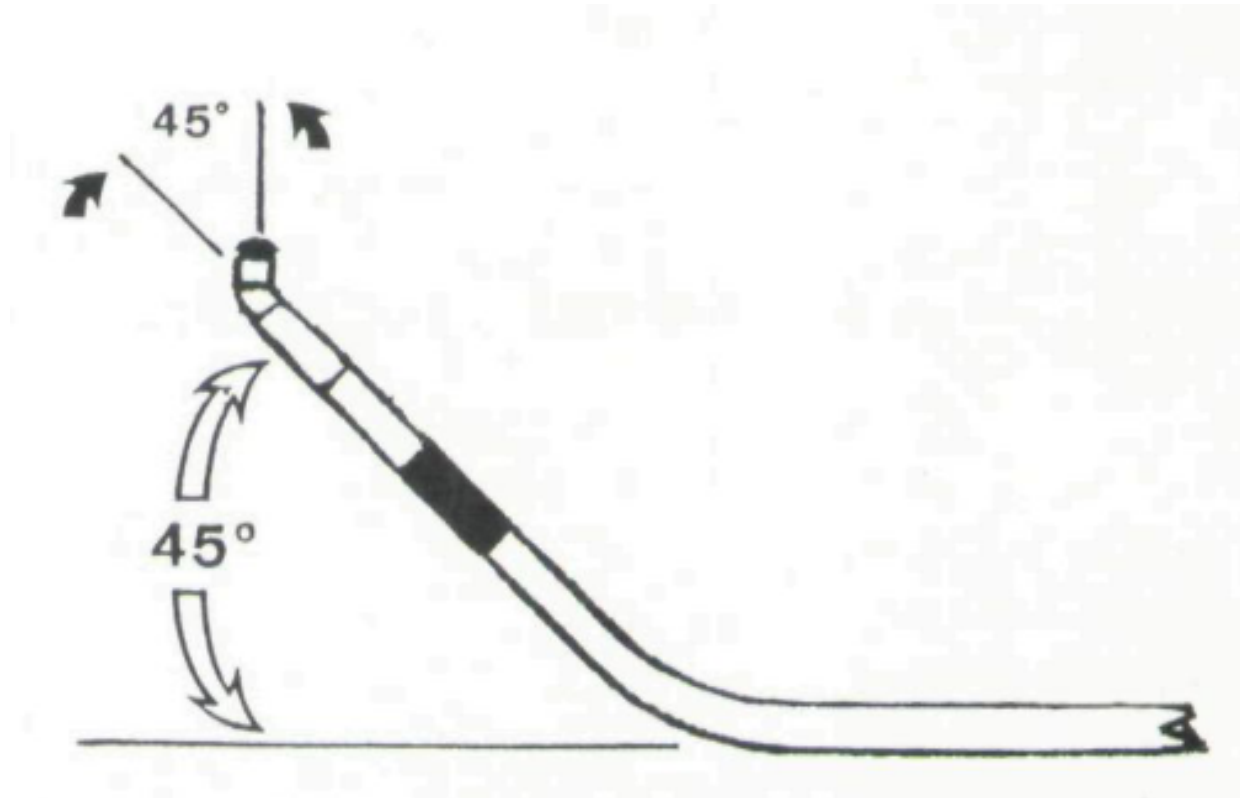
Eur Heart J 1990; 11: 237

AMCV, 1994; 87: 1535-46

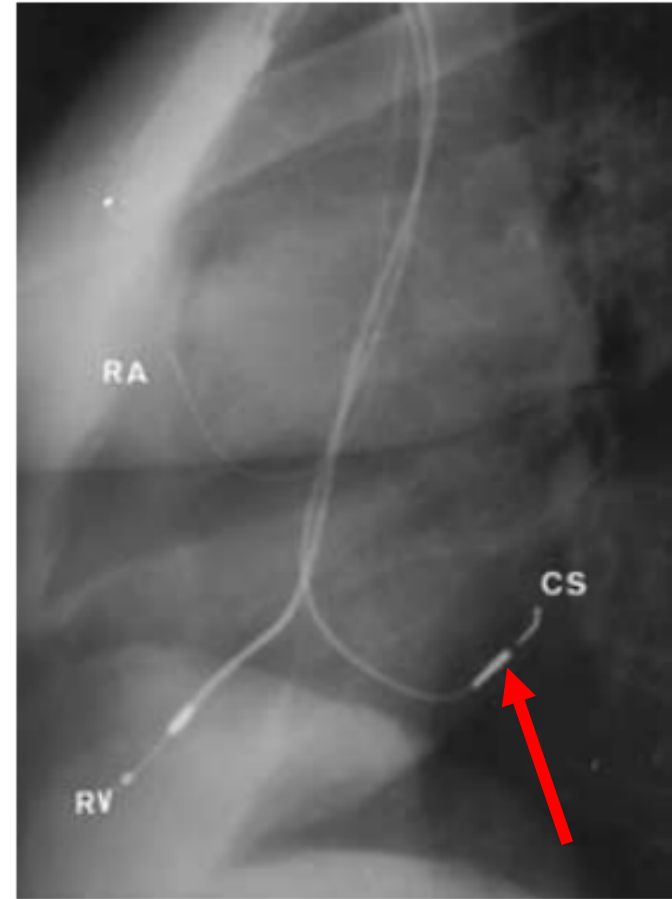
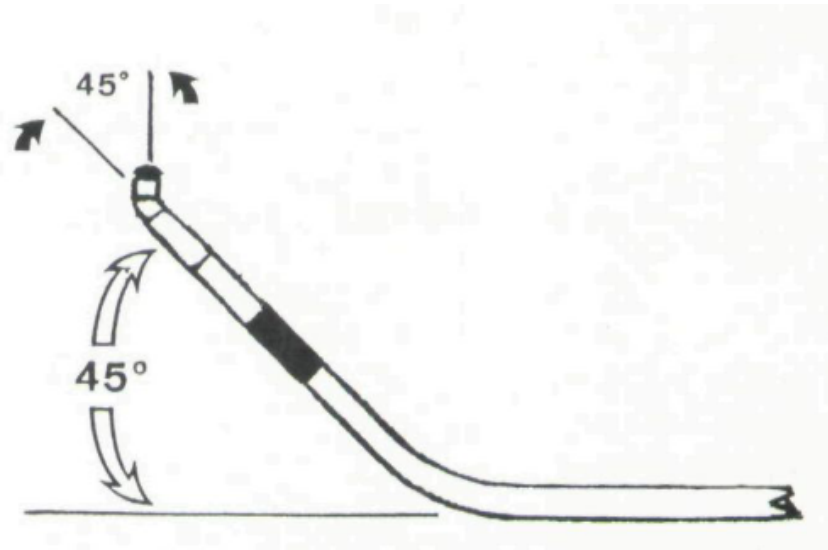
J Cardiovasc Electrophysiol 2000; 11:1081-91

Stimulation bi-atriale

Une sonde qui va tout changer...



Une sonde qui va tout changer...



Sonde Medtronic SP 2188

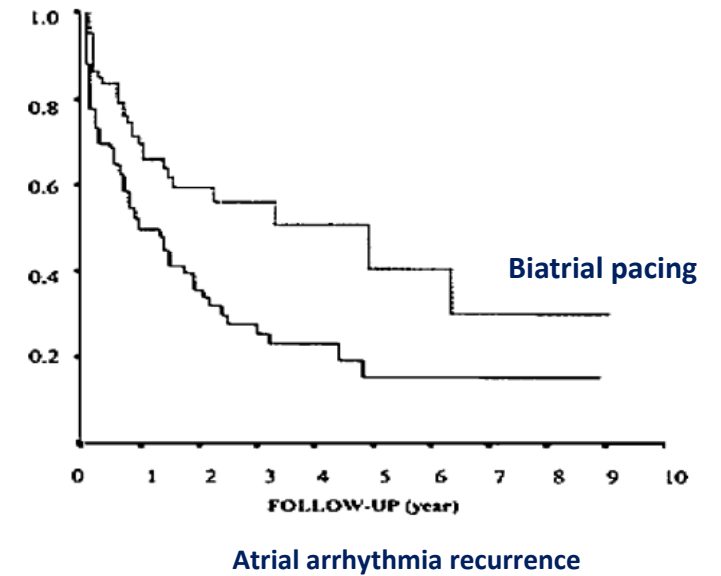
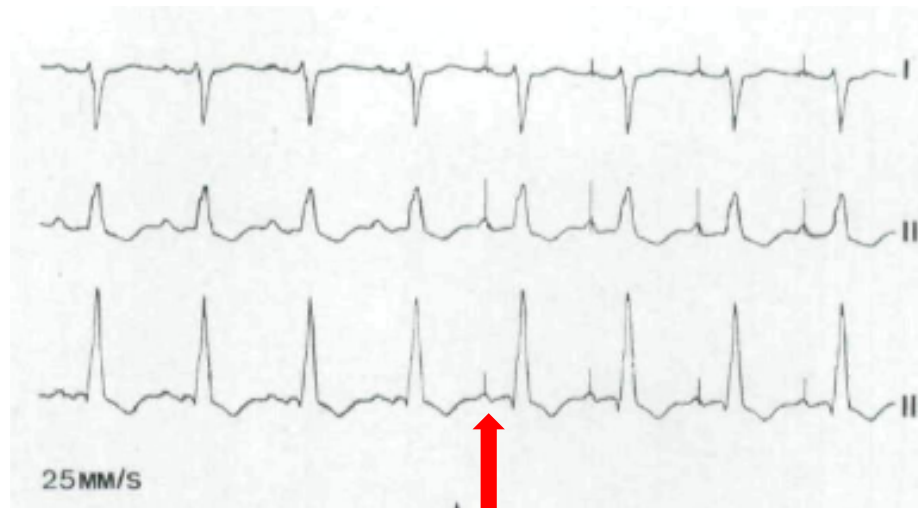
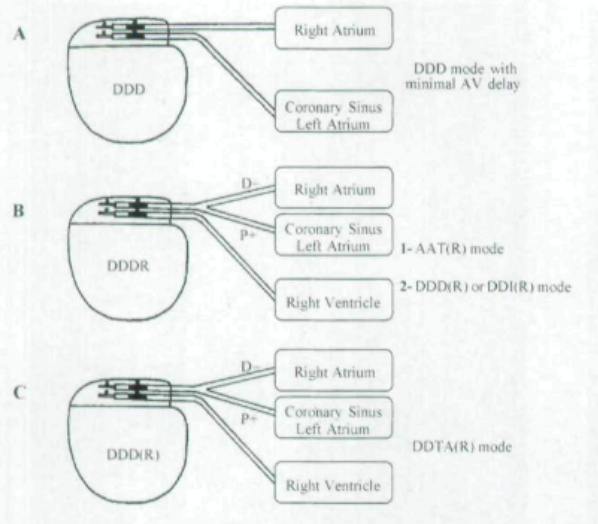
Eur Heart J 1990; 11: 237

AMCV, 1994; 87: 1535-46

J Cardiovasc Electrophysiol 2000; 11:1081-91

Long-Term Effects of Batrial Synchronous Pacing to Prevent Drug-Refractory Atrial Tachyarrhythmia: A Nine-Year Experience

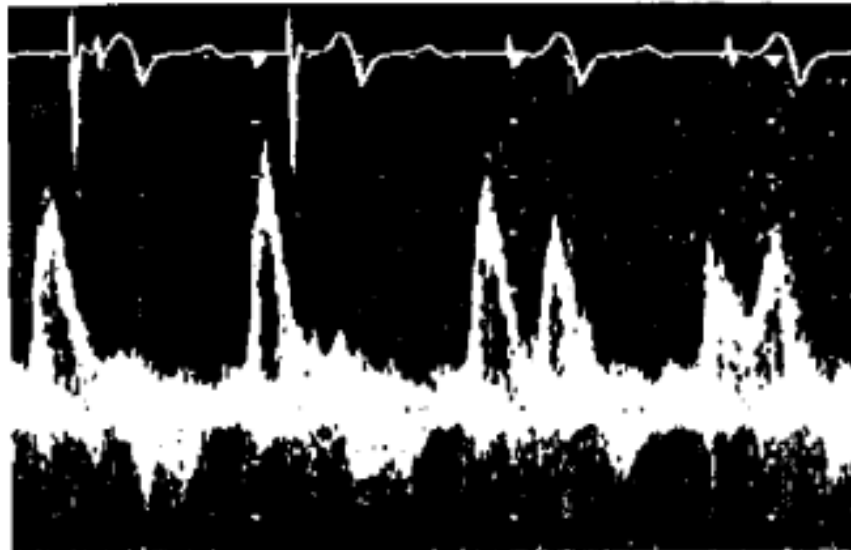
GILLES REVAULT D'ALLONNES, M.D., DOMINIQUE PAVIN, M.D.,
CHRISTOPHE LECLERCQ, M.D., JEAN-EMMANUEL ECKE, M.D.,
GAEL JAUVERT, M.D., PHILIPPE MABO, M.D., and JEAN-CLAUDE DAUBERT, M.D.



Algorithme dédié développé par Ela Médical
(Mode déclenché à l'étage atrial)

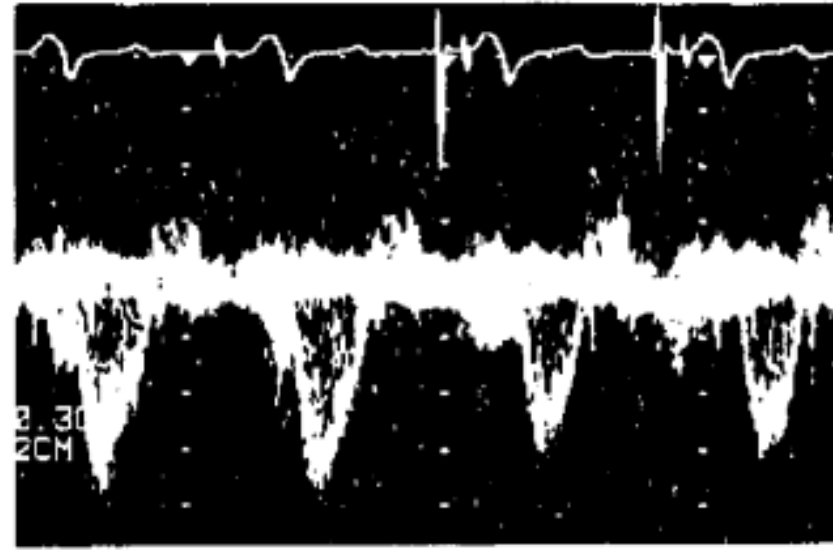
Des arythmies à l'hémodynamique

TRANSMITRAL FLOW



Single RA Pacing → Dual Atrium Pacing

LV EJECTION FLOW



Dual Atrium Pacing → Single RA Pacing

Optimisation du remplissage VG et du débit en mode DDD

Quid des ventricules ?

Un cas clinique, début d'une longue histoire

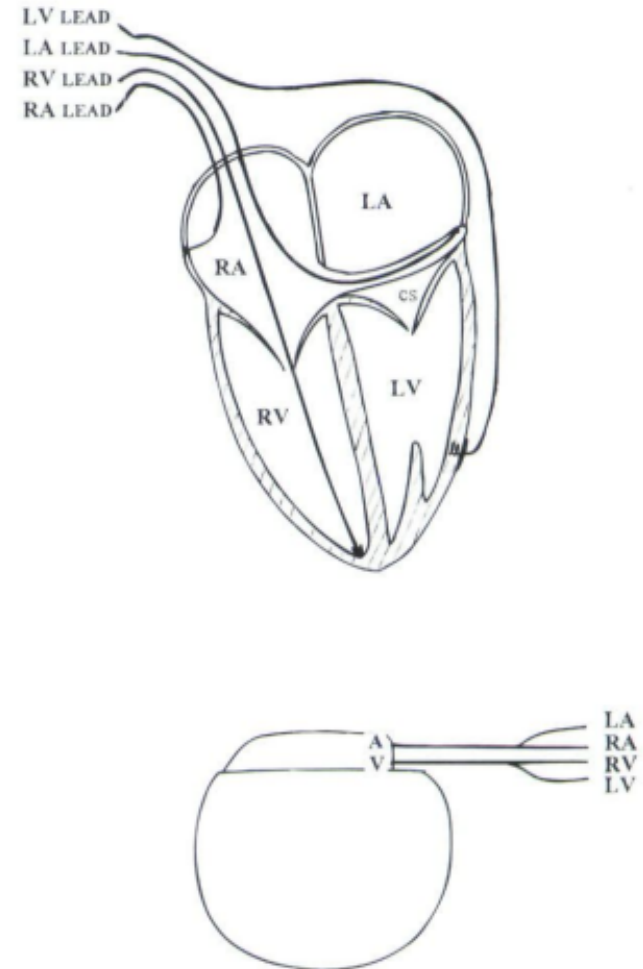
Four Chamber Pacing in Dilated Cardiomyopathy

S. CAZEAU, P. RITTER, S. BAKDACH, A. LAZARUS, M. LIMOUSIN,*
L. HENAO, O. MUNDLER,** J.C. DAUBERT,† and J. MUGICA

From the Val d'Or Surgical Centre, St. Cloud, the *Clinical Research Department, Ela Medical, Le Plessis Robinson, the **Department of Nuclear Medicine, University Hospital of Lariboisière, Paris, and the †University Hospital of Rennes, France

CAZEAU, S., ET AL.: Four Chamber Pacing in Dilated Cardiomyopathy. A 54-year-old man received a four chamber pacing system for severe congestive heart failure (NYHA functional Class IV). His ECG showed a left bundle branch block (200-msec QRS duration) with 200-msec PR interval, normal QRS axis, and 90-msec interatrial interval. An acute hemodynamic study with insertion of four temporary leads was performed prior to the implant, which demonstrated a significant increase in cardiac output and decrease of pulmonary capillary wedge pressure. A permanent pacemaker was implanted based on the encouraging results of the acute study. The right chamber leads were introduced by cephalic and subclavian approaches. The left atrium was paced with a coronary sinus lead, Medtronic SP 2188-58 model. An epicardial Medtronic 5071 lead was placed on the LV free wall. The four leads were connected to a standard bipolar DDD pacemaker, Chorus 6234. The two atrial leads were connected via a Y-connector to the atrial channel of the pacemaker with a bipolar pacing configuration. The two ventricular leads were connected in a similar fashion to the ventricular channel of the device. The right chamber leads were connected to the distal poles. The left chamber leads were connected to the proximal poles of the pacemaker. Six weeks later, the patient's clinical status improved markedly with a weight loss of 17 kg and disappearance of peripheral edema. His functional class was reduced to NYHA II. Four chamber pacing is technically feasible. In patients with evidence of interventricular dyssynchrony, this original pacing mode probably provides a mechanical activation sequence closer to the natural one. We doubt that this technique will have an impact on long-term survival, but it could be of major importance to improve the patient's well-being and control heart failure. (PACE 1994; 17(Pt. II):1974-1979)

1994 > 30 ans !



Un cas clinique, début d'une longue histoire

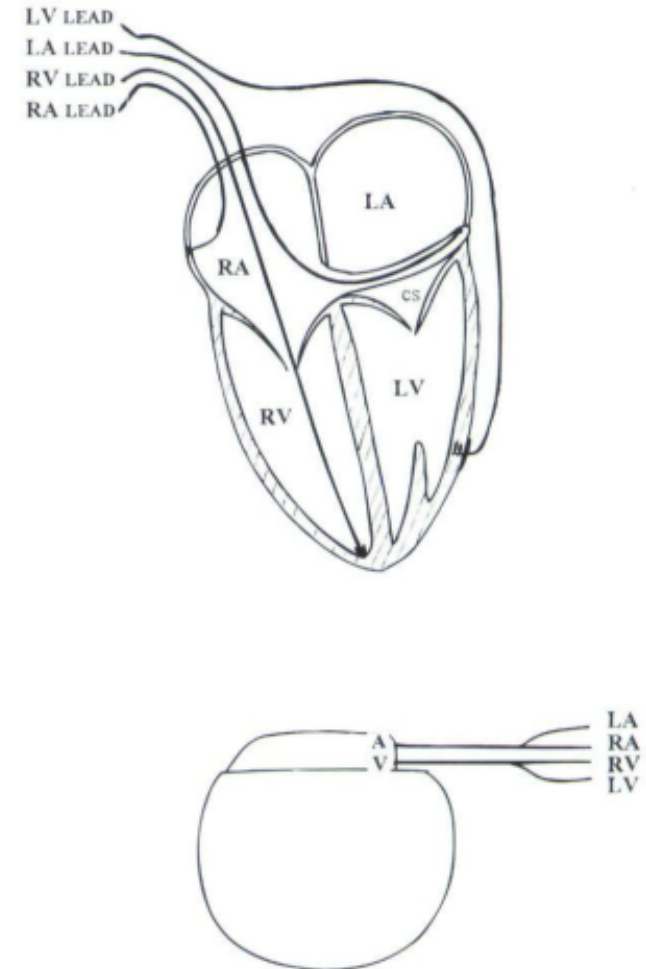
1994 > 30 ans !

Four Chamber Pacing in Dilated Cardiomyopathy

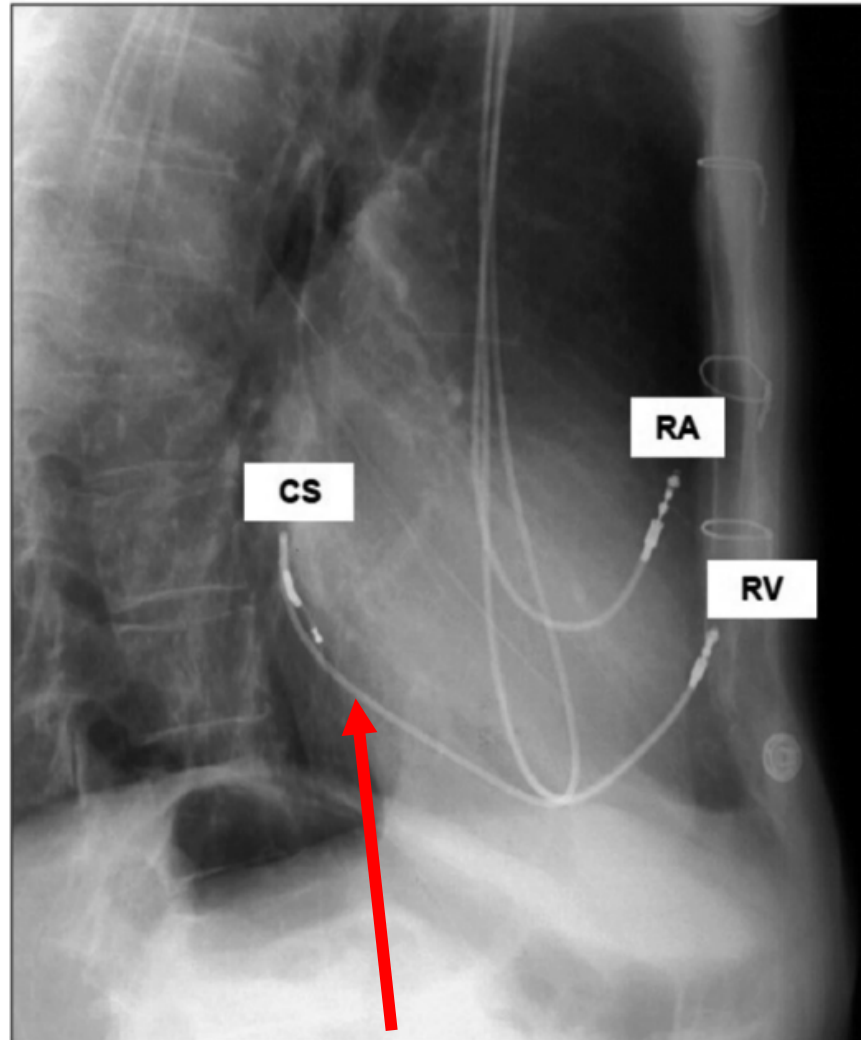
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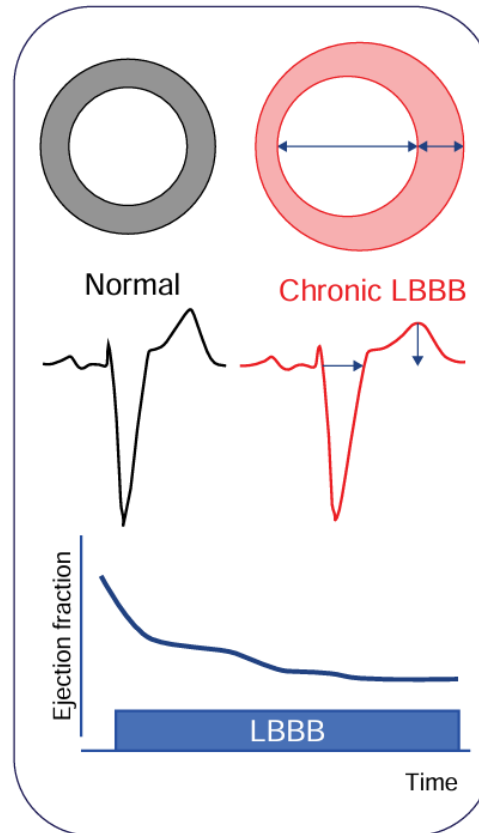
Faisons plus simple: la voie endoveineuse



Sonde Medtronic SP 2188

Resynchronisation cardiaque

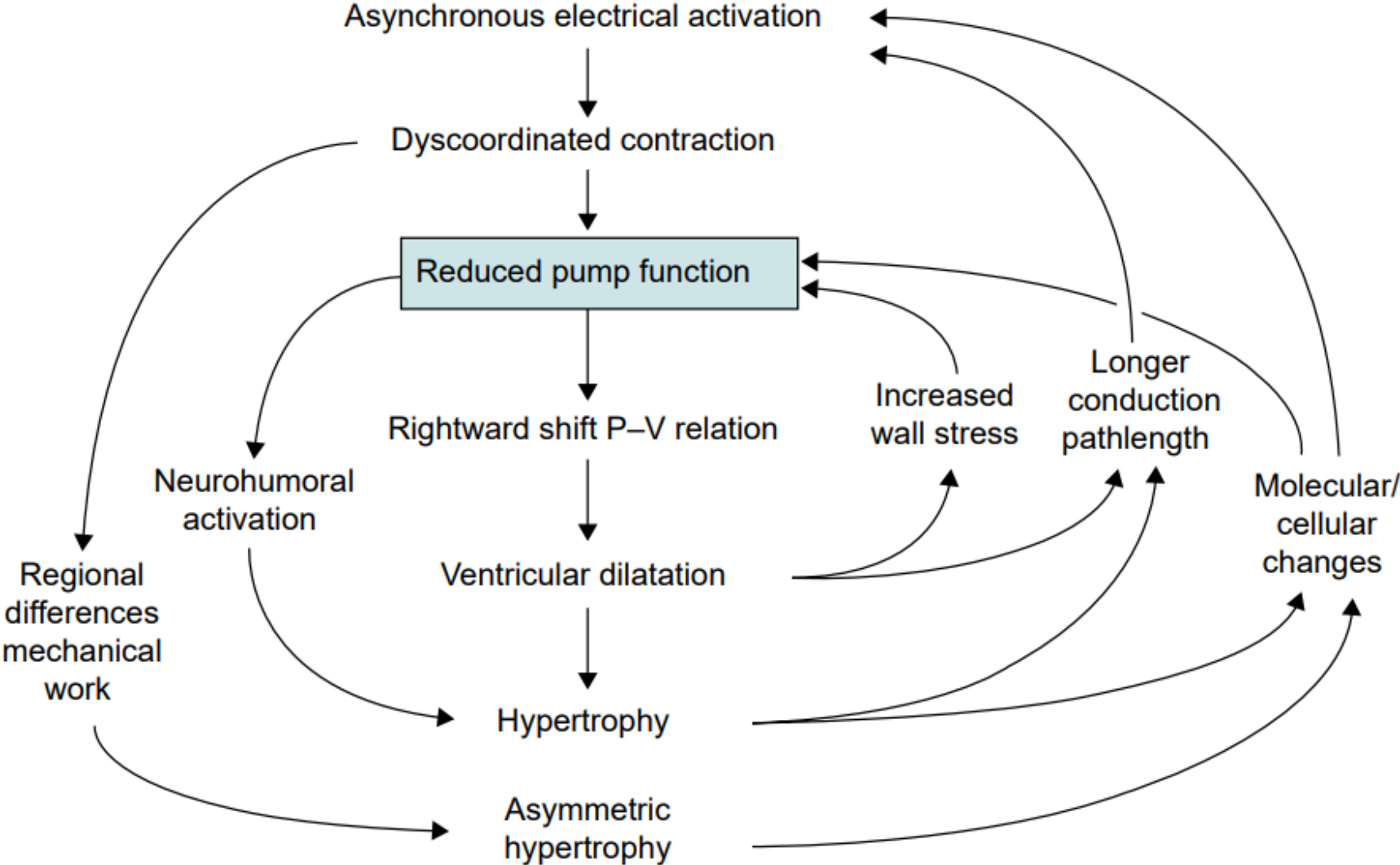
Un objectif hémodynamique et structurel



FEVG \leq 35 %

LBBB: bloc de branche gauche

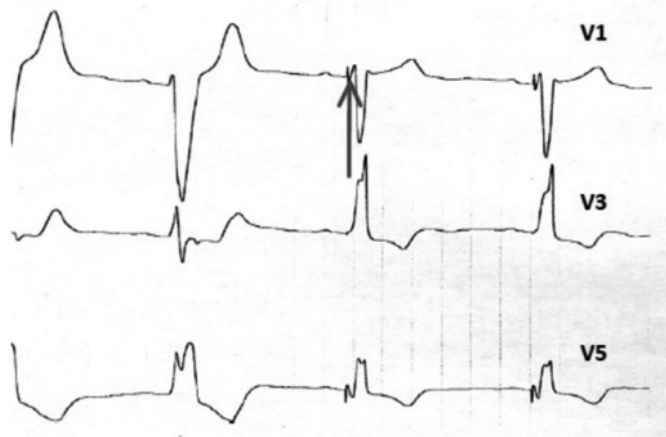
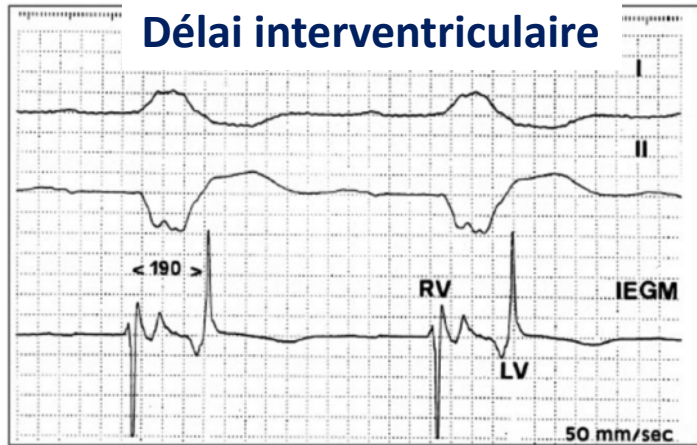
Asynchronisme électrique et dysfonction ventriculaire gauche



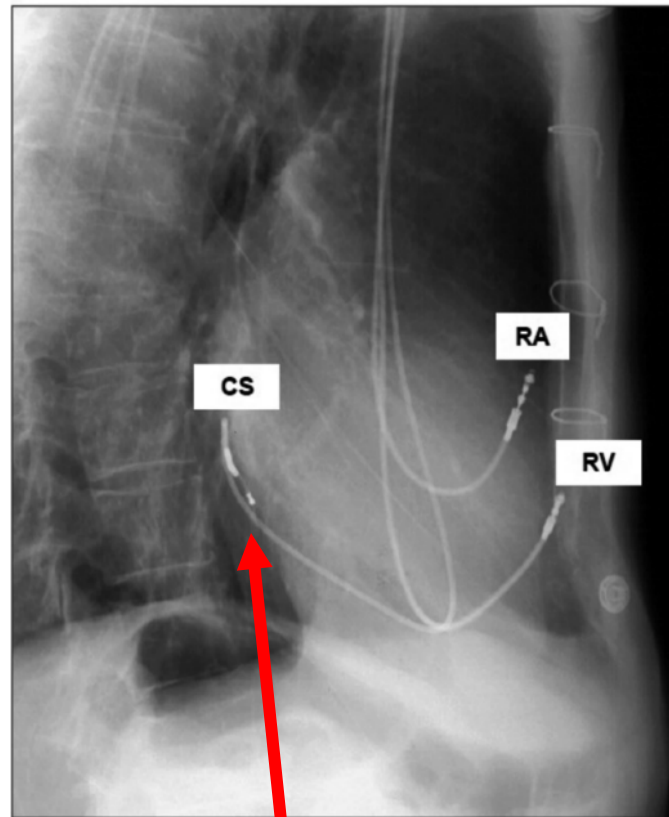
Adapted from Vernooij K, Interv Cardiol 2023

Stimulation atrio-biventriculaire par voie endoveineuse

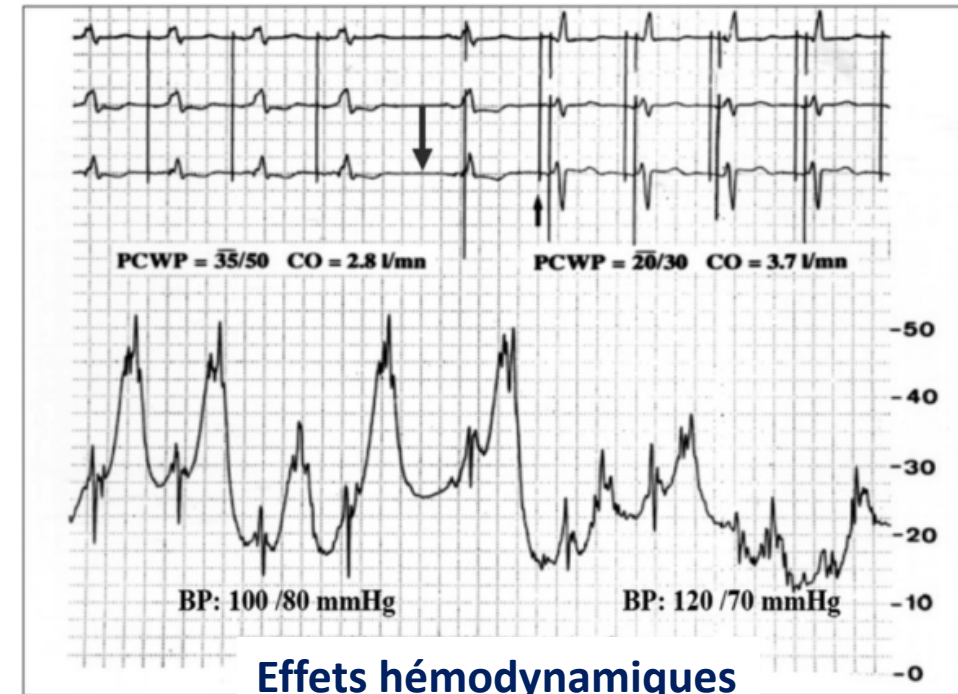
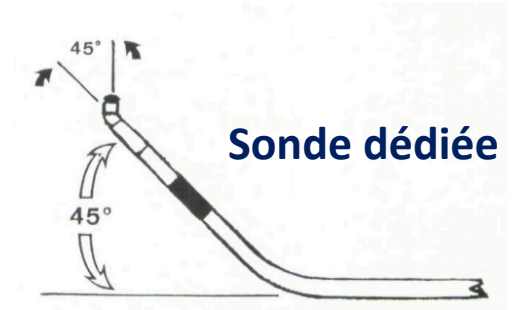
Un effet « on-off »

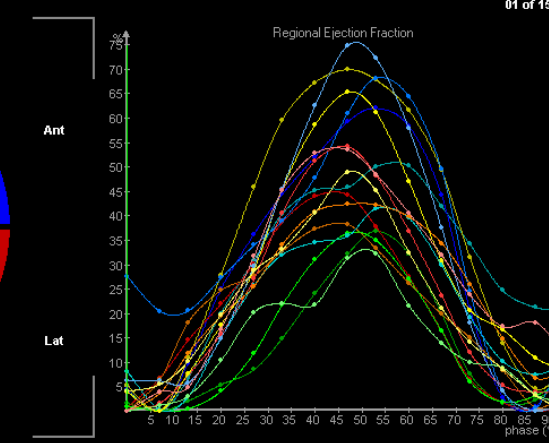
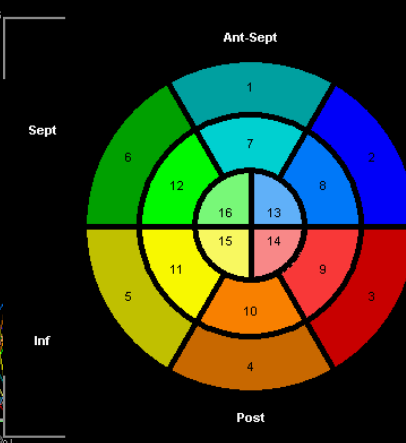
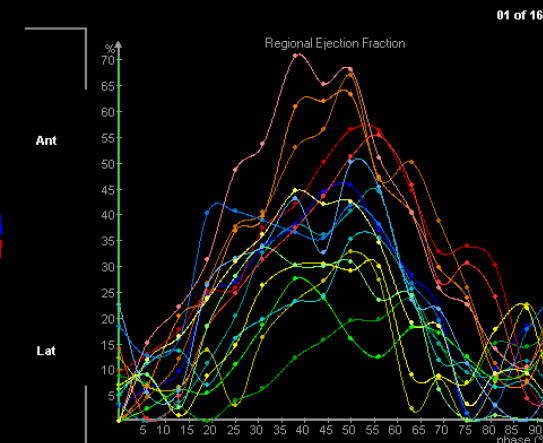
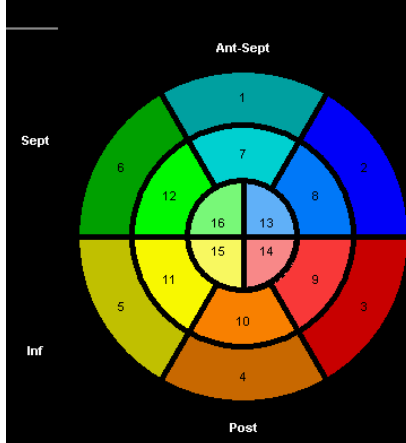
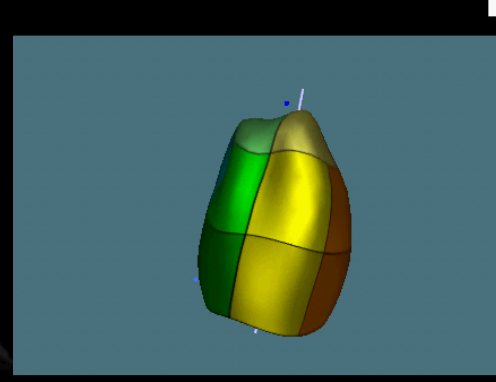
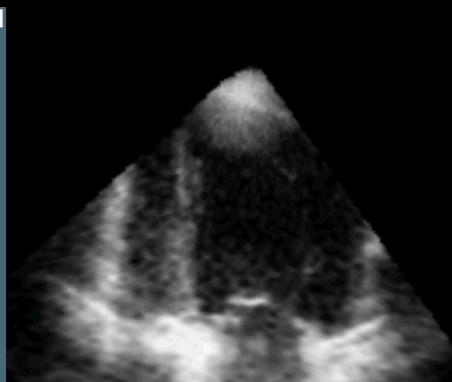
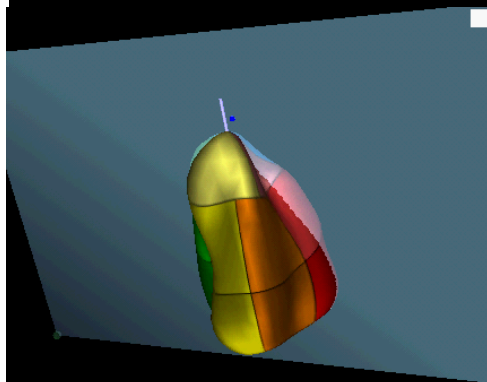


Affinement du QRS



Sonde Medtronic SP 2188

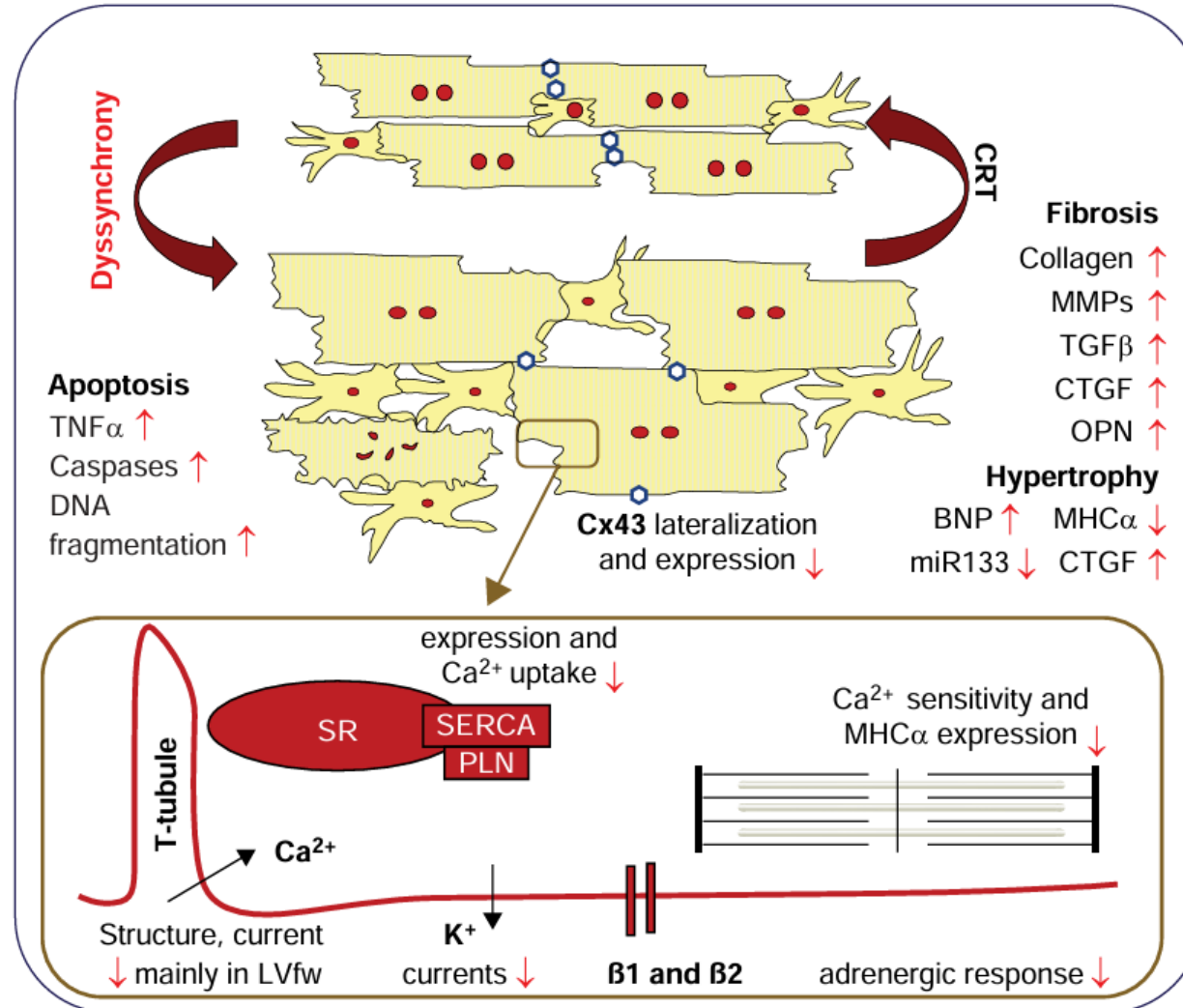




**Asynchronisme VG corrigé par la
resynchronisation cardiaque**

Asynchronisme et resynchronisation

Remodelage cellulaire et structurel



MUSTIC trial: 1ère étude randomisée

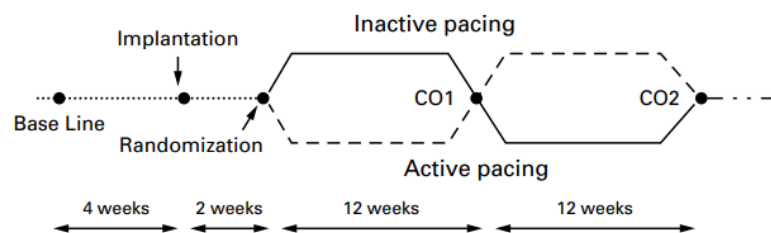
ORIGINAL ARTICLE

Effects of Multisite Biventricular Pacing in Patients with Heart Failure and Intraventricular Conduction Delay

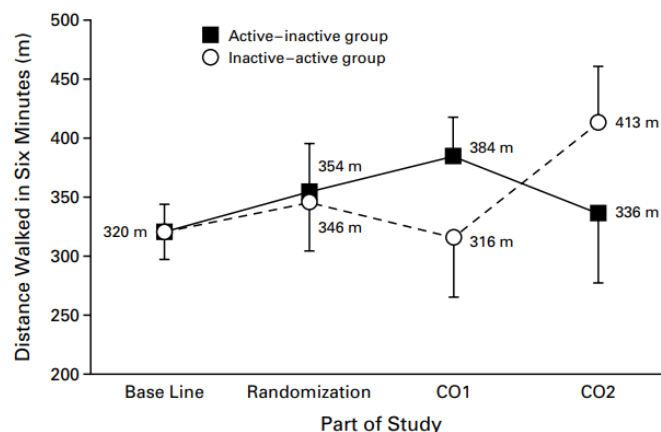
Serge Cazeau, M.D., Christophe Leclercq, M.D., Thomas Lavergne, M.D., Stuart Walker, M.D., Chetan Varma, M.D., Cecilia Linde, M.D., Stéphane Garrigue, M.D., Lukas Kappenberger, M.D., Guy A. Haywood, M.D., Massimo Santini, M.D., Christophe Bailleul, Ph.D., Philippe Mabo, M.D., *et al.*, for the Multisite Stimulation in Cardiomyopathies (MUSTIC) Study Investigators*

N Engl J Med 2001; 344:873-880

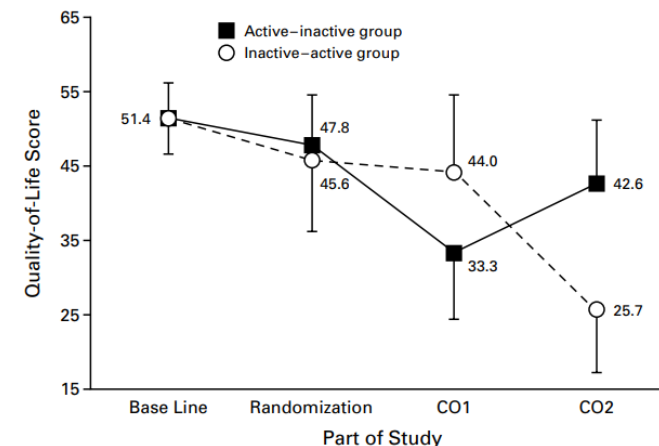
N = 67 patients



Study design



6 mn WT



QoL score

MUSTIC trial: 1ère étude randomisée

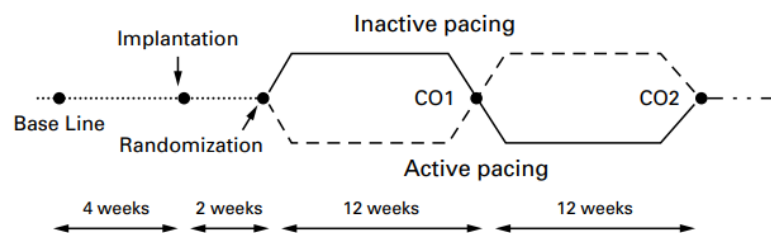
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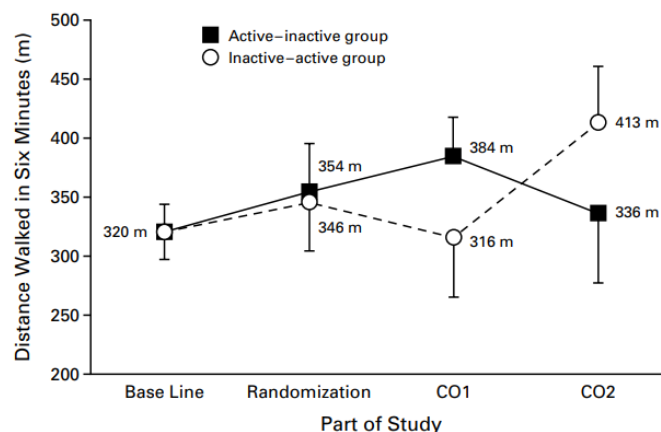
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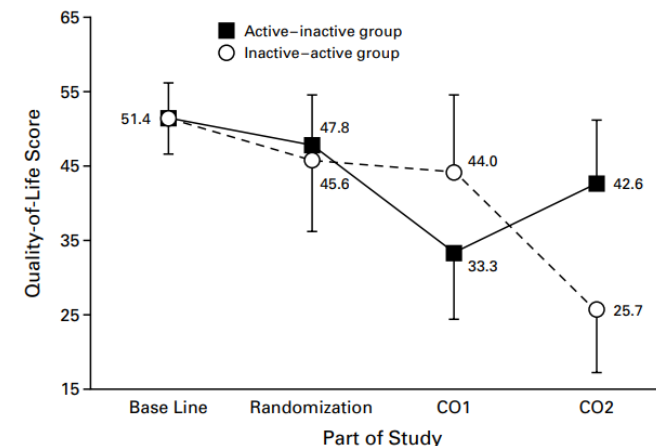
Durée de QRS ≥ 150 ms: pourquoi ?



Study design



6 mn WT



QoL score

MUSTIC trial: 1ère étude randomisée

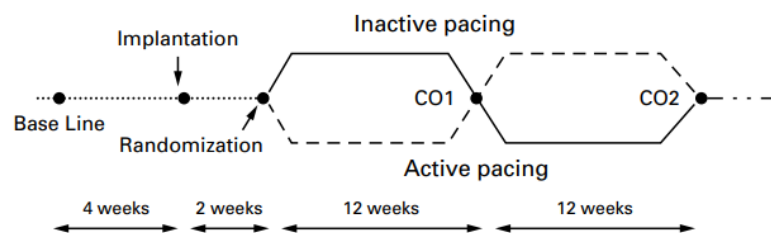
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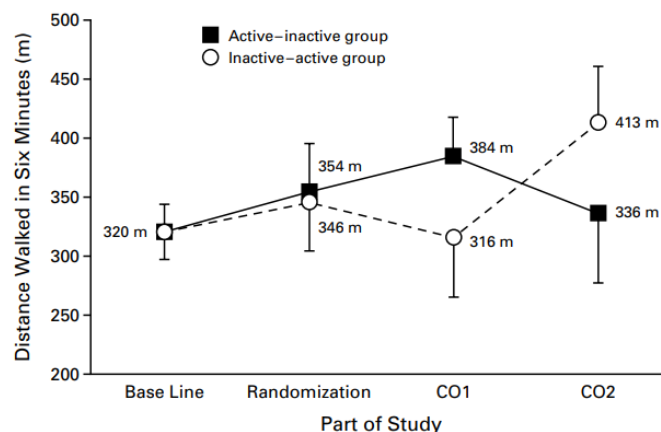
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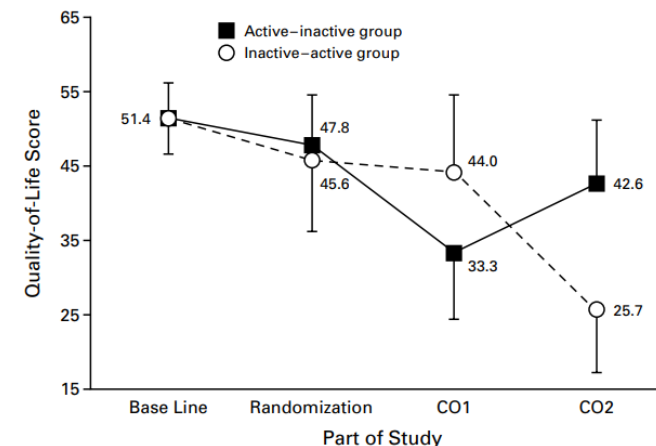
Discussions acharnées: de 120 à 180 ms... le compromis 150 ms !



Study design



6 mn WT



QoL score

MUSTIC trial: 1ère étude randomisée

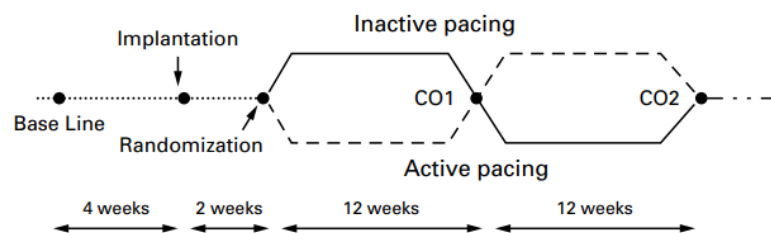
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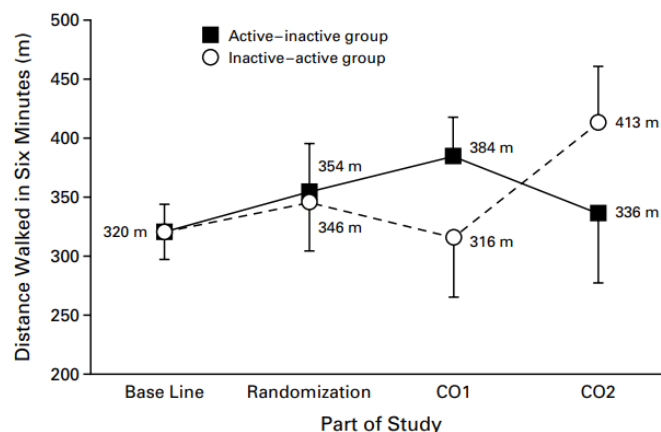
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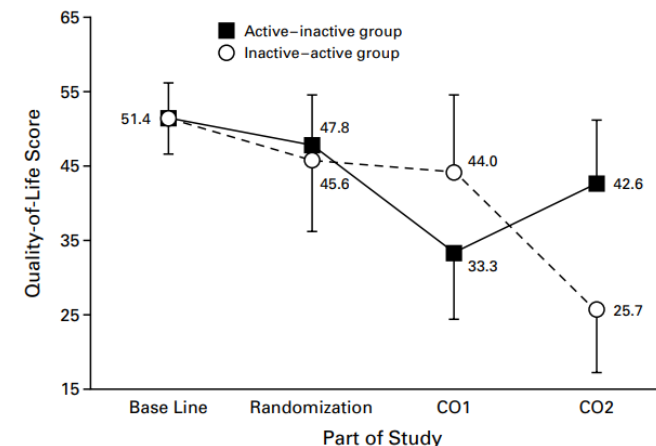
Quelle particularité pour cette étude ?



Study design



6 mn WT



QoL score

MUSTIC trial: 1ère étude randomisée

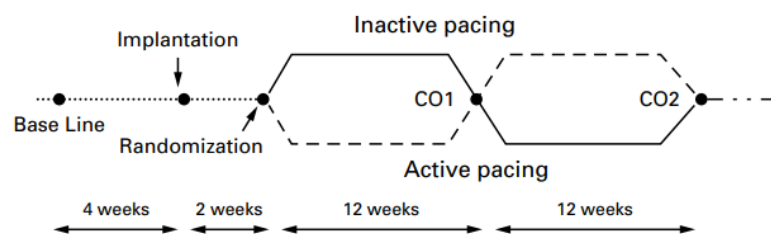
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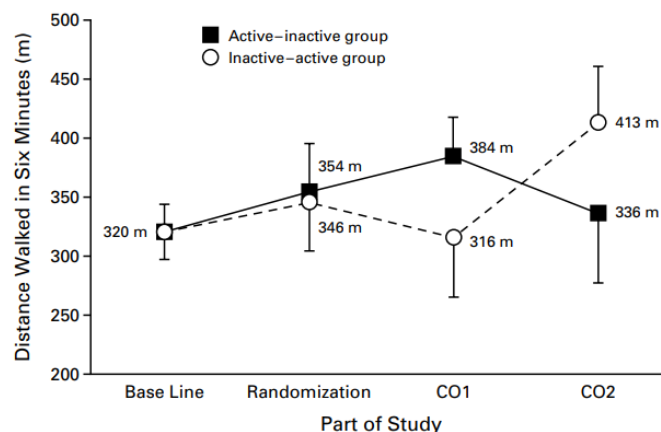
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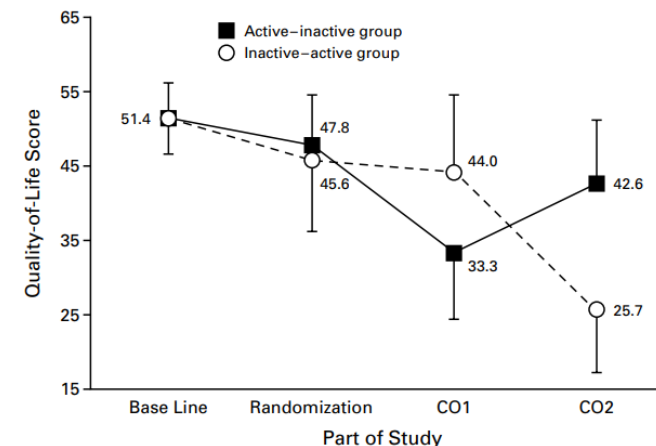
Deux « concurrents » associés: Ela Médical (le boîtier) et Medtronic (la sonde)



Study design



6 mn WT



QoL score

Une équipe médicale rennaise couronnée en Amérique Des électrodes pour aider le cœur

L'équipe de cardiologie du Centre hospitalier universitaire (CHU) de Rennes entre dans l'élite mondiale de la spécialité. Elle a mis au point un stimulateur du muscle cardiaque dont l'efficacité vient de lui valoir une publication dans le *New England Journal of medicine*, la revue de recherche médicale.

RENNES. – La stimulation multisisite biventriculaire: c'est la dernière invention de l'équipe conduite par le professeur Jean-Claude Daubert, responsable du département de cardiologie au centre hospitalier universitaire de Rennes. Mise à l'étude en 1994, cette technique a déjà été expérimentée sur 600 malades en France, dont 200 à Rennes. Elle ouvre de nouvelles perspectives pour les



Le Pr Jean-Claude Daubert, du CHU de Rennes, et le Dr Serge Cazeau, un ancien élève, ont mis au point un système qui met les cavités du cœur en synchrone.

Pour un breton, c'est mieux que le NEJM !

sonnes âgées, souligne Jean-Claude Daubert. Il y a dix ans, nous étions désarmés. A part la greffe, on ne pouvait rien faire pour elles.» Selon le cardiologue rennais, l'insuffisance cardiaque va devenir un vrai problème de santé publique. «Plus de 600 000 personnes sont touchées en France. C'est une pathologie qui coûte cher, la première cause d'hospitalisation pour les plus de 65 ans.»

A base d'électricité

Testée avec succès dans 16 centres européens, la technique *Mustic*, terme anglais qui désigne la stimulation multisisite biventriculaire, vient d'avoir les honneurs de la prestigieuse revue américaine *The New-England journal of mede-*

et Paris.

État amélioré pour 85 % des patients

«L'insuffisance cardiaque, c'est une pompe défaillante. Pour la réparer, nous avons eu une approche différente. C'est peut-être parce que nous sommes passionnés d'électricité et de mécanique.» Le système conçu à Rennes consiste en la pose, par voie veineuse et sous anesthésie locale, d'électrodes destinées à stimuler des zones bien précises du muscle cardiaque, dans l'oreillette et les deux ventricules. «Il s'agit de faire travailler les cellules au même pas. Les anomalies se traduisent par une baisse de puissance et des

Daubert et ses élèves ont décidé de lancer une étude de validation. Il leur a fallu encore deux ans pour réunir les fonds de recherche et lancer l'étude. Après une évaluation, portant sur 130 patients, les résultats sont considérés comme concluants, tant pour la qualité de vie que pour la tolérance à l'effort et le nombre d'hospitalisations, trois fois moins nombreuses. «85 % des patients disent que leur état s'est amélioré.»

Le moment est venu pour l'équipe rennaise, qui reste propriétaire des résultats, de trouver d'autres applications à la prothèse. On pense par exemple à un stimulateur capable de prévenir les morts cardiaques subites.

Alain THOMAS.

Puis MIRACLE...

The New England Journal of Medicine

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VOLUME 346

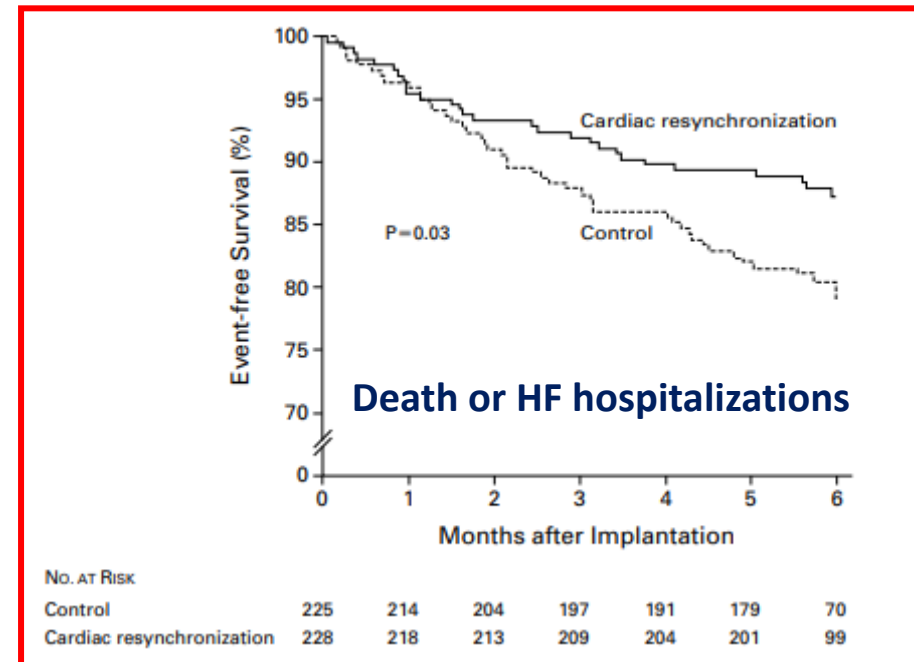
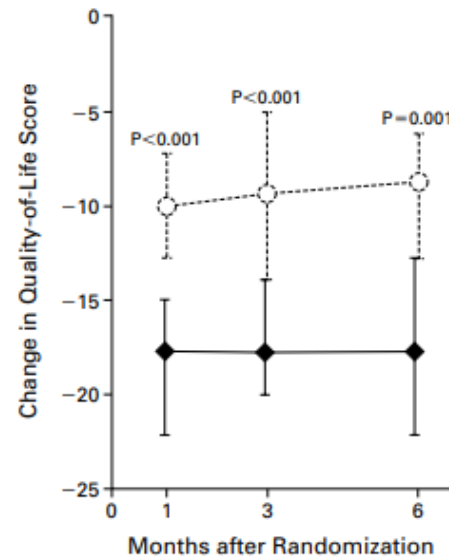
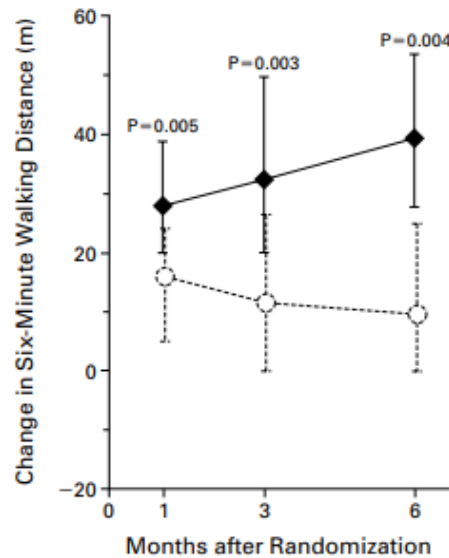
JUNE 13, 2002

NUMBER 24



CARDIAC RESYNCHRONIZATION IN CHRONIC HEART FAILURE

WILLIAM T. ABRAHAM, M.D., WESTBY G. FISHER, M.D., ANDREW L. SMITH, M.D., DAVID B. DELURGIO, M.D.,
ANGEL R. LEON, M.D., EVAN LOH, M.D., DUSAN Z. KOCOVIC, M.D., MILTON PACKER, M.D., ALFREDO L. CLAVELL, M.D.,
DAVID L. HAYES, M.D., MYRVIN ELLESTAD, M.D., AND JOHN MESSENGER, M.D., FOR THE MIRACLE STUDY GROUP*



No. AT RISK

Control	225	214	204	197	191	179	70
Cardiac resynchronization	228	218	213	209	204	201	99

Puis MIRACLE...

The New England Journal of Medicine

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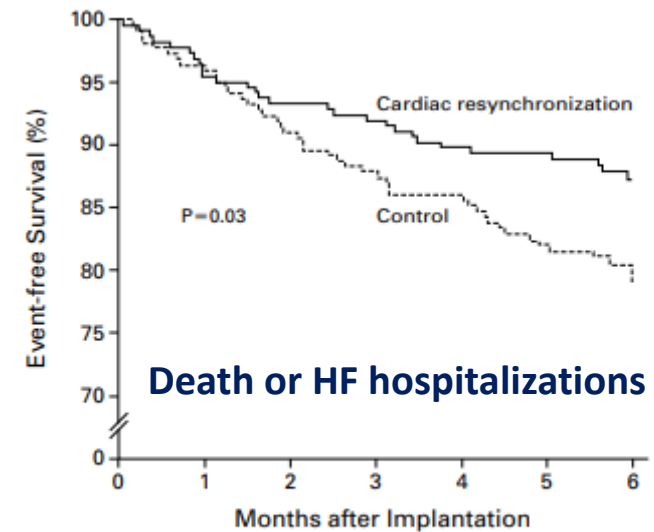
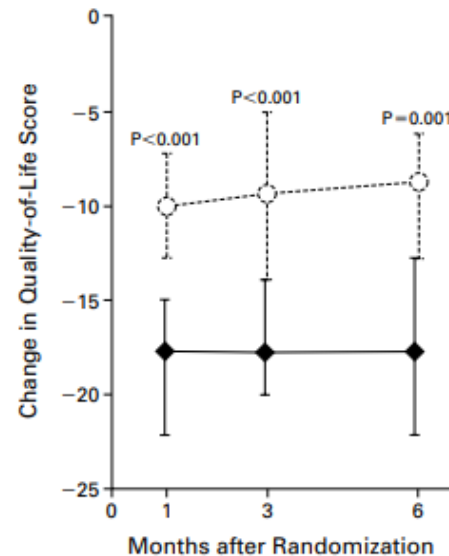
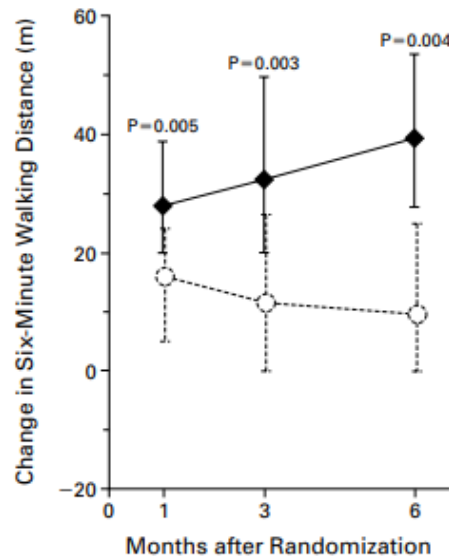
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Packer Clinical Composite Score
mPCCS
Cardiac death
HF hospitalization
NYHA class
QoL MLHFQ



No. AT RISK

Control	225	214	204	197	191	179	70
Cardiac resynchronization	228	218	213	209	204	201	99

Trial	Patients	NYHA class	LVEF(%)	LVEDD (mm)	SR/AF	QRS (ms)	ICD
PATH CHF	41	III,IV	≤35%	Not specified	SR	≥120	No
MUSTIC-SR	58	III	≤35%	≥60	SR	≥150	No
MIRACLE	453	III,IV	≤35%	≥55	SR	≥130	No
MUSTIC AF	43	III	≤35%	≥60	AF	≥200	No
MIRACLE ICD	369	III,IV	≤35%	≥55	SR	≥130	Yes
CONTAK CD							Yes
MIRACLE ICD II							Yes
PATH CHF II	89	III,IV	≤35%	Not specified	SR	≥120	Yes/No
COMPANION	1520	III,IV	≤35%	Not specified	SR	≥120	Yes/No
CARE HF	814				SR	≥120 & Dys	No
RethinQ	172				SR	≤130 & Dys	Yes
REVERSE	610	I,II	≤40%	≥55	SR	≥120	Yes/No
MADIT CRT	1800	I,II	≤30%	Not specified	SR	≥130 ms	Yes
RAFT	1800	II,III	≤30%	>60	SR/AF	≥130; ≥200 *	Yes
BLOCK-HF	691	I,II,III	≤50%	Not specified	SR/AF	Any	Yes/No
Echo-CRT	821	III,IV	≤35%	Not specified	SR	≤130 & Dys	Yes
BLOCK-HF	791	I-III	≤50%	Not specified	SR / AF	No criteria	Yes/ no
BIOPACE	1810	No	Not SPecified	Not specified	SR / AF	No criteria	No
More CRT MPP	5850	II-III	≤35%	Not specified	SR	≥130 ms	Yes no
AdaptResponse	3620	II-III	≤35%	NOT SPECIFIED	SR	≥130/140 ms	Yes

Puis toutes les autres études randomisées

25000 patients inclus

Stimulation bi-ventriculaire: études pivots

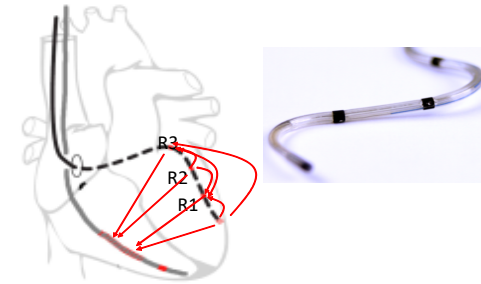
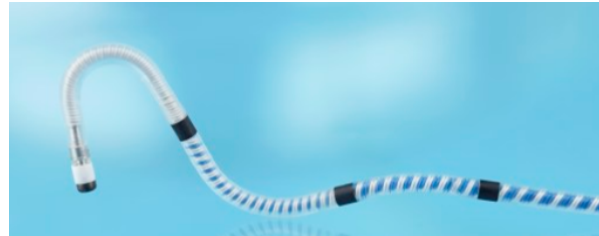
Trial	Year	Patients, n	NYHA class	QRS, ms	Comparison	Recommended OMT	Primary end points(s)	Main results of primary end primary end point(s)
MUSTIC	2001	67	III	≥150	CRT ON + OMT vs CRT OFF + OMT	D + ACEi	6minWD—QoL	Mean change, +23% WD; QoL score, -32%
MIRACLE	2002	453	III-IV	≥130	CRT-D + OMT vs OMT	D + ACEi/ARB + BB	NYHA class—6minWD—QoL	Mean change, +29m WD; QoL score, -9 pts
COMPANION	2004	1520	III-IV	>120	CRT-D + OMT vs OMT; CRT-P + OMT vs OMT	D + ACEi/ARB + BB	Hosp. any cause or death any cause - 20%	CRT-P: HR, 0.81 (95% CI, 0.69-0.96); CRT-D: HR, 0.80 (95% CI, 0.68-0.95)
CARE-HF	2005	813	III	≥150	CRT-P + OMT vs OMT	D + ACEi/ARB + BB	Death any cause or HF hosp. - 37%	HR, 0.63 (95% CI, 0.51-0.77)
REVERSE	2008	610	II	≥150	CRT ON + OMT vs CRT OFF + OMT	D + ACEi/ARB + BB	LV remodeling: LV end systolic volume	Mean change, -18 mL/m ²
MADIT-CRT	2009	1820	I-II	≥150	CRT-D + OMT vs ICD + OMT	D + ACEi/ARB + BB + MRA	Death any cause or HF event - 34%	HR, 0.66 (95% CI, 0.52-0.84)
RAFT	2010	1798	II-III	≥120	CRT-D + OMT vs ICD + OMT	D + ACEi/ARB + BB + MRA	Death any cause or HF hosp. - 25%	HR, 0.75 (95% CI, 0.64-0.87)

Stimulation bi-ventriculaire: études pivots

Trial	Year	Patients, n	NYHA class	QRS, ms	Comparison	Recommended OMT	Primary end points(s)	Main results of primary end primary end point(s)
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COMPANION	Réduction de la mortalité et de la morbidité validée							
CARE-HF	2005	813	III	≥150	CRT-P + OMT vs OMT	D + ACEi/ARB + BB	Death any cause or HF hosp.	HR, 0.63 (95% CI, 0.51-0.77)
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Depuis 25 ans, des avancées technologiques

- Sondes/gaines



- Prothèses

Connectique

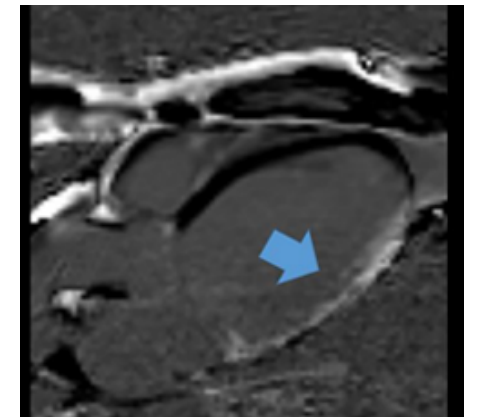
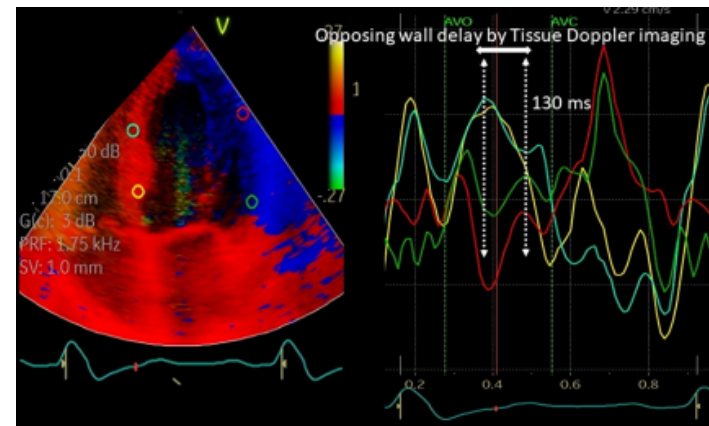
Algorithmes/capteurs

Longévité

Télésuivi





- Outils d'imagerie

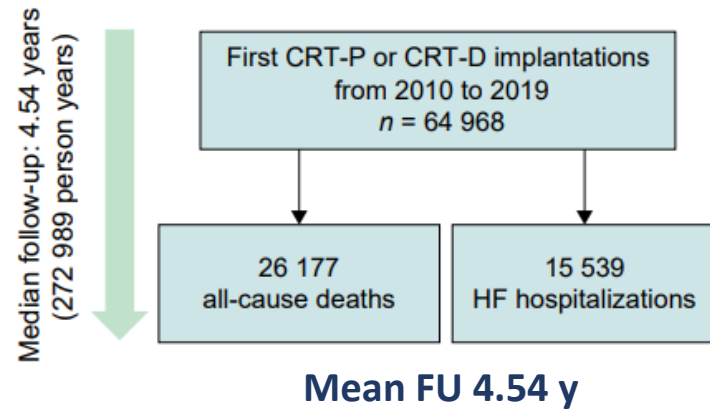


Improved prognosis after cardiac resynchronization therapy over a decade

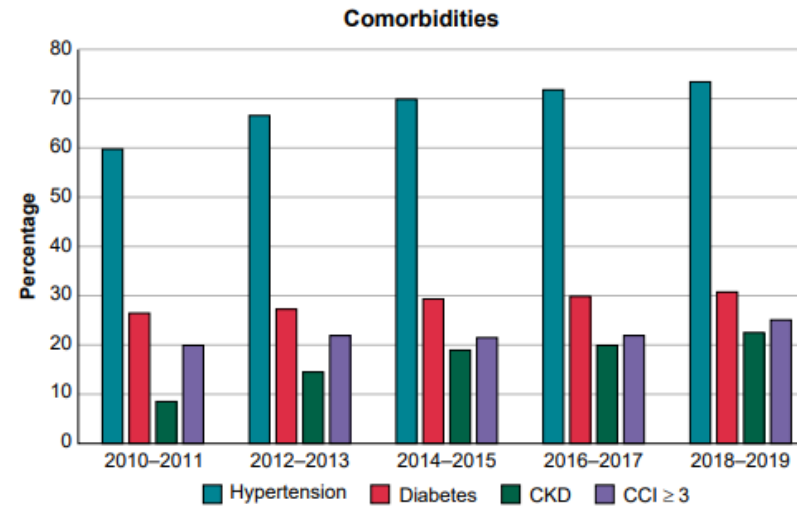
Europace 2023; 25: 1–110

Francisco Leyva ^{1*}, Abbasin Zegard ^{1,2}, Peysh Patel², Berthold Stegemann ^{1,2}, Howard Marshall ², Peter Ludman ², Joseph de Bono ², Giuseppe Boriani ³, and Tian Qiu²

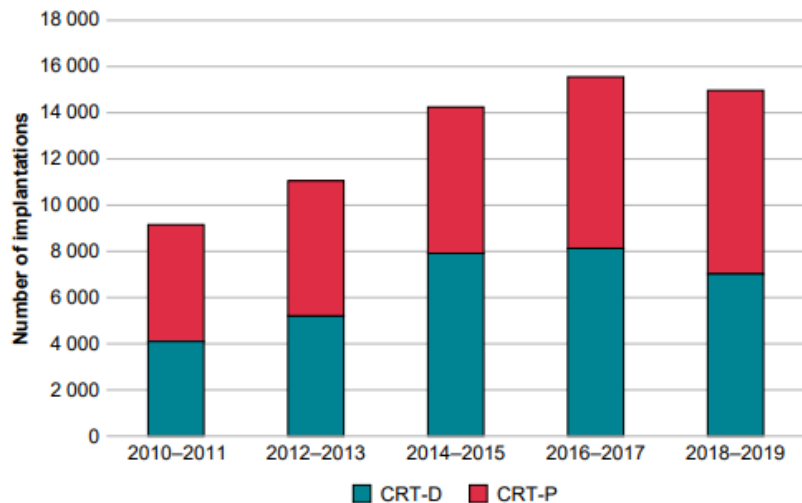
Study population



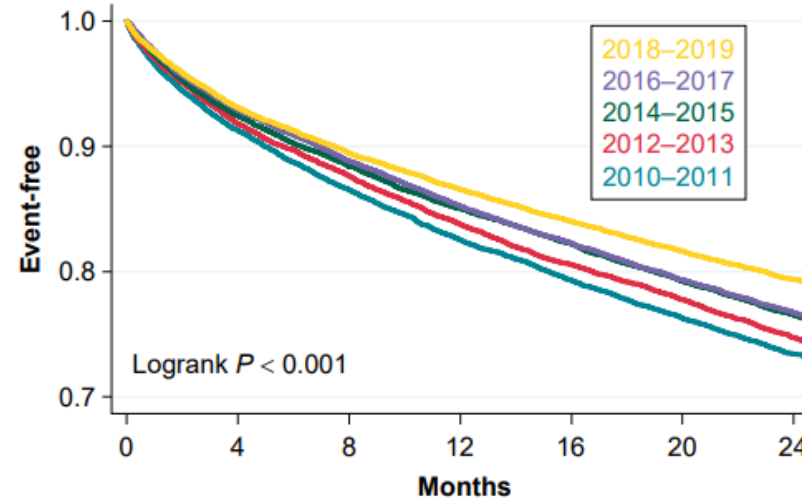
Temporal trends



CRT implantations

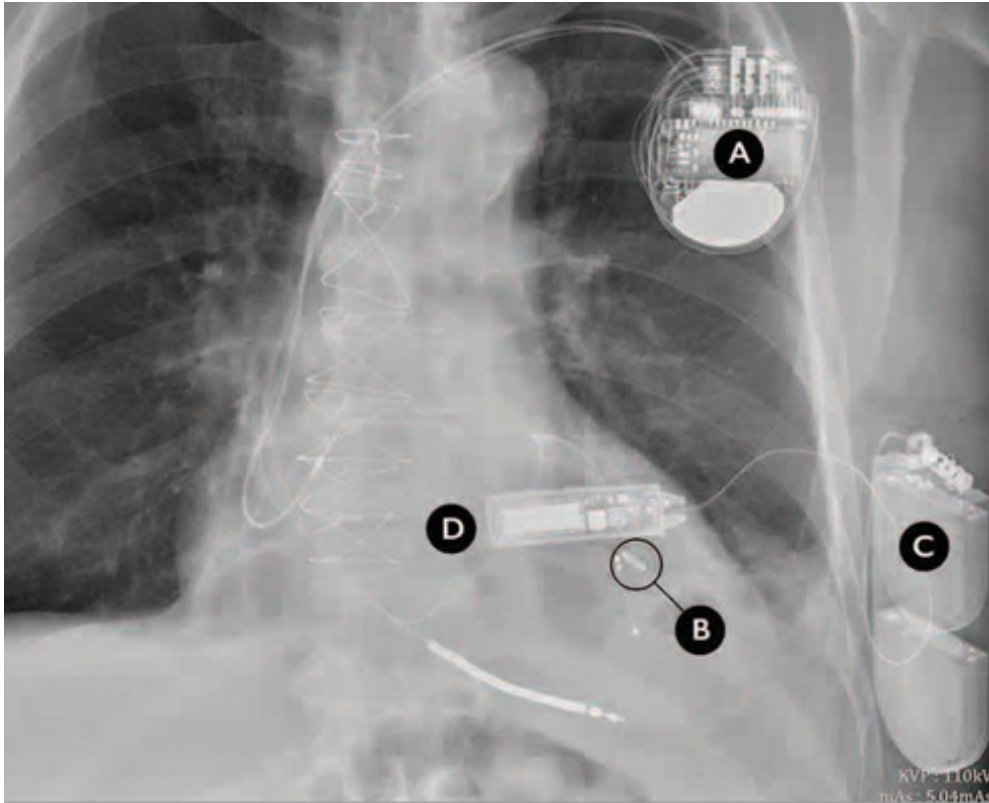


Total mortality or HF hospitalization



La stimulation bi-ventriculaire par ultrasons

Système WISE (EBR systems)



A: défibrillateur automatique + sonde VD
B: capsule intra VG, C: transducteur US, D: générateur

Etude SOLVE-CRT

183 patients (échec sonde SC, ou déjà implantés)

Echecs implantation: 2,7%

Dysfonctionnements: n = 12

Suivi à 6 mois

Réduction du VTSVG de 9,3 %

%age augmentation FEVG: + 5,2 %

Classe NYHA: patients améliorés 55 %

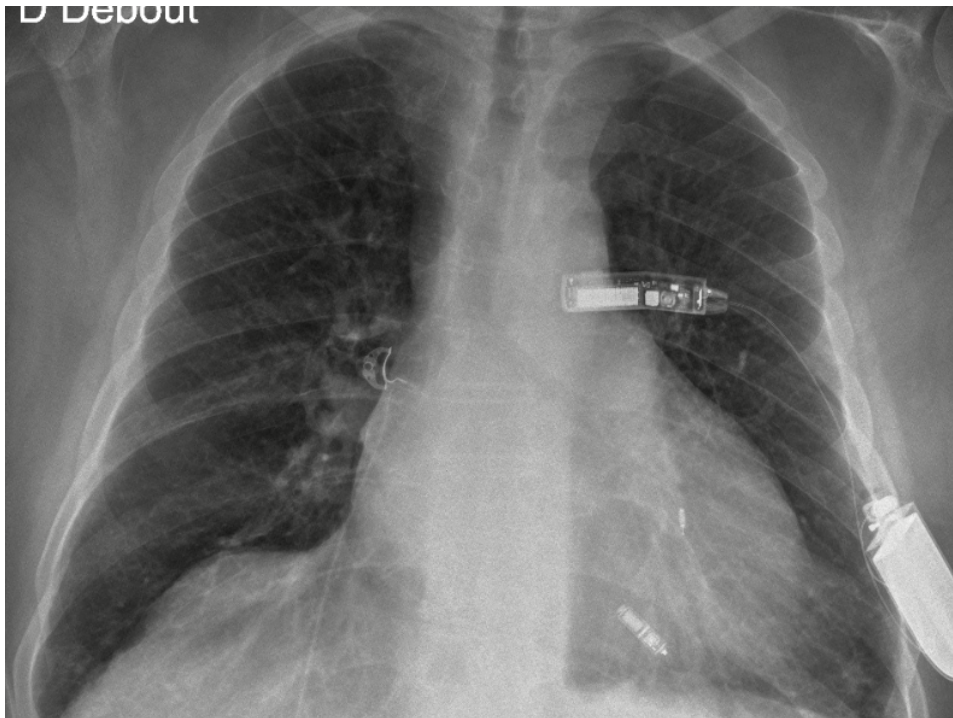
patients stabilisés 41 %

patients aggravés 4 %

La stimulation BiV sans sonde intracardiaque

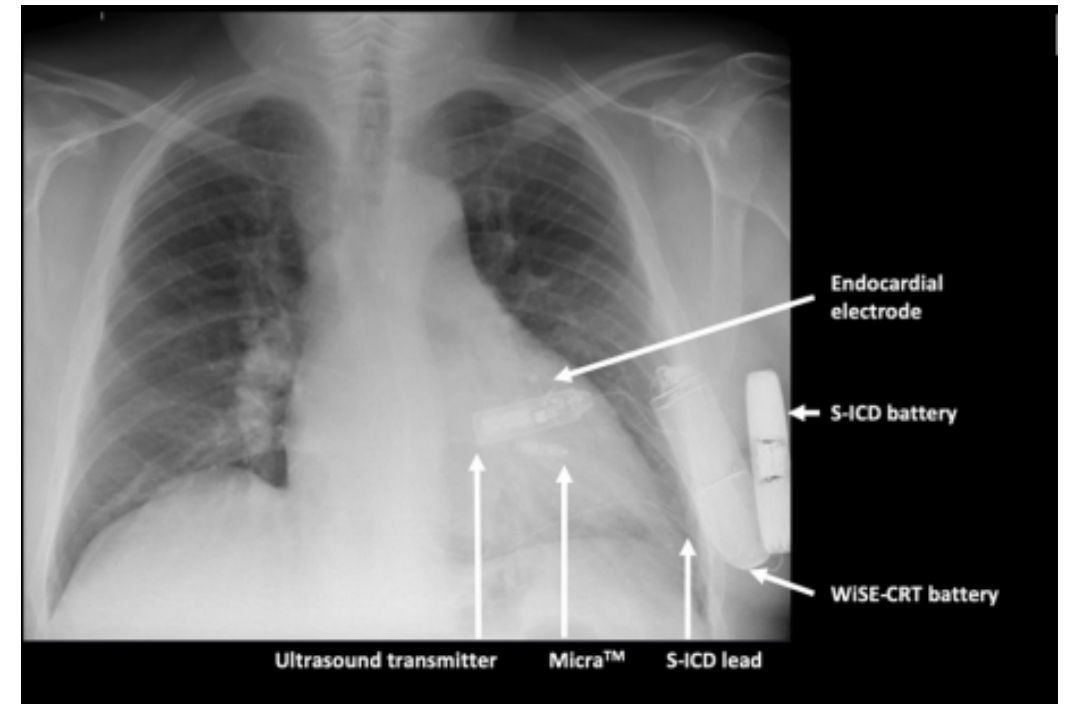
Une niche aujourd'hui, des espoirs pour demain...

CRT-P



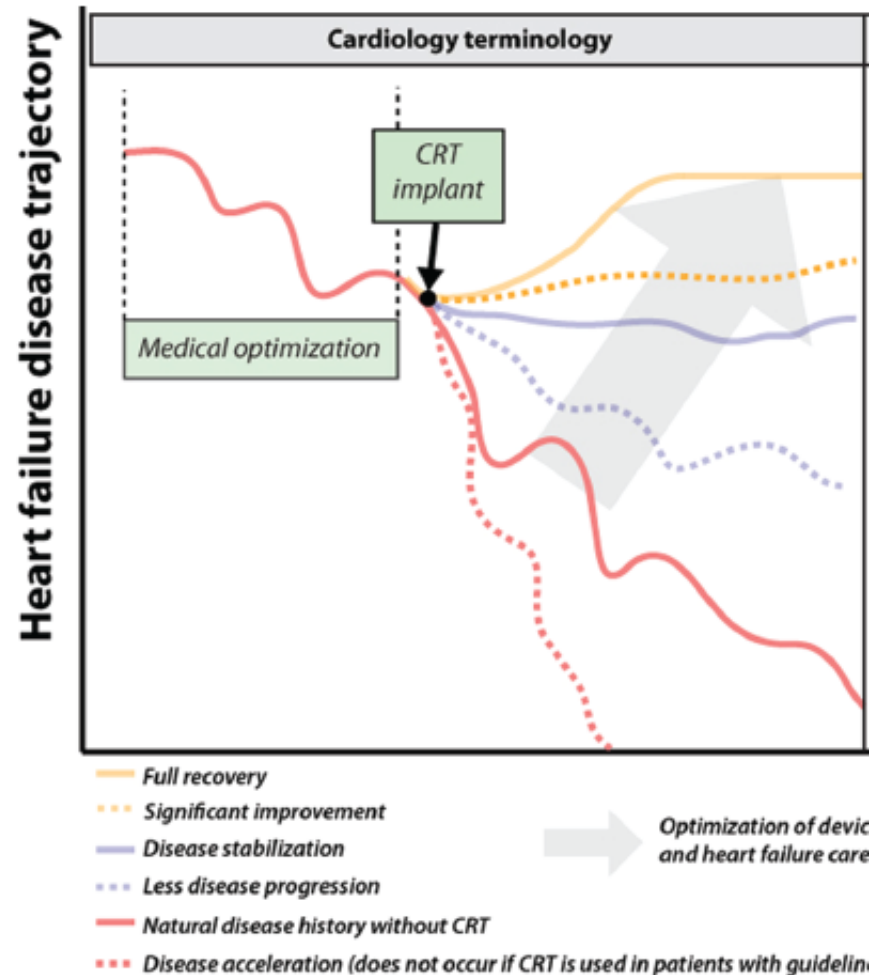
V Galand, Eur Heart J 2019

CRT-D



BS Sidhu, JACC Clinical EP 2020

Depuis 25 ans, un caillou dans la chaussure: les « non répondeurs »

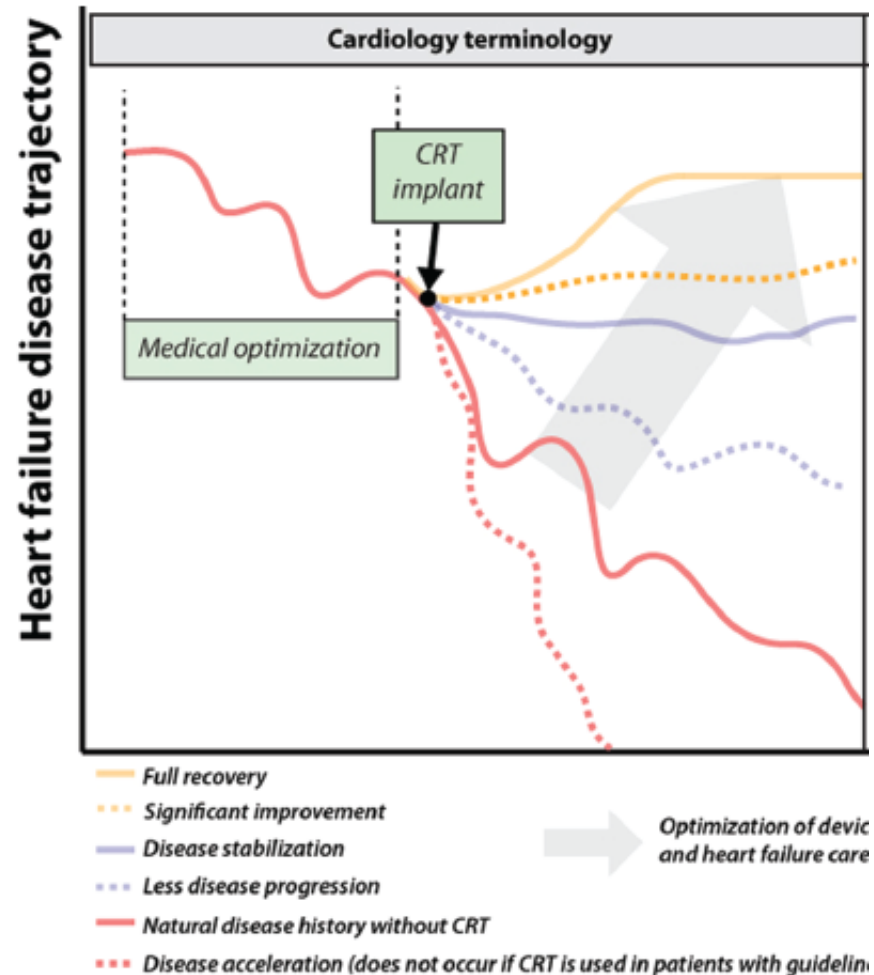


Une approche « idéaliste » du résultat

Répondeurs :
Uniquement les patients améliorés
70 → 80 %

Non répondeurs:
Tous les autres
20 → 30 %

Depuis 25 ans, un caillou dans la chaussure: les « non répondeurs »



Une approche « idéaliste » du résultat

Répondeurs :
Uniquement les patients améliorés
70 → 80 %

Non répondeurs:
Tous les autres
20 → 30%

Comment faire mieux ?

Mieux sélectionner les patients

L'activation électrique: ECG, cartographie

L'activation mécanique: échocardiographie, IRM

La fibrose: IRM

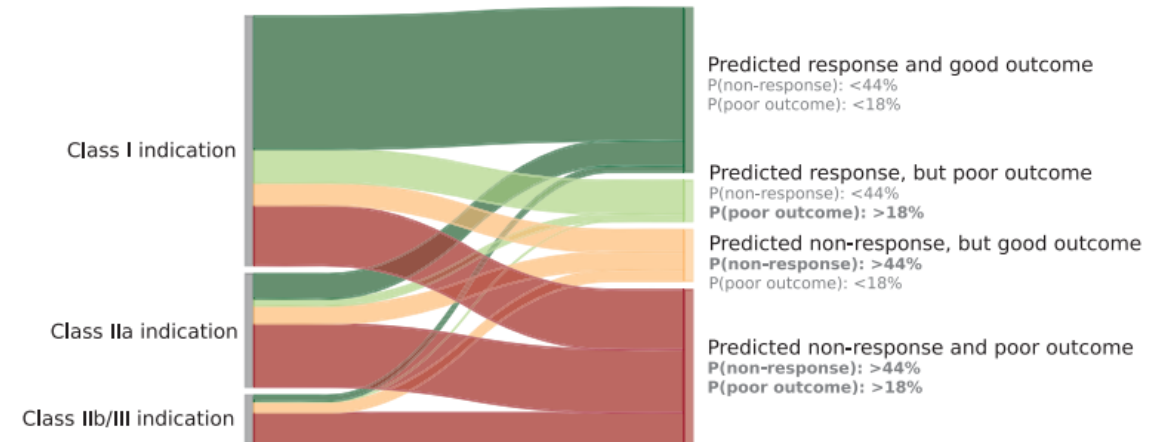
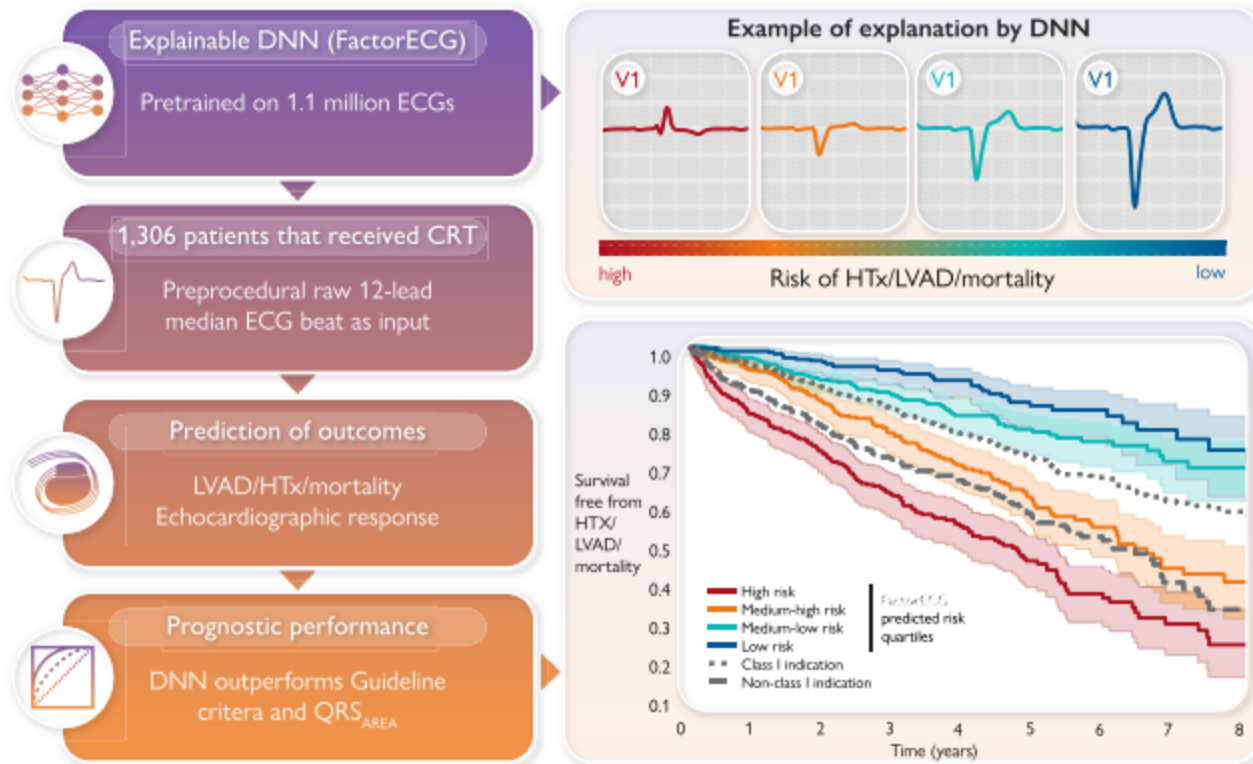
La cardiopathie

Les comorbidités

...

Electrocardiogram-based deep learning improves outcome prediction following cardiac resynchronization therapy

Philippe C. Wouters ^{1*}, Rutger R. van de Leur ^{1†}, Melle B. Vessies ¹, Antonius M.W. van Stipdonk ², Mohammed A. Ghossein ³, Rutger J. Hassink ¹, Pieter A. Doevendans ^{1,4}, Pim van der Harst ¹, Alexander H. Maass ⁵, Frits W. Prinzen ³, Kevin Vernooij ², Mathias Meine ¹, and René van Es ¹



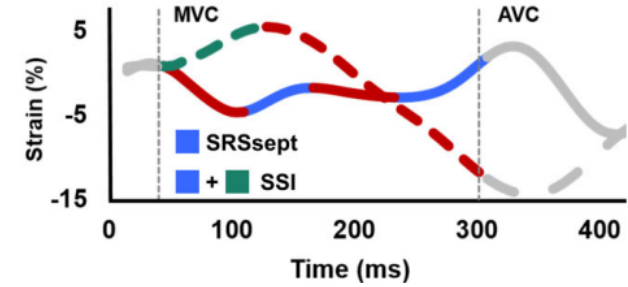
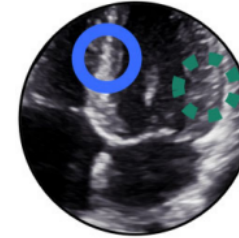
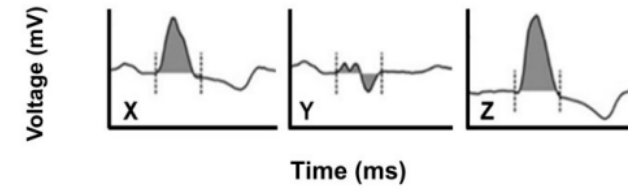
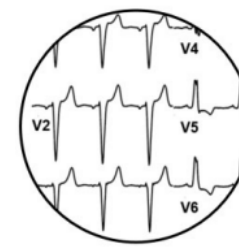
Reclassification flow from current guideline indications to a combination of predicted outcome and response using the FactorECG

- ECG factors predictors for poor outcome:**
- inferolateral T-wave inversion
 - smaller right precordial S - T-wave amplitude
 - ventricular rate - increased PR interval
 - P-wave duration

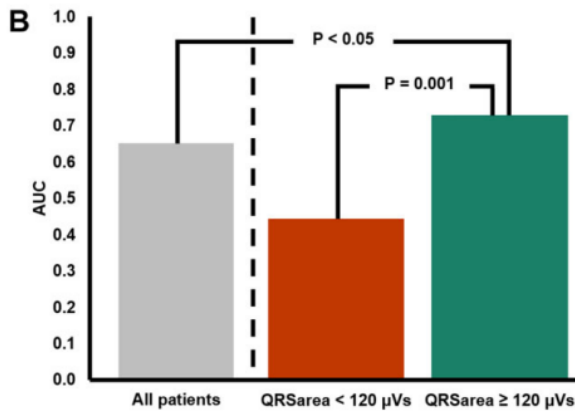
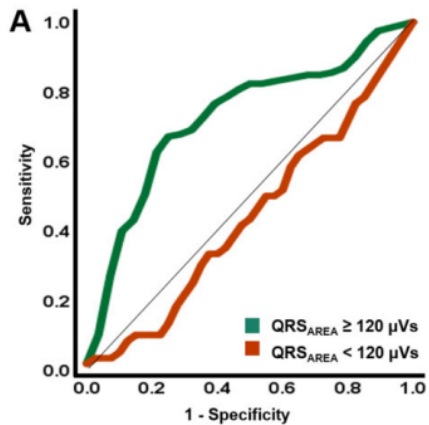
DNN: Deep Neural Network

Does mechanical dyssynchrony in addition to QRS area ensure sustained response to cardiac resynchronization therapy?

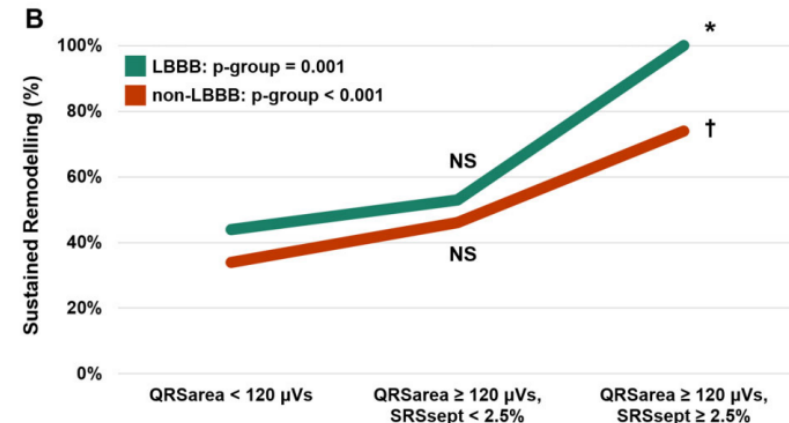
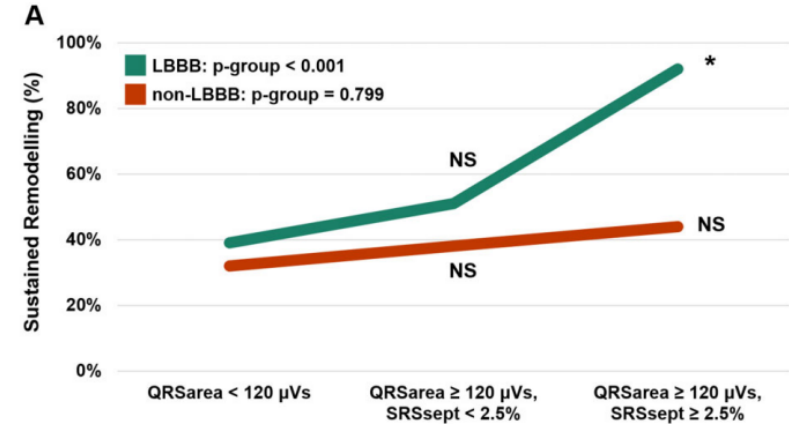
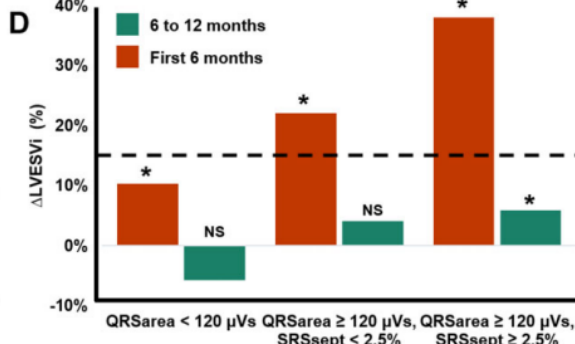
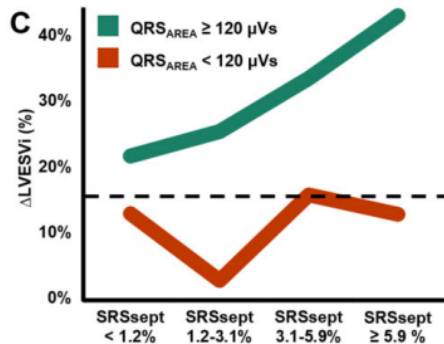
Philippe C. Wouters ^{1*}, Wouter M. van Everdingen ¹, Kevin Vernoooy ^{2,3}, Bastiaan Geelhoed ⁴, Cornelis P. Allaart ⁵, Michiel Rienstra ⁴, Alexander H. Maass ⁴, Marc A. Vos ⁶, Frits W. Prinzen ⁷, Mathias Meine ¹, and Maarten J. Cramer ¹



Electrical substrate influences the association between SRSsept and response





N = 240 pts
 Mean age: 66 y
 Mean QRS: 180 ms
 ICM: 42%
 LVESVi : - 22± 24%

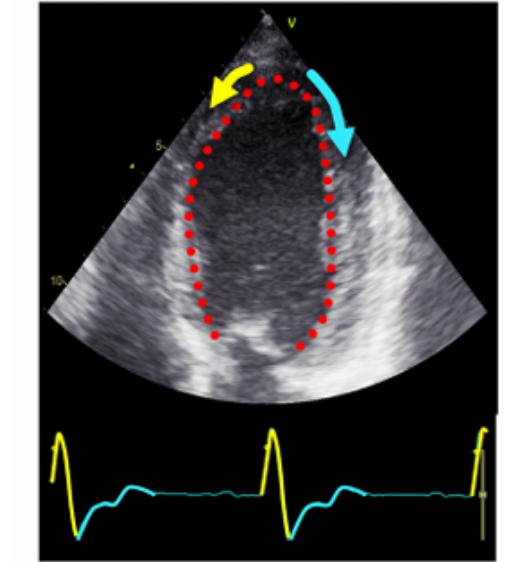
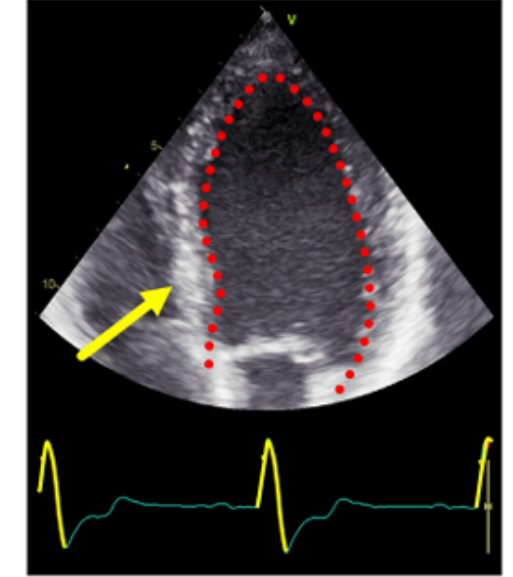
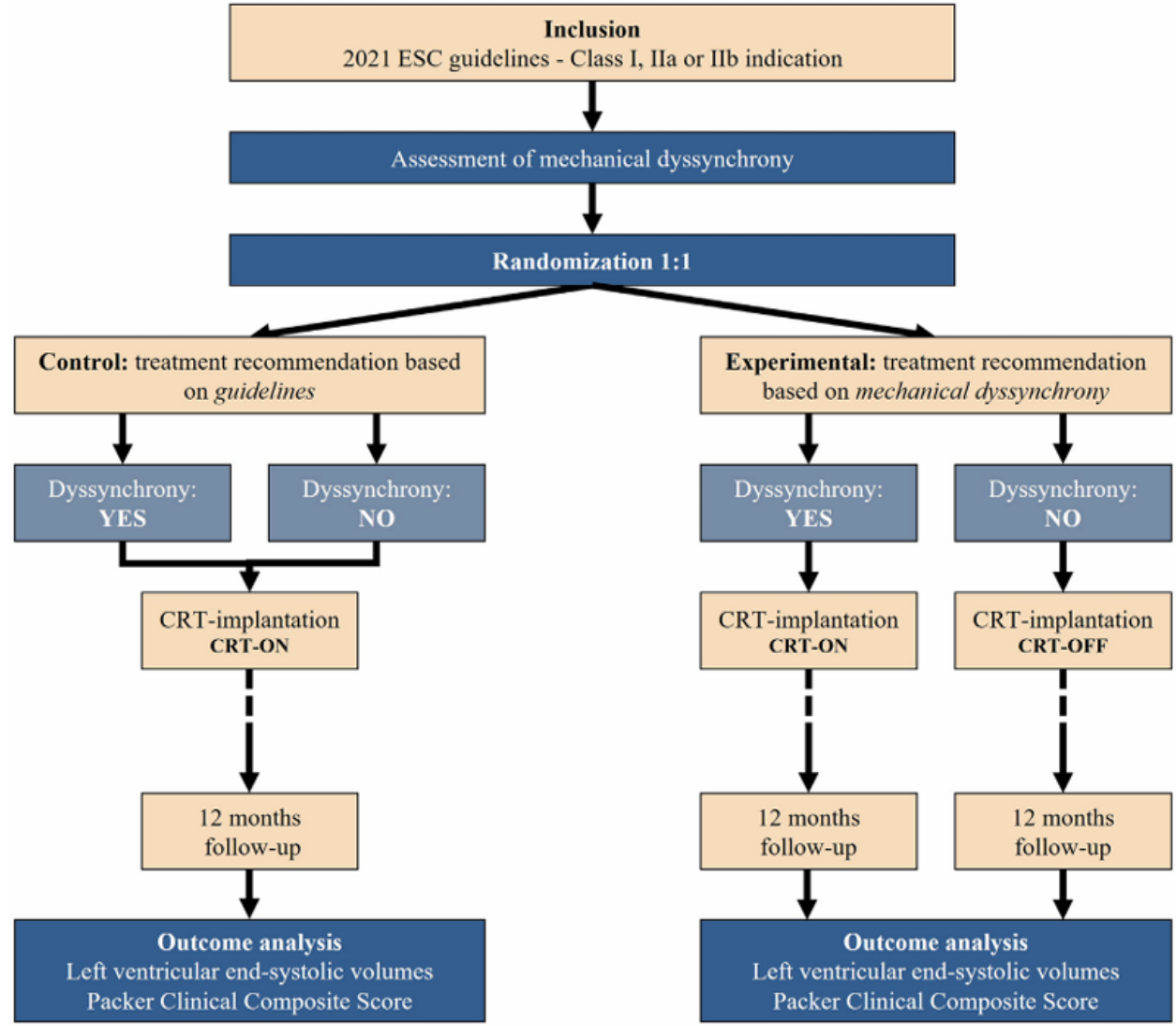


SRSsept: systolic rebound stretch of the septum – SSI: systolic stretch index

Mechanical dyssynchrony as a selection criterion for cardiac resynchronization therapy: Design of the AMEND-CRT trial

Alexis Puvrez^{1,2} , Jürgen Duchenne^{1,2}, Erwan Donal^{3,4}, John Gorcsan III⁵, Hitesh C. Patel^{6,7,8}, Thomas H. Marwick⁸, Otto A. Smiseth⁹, Peter Søgaard^{10,11}, Ivan Stankovic^{12,13}, Pedro G. Diogo^{1,2}, Gábor Vörös^{1,2} and Jens-Uwe Voigt^{1,2*} 

ESC Heart Failure 2024; 11: 4390–4399

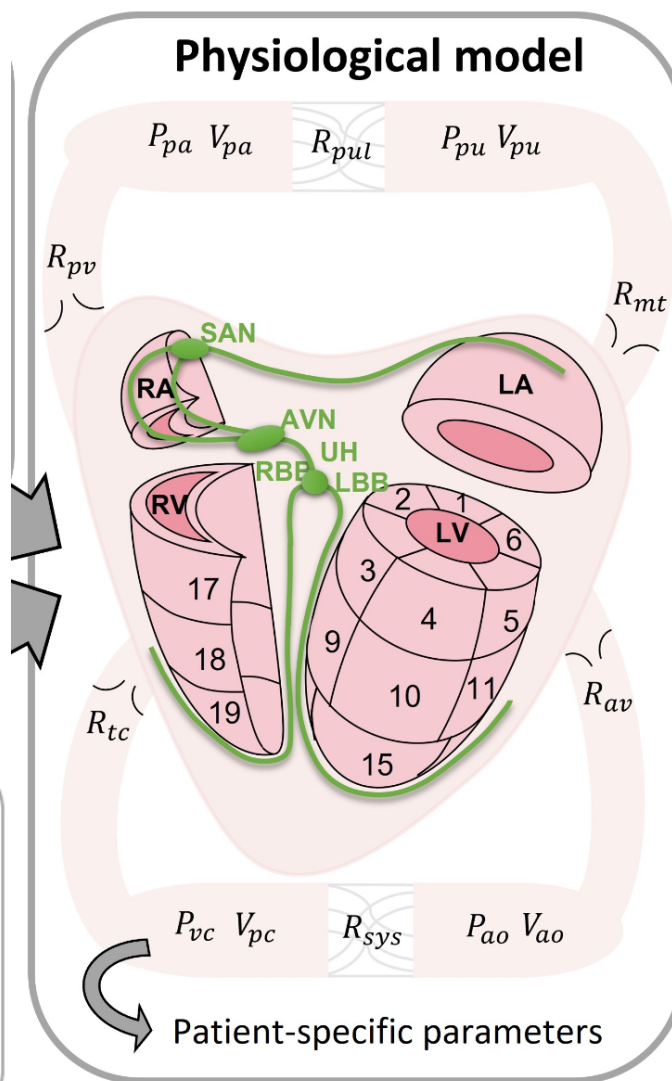
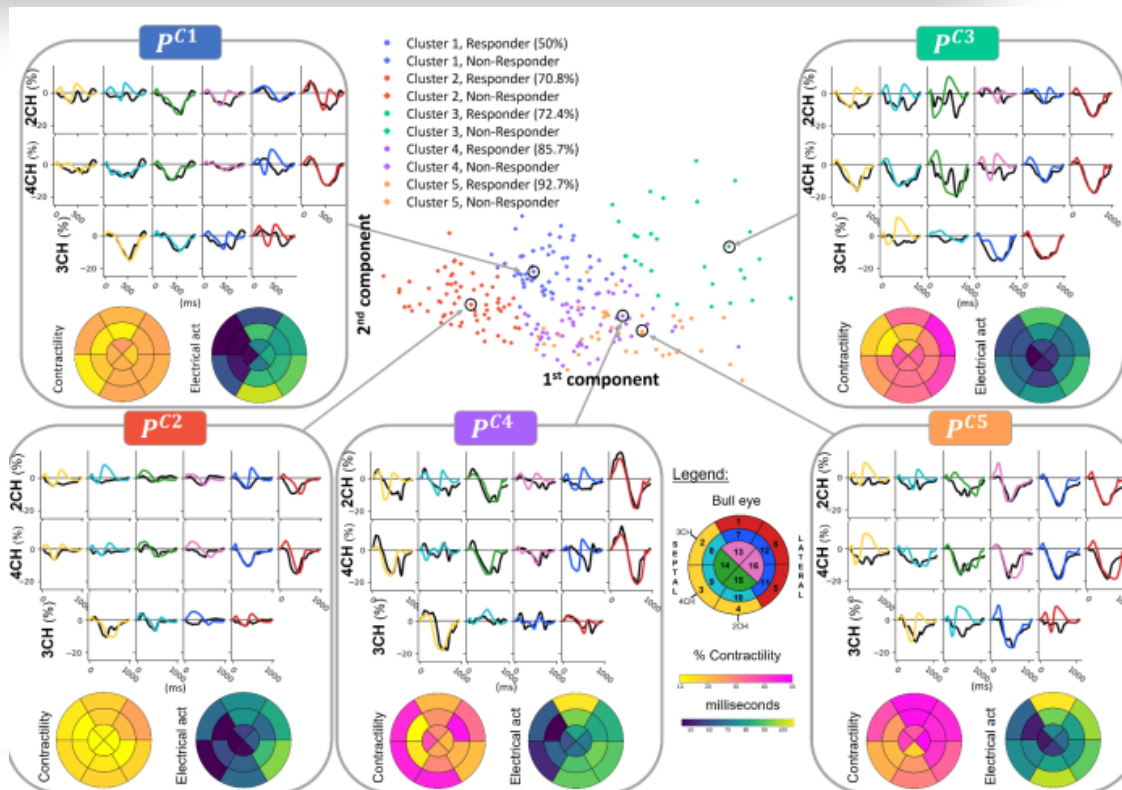
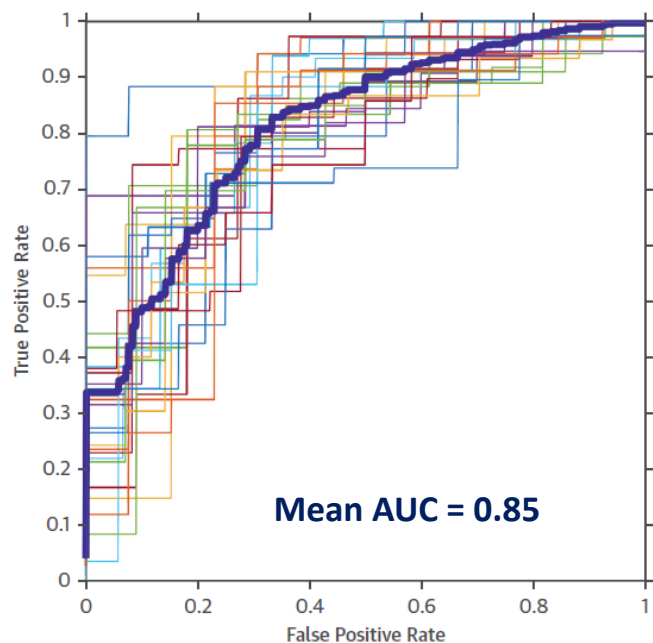


IA et jumeaux numériques, la voie est ouverte...

Objective: To estimate responders to CRT using ECG and Strain signals obtained from echocardiography.

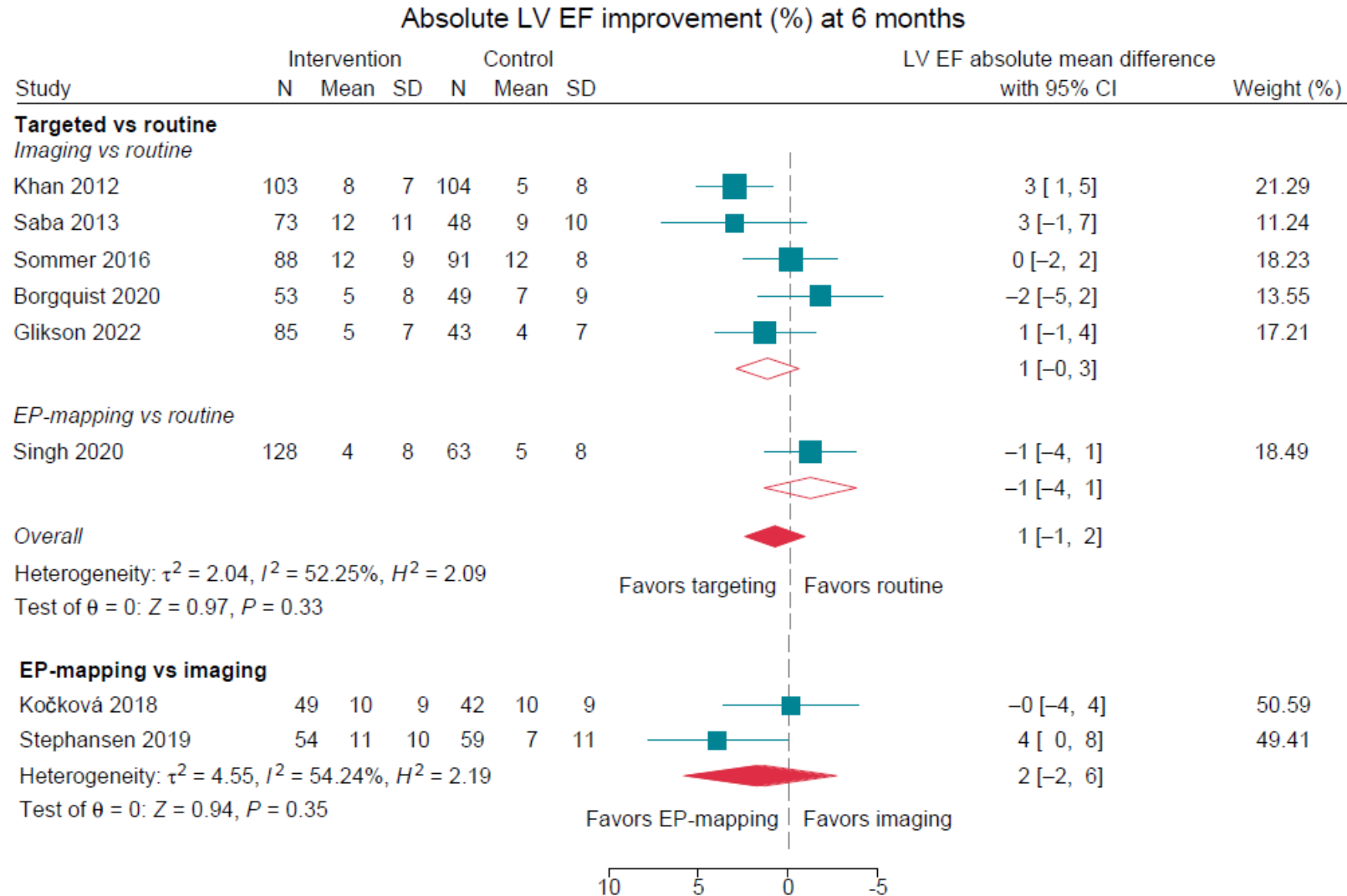
Hypothesis: Combining information from electrophysiology and cardiac mechanics. Exploiting the dynamics and waveform of strain signals

Data: International cohort PI: E. Donal



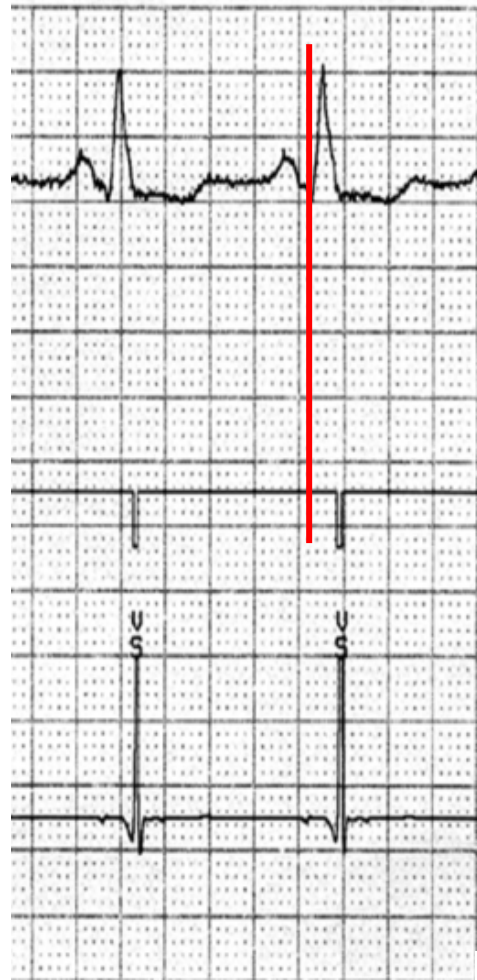
Mieux positionner les sondes

Des outils d'optimisation: imagerie, cartographie ?

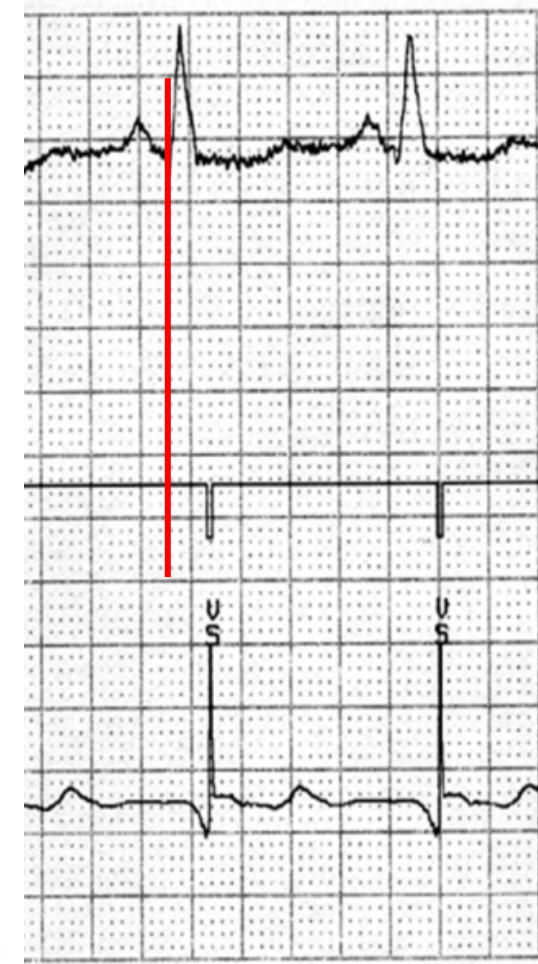
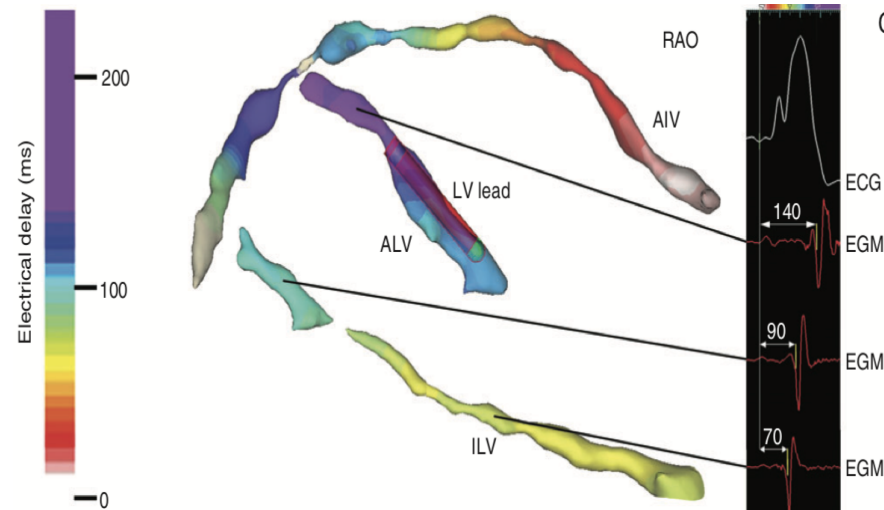


Retour aux sources !

Détection la plus tardive dans le réseau veineux coronaire



90 ms

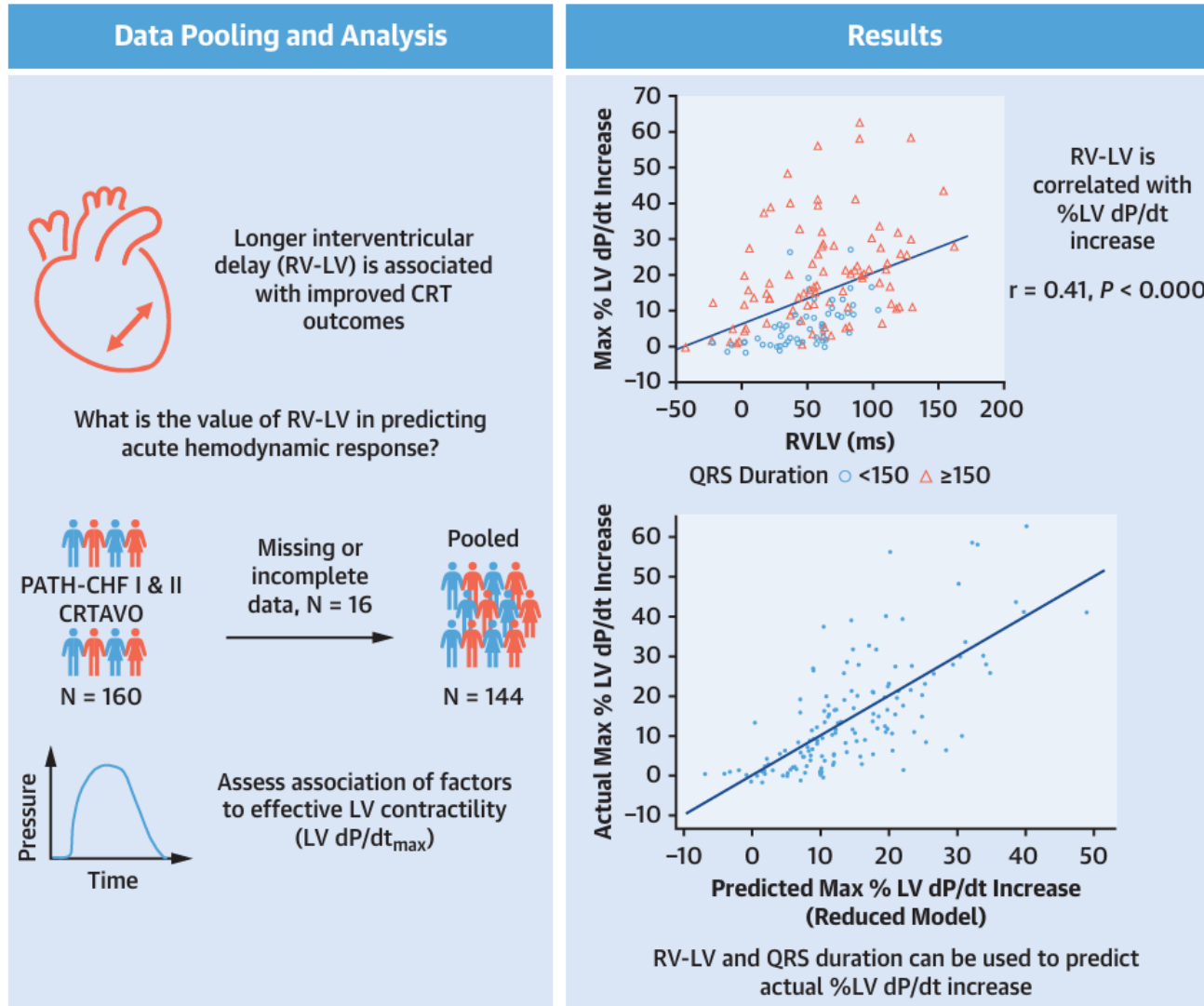


150 ms



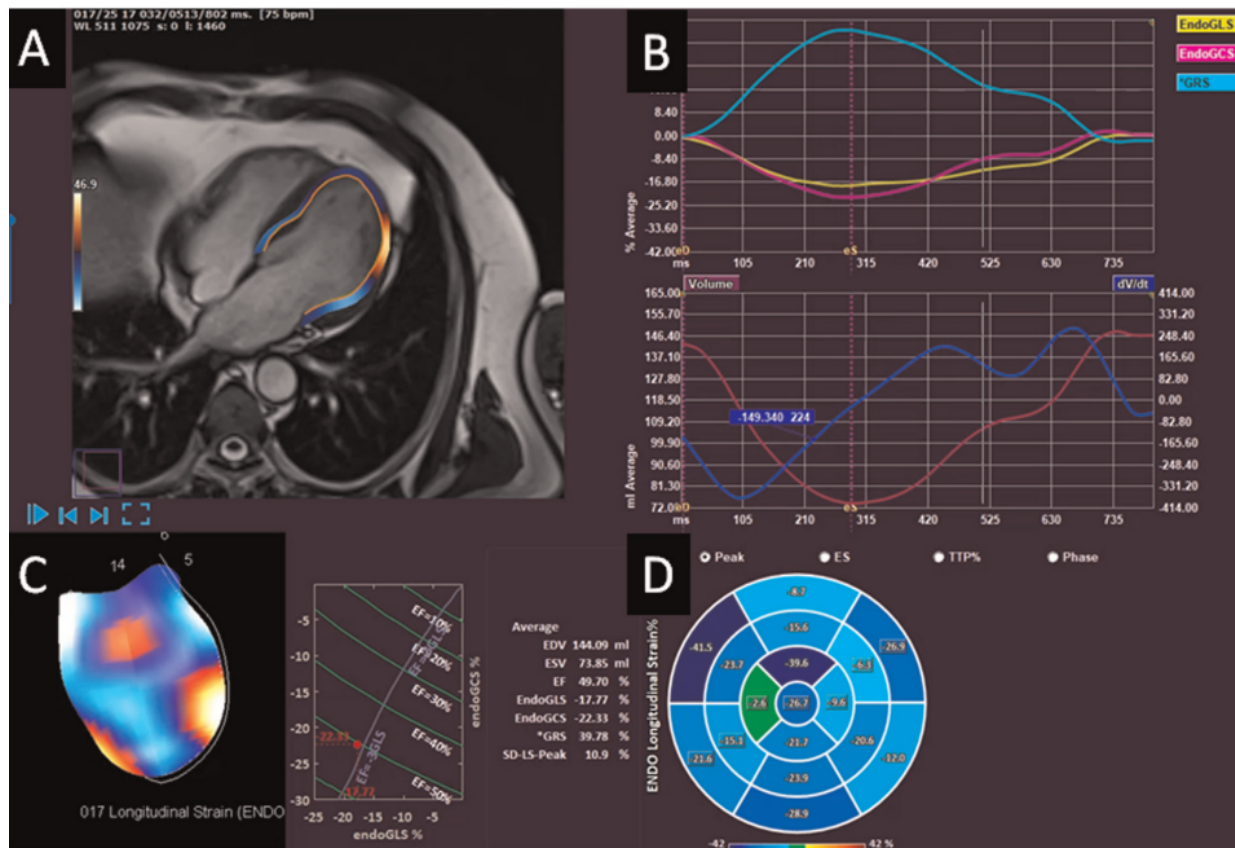
The Association of Electrical Delay on Hemodynamic Response With Cardiac Resynchronization Therapy

Angelo Auricchio, MD, PhD,^a Kris Siejko, MS,^b Nicholas Wold, MS,^b Yinghong Yu, MS,^b Michael R. Gold, MD, PhD^c

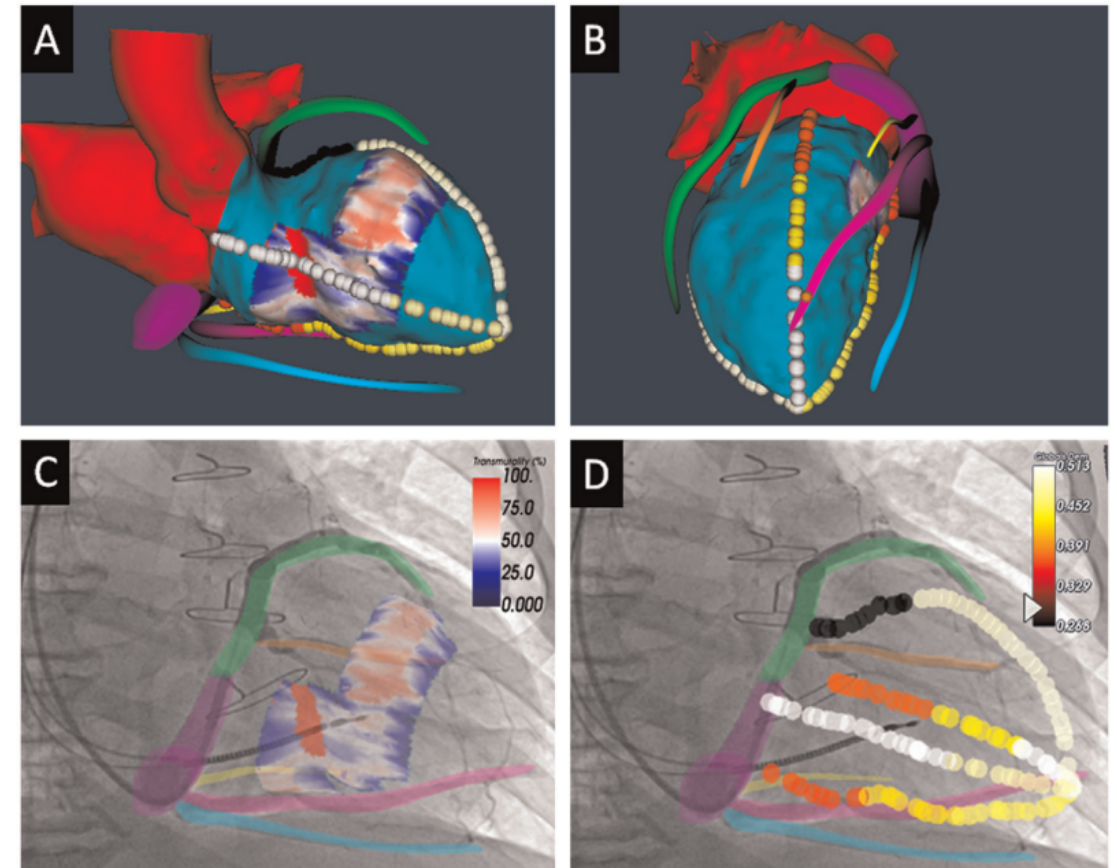


Des outils d'optimisation en cours d'évaluation

IRM: nouvelles modalités d'analyse

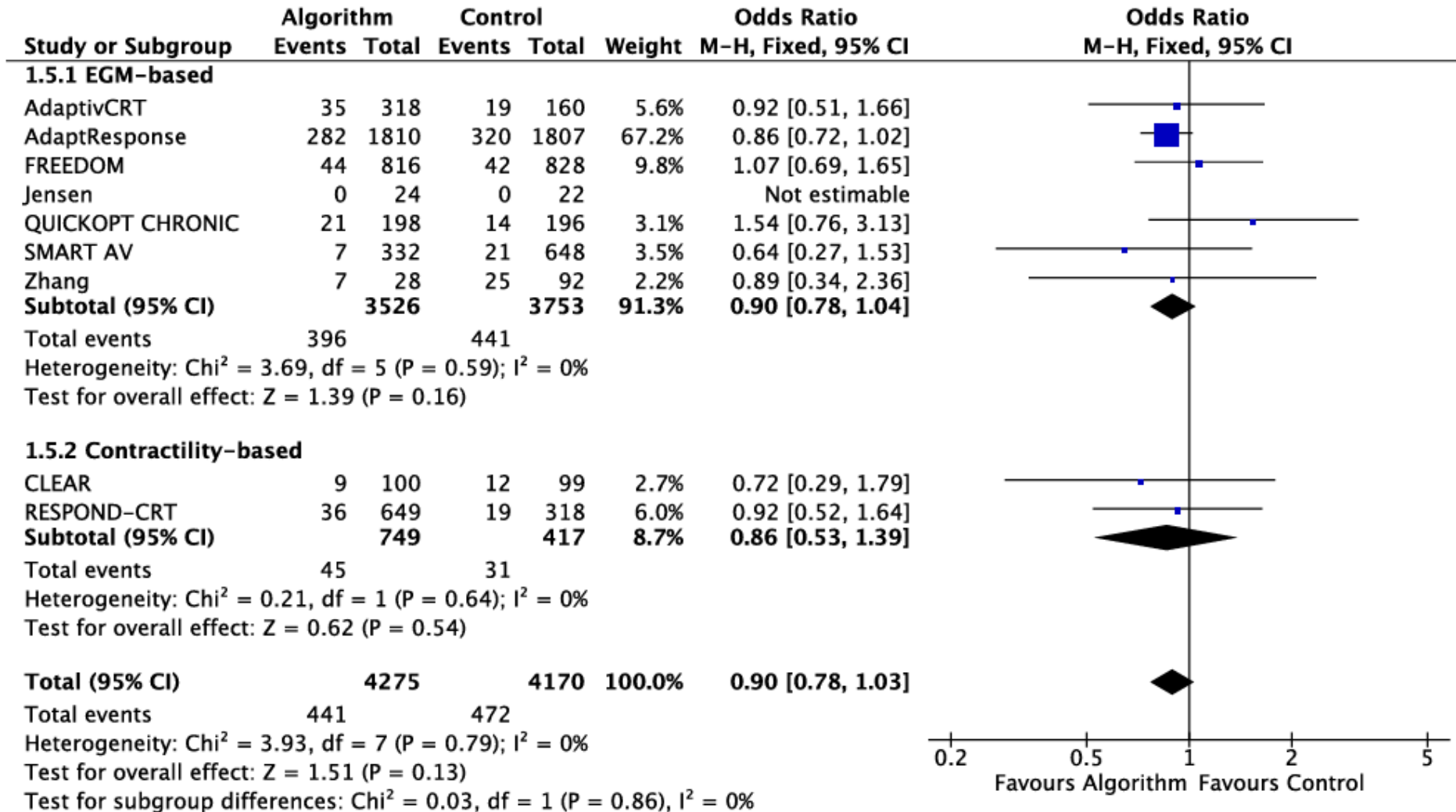


Modélisation 3D: scanner, IRM, écho



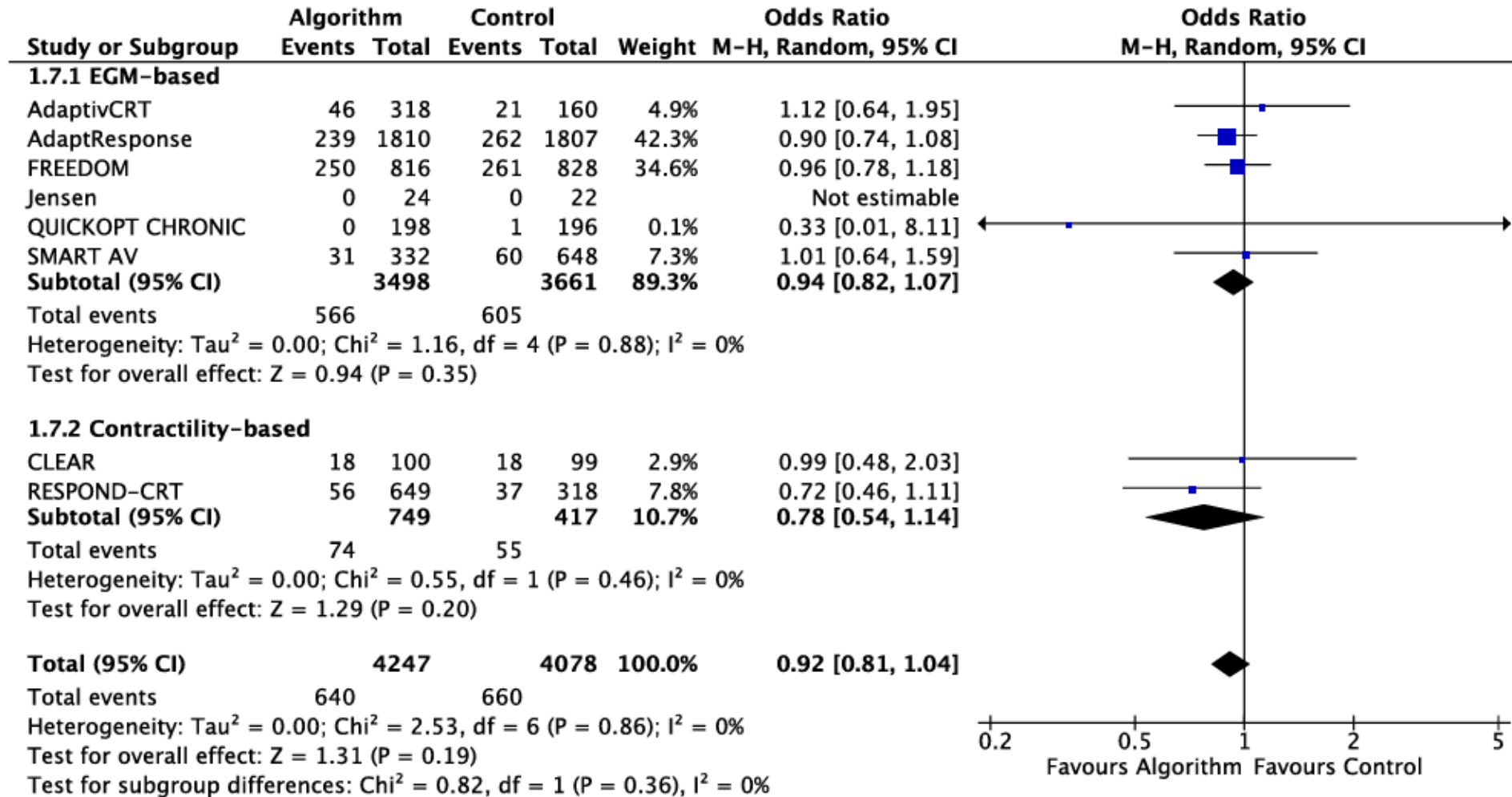
Mieux délivrer la thérapie

Des algorithmes dédiés



All cause mortality

Des algorithmes dédiés



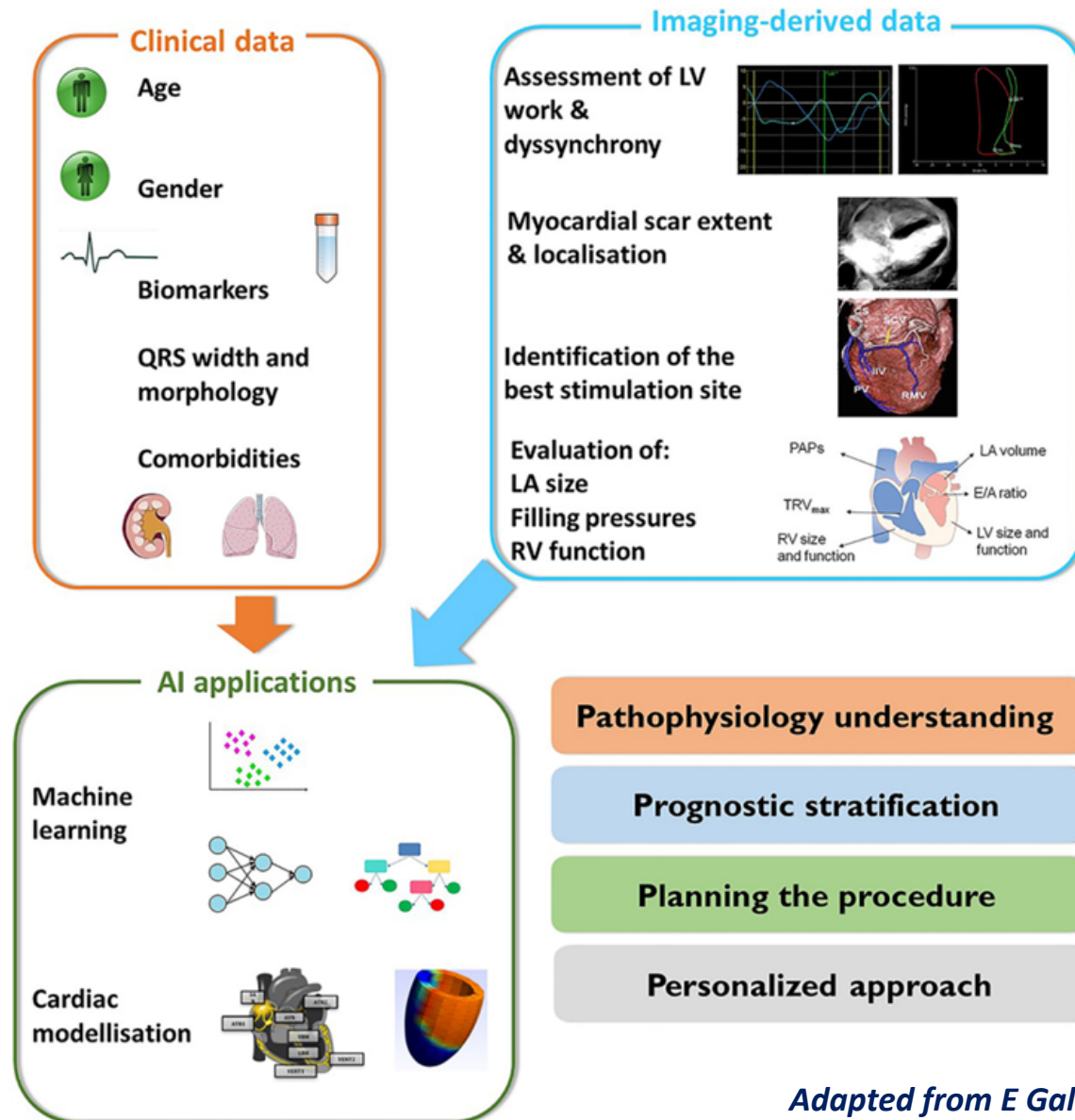
HF hospitalization

Le dernier évalué: AdaptResponse > 3600 patients

Secondary endpoint	Adaptive CRT (n=1810)	Conventional CRT (n=1807)	Treatment effect	P-value
	Occurrence rate at 5 years		HR (95% CI)	
All-cause mortality	15.6%	17.7%	0.88 (0.75-1.03)	0.12
HF event	13.2%	14.5%	0.91 (0.76-1.8)	0.28
AF (≥ 6 hours)	18.8%	19.8%	0.99 (0.85-1.16)	0.89
	Percent of patients		OR (95% CI)	
Clinical Composite Score	Improved	71.4%	0.89 (0.77-1.03)	0.11
	Stabilized	21.4%		
	Worsened	7.1%		
	Rate per 100 patient-years		RR (95% CI)	
30-day readmission after HFH	1.07	0.93	1.15 (0.75-1.75)	0.52
	Mean (SD) change baseline to 2 yrs		Difference (95% CI)	
KCCQ	16.8 (21.2)	16.5 (20.4)	-0.1 (-1.0-0.9)	0.88
EQ-5D Utility index*	54 (190)	48 (180)	1.3 (-6.8-9.4)	0.75

**Aucune valeur ajoutée
de l'algorithme
sur le critère primaire composite
et les critères secondaires**

Faire mieux : une approche multiparamétrique

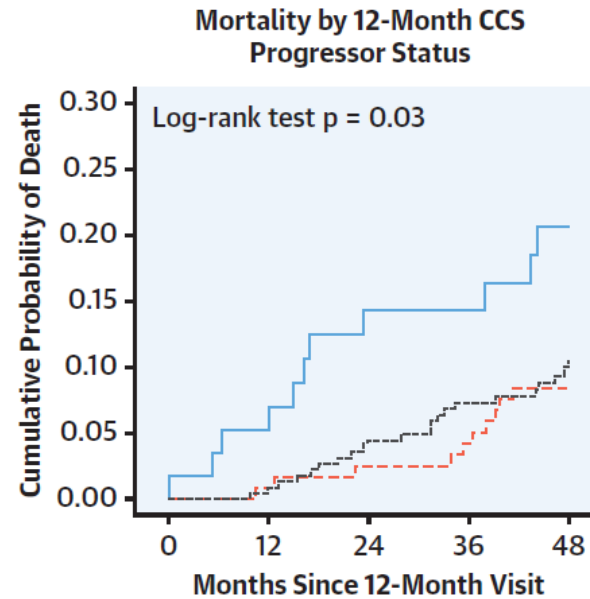
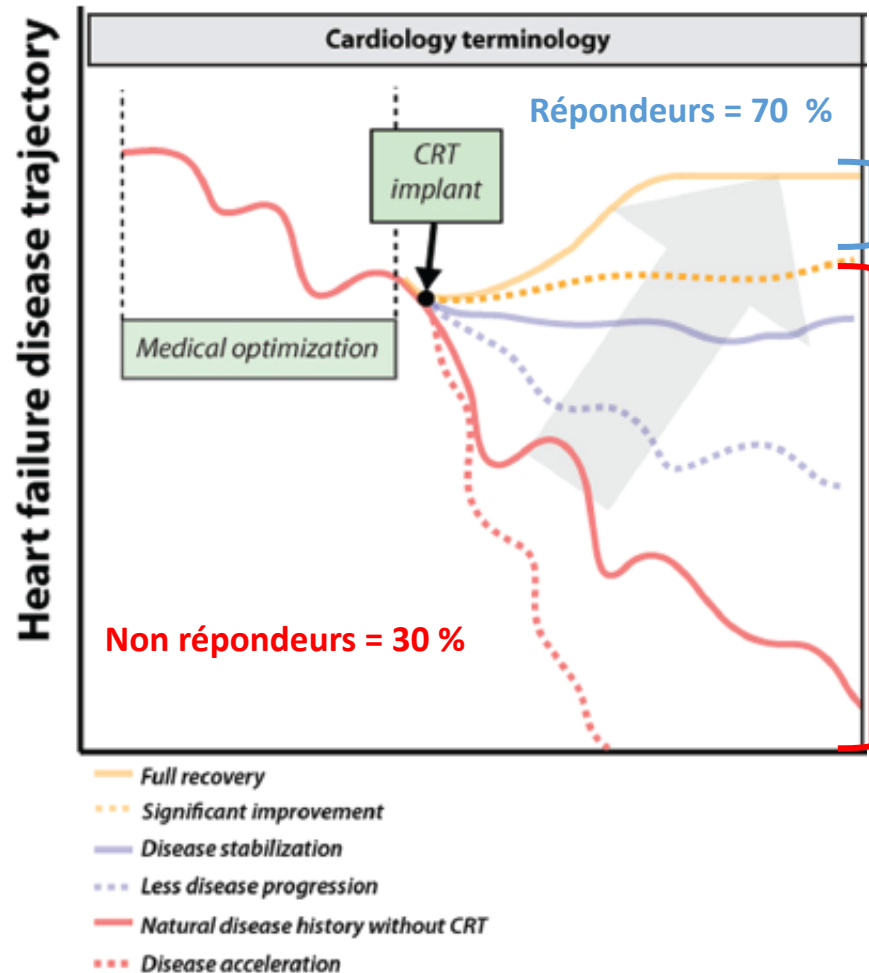


« NON-REPONDEURS »

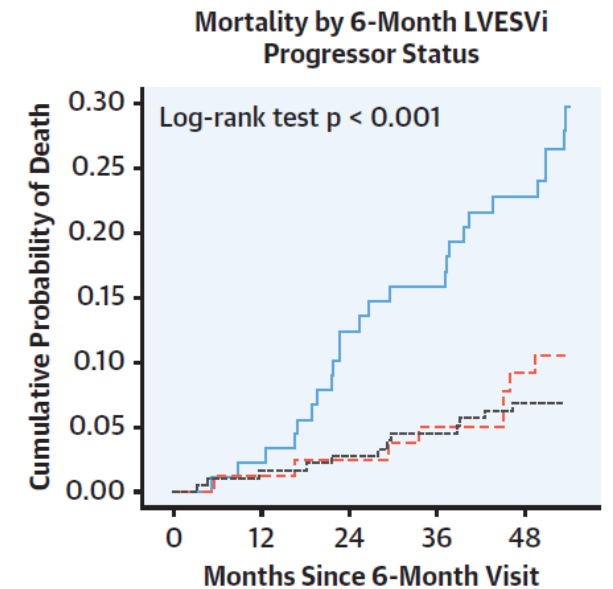
Avons-nous fait fausse route ?

« non-répondeurs »: une définition à revoir

Une approche « idéaliste » du résultat



No. at risk:	0	12	24	36	48
Worsened	57	55	48	48	38
Stabilized	123	120	117	114	108
Improved	226	224	212	198	85

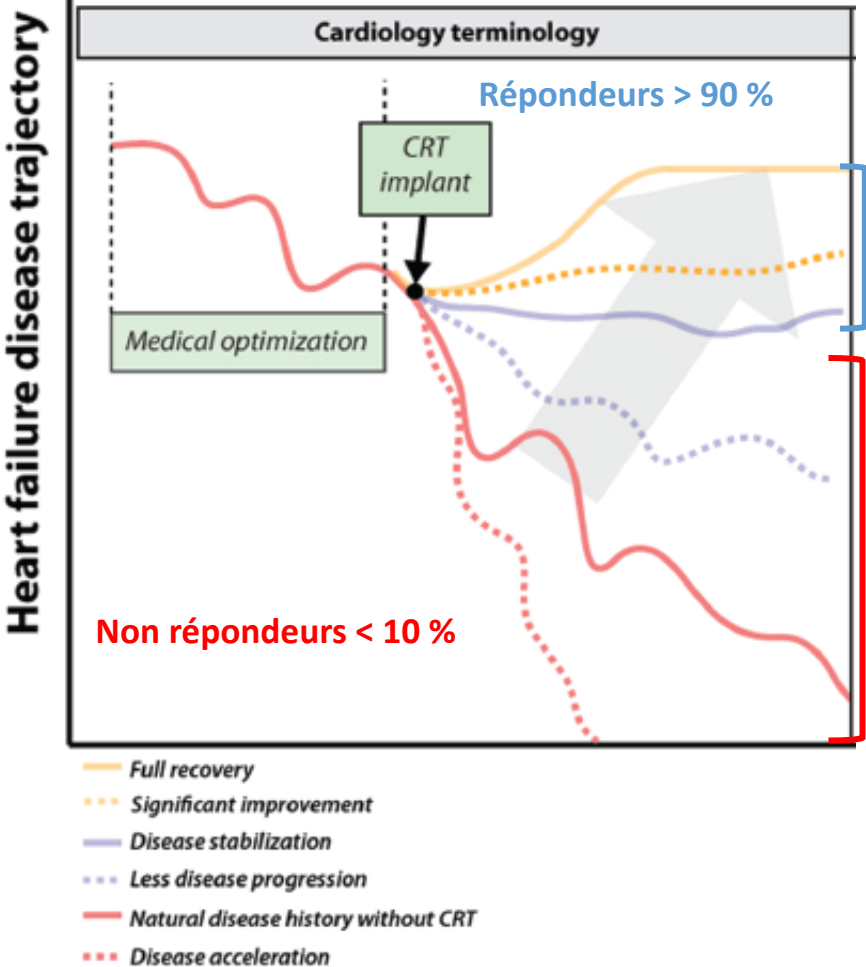


No. at risk:	0	12	24	36	48
Worsened	89	88	78	75	66
Stabilized	81	80	79	74	67
Improved	183	178	173	168	155

Patients améliorés ou stabilisés: même pronostic

Non-répondeurs: question toujours d'actualité ?

Une approche réaliste du résultat



Etude AdaptResponse (Lancet 2023; 402: 1147-57)

Secondary endpoint	Adaptive CRT (n=1810)	Conventional CRT (n=1807)	Treatment effect	P-value
	Occurrence rate at 5 years		HR (95% CI)	
All-cause mortality	15.6%	17.7%	0.88 (0.75-1.03)	0.12
HF event	13.2%	14.5%	0.91 (0.76-1.8)	0.28
AF (≥ 6 hours)	18.8%	19.8%	0.99 (0.85-1.16)	0.89
	Percent of patients		OR (95% CI)	
Clinical Composite Score				
Improved	69.1%	71.4%	0.89 (0.77-1.03)	0.11
Stabilized	23.3%	21.4%		
Worsened	7.6%	7.1%		

3617 patients en classe NYHA II-IV
 Taux de patients répondeurs > 90%
 Mortalité toute cause à 5 ans: 16 %

En pratique, deux questions:

Stimulation bi-ventriculaire

pour qui ?

quand ?

Stimulation bi-ventriculaire: pour qui ?



ESC

European Society
of Cardiology

European Heart Journal (2021) **42**, 3599–3726
doi:10.1093/eurheartj/ehab368

ESC GUIDELINES

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)

With the special contribution of the Heart Failure Association (HFA) of the ESC

Authors/Task Force Members: Theresa A. McDonagh* (Chairperson) (United Kingdom), Marco Metra * (Chairperson) (Italy), Marianna Adamo (Task Force Coordinator) (Italy), Roy S. Gardner (Task Force Coordinator) (United Kingdom), Andreas Baumbach (United Kingdom), Michael Böhm (Germany), Haran Burri (Switzerland), Javed Butler (United States of America), Jelena Čelutkienė (Lithuania), Ovidiu Chioncel (Romania), John G.F. Cleland (United Kingdom), Andrew J.S. Coats (United Kingdom), Maria G. Crespo-Leiro (Spain), Dimitrios Farmakis (Greece), Martine Gilard (France), Stephane Heymans

Recommandations ESC 2021

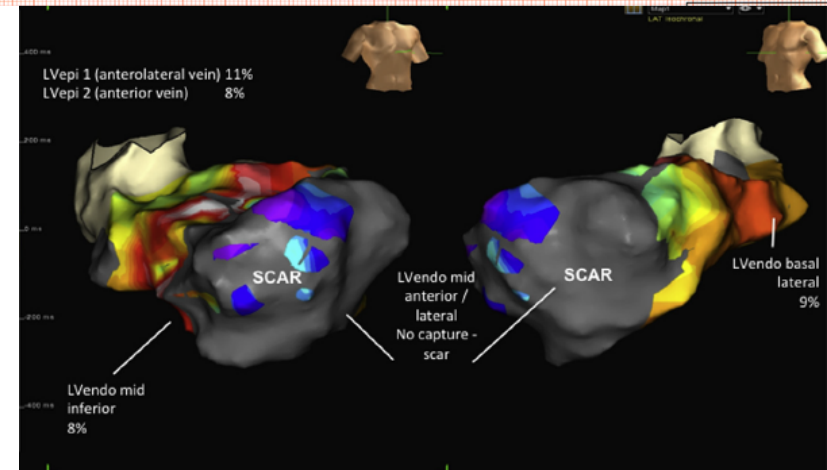
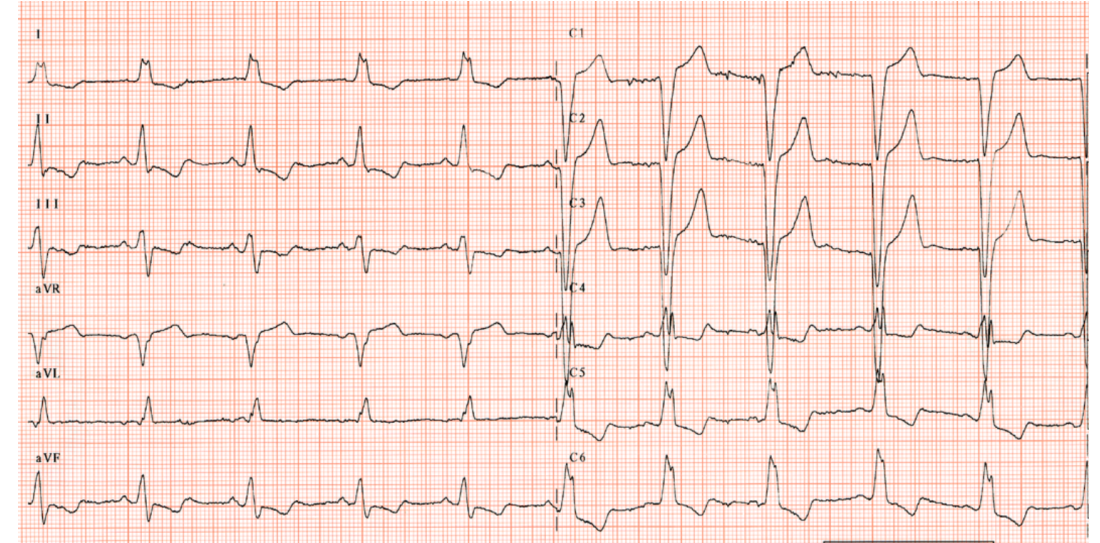
Resynchronisation cardiaque - Patients en rythme sinusal - FEVG ≤ 35%

Recommendations		Class	Level
LBBB QRS morphology			
	CRT is recommended for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration ≥150 ms, and LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity and mortality.	I	A
	CRT should be considered for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration 130–149 ms, and LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity and mortality.	IIa	B
			BBG QRS ≥ 150 ms
			BBG QRS 130-149 ms
Recommendations		Class	Level
Non-LBBB QRS morphology			
Non BBG QRS ≥ 150 ms	CRT should be considered for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration ≥150 ms, and non-LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity.	IIa	B
Non BBG QRS 130-149 ms	CRT may be considered for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration 130–149 ms, and non-LBBB QRS morphology despite OMT, in order to improve symptoms and reduce morbidity.	IIb	B

Savoir “personnaliser” les recommandations...

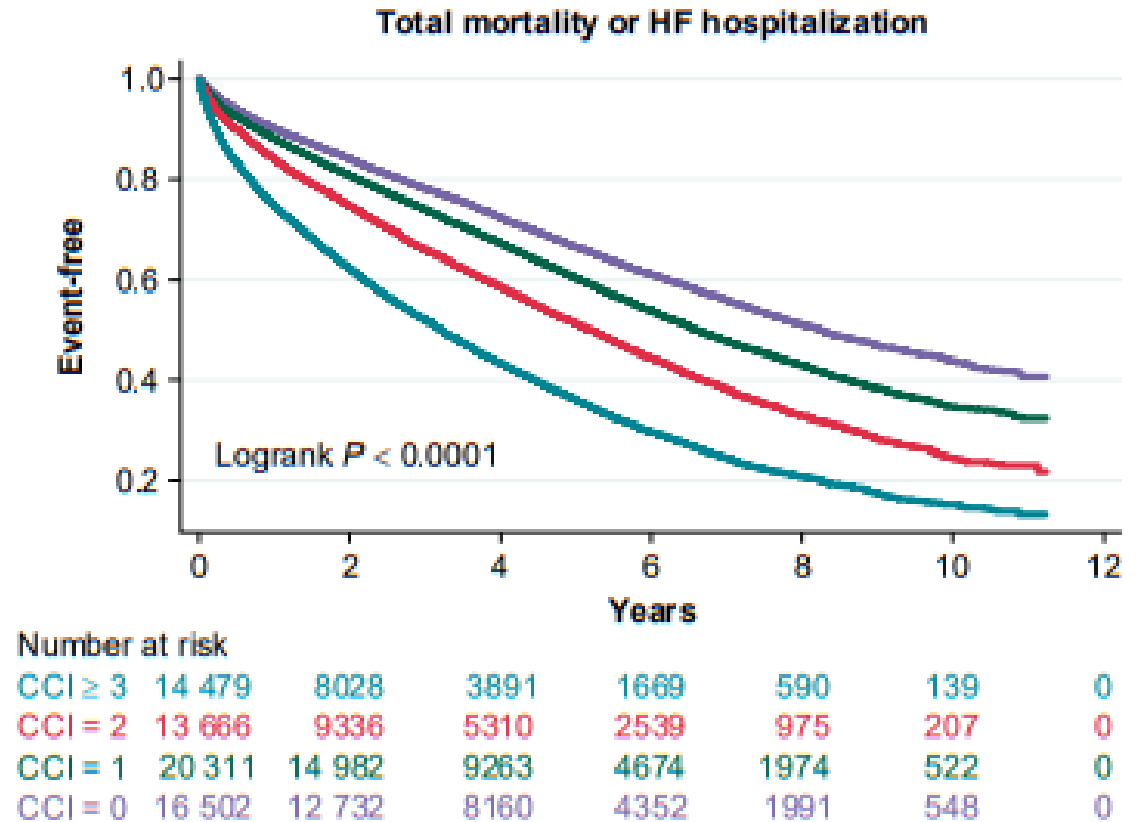
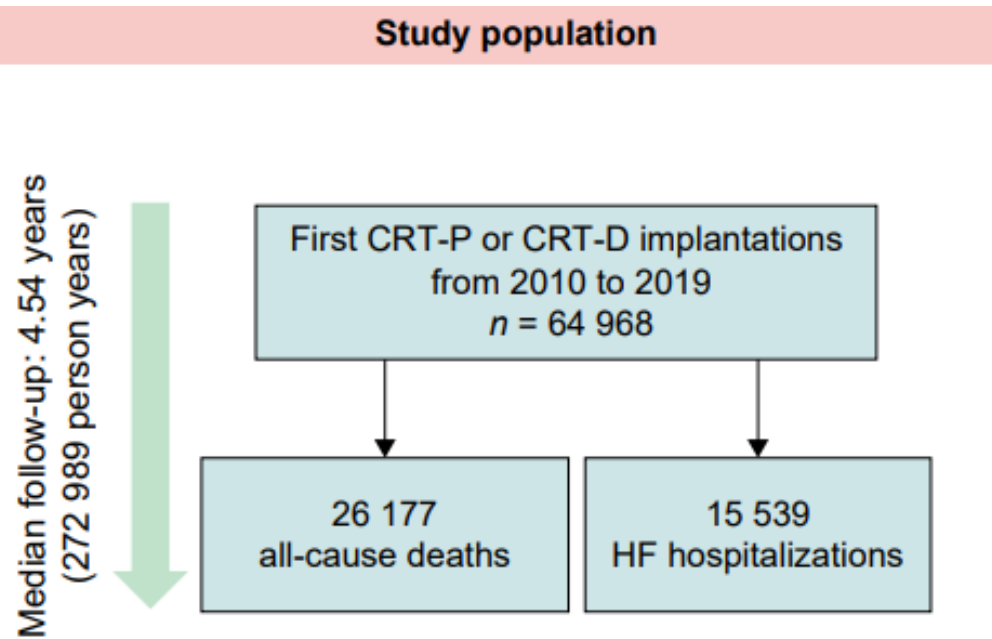
- Bien analyser le QRS (BBD: non)
- FEVG non effondrée (< 20%)
- Etiologie: non isch. > isch.
- Etendue de la fibrose
- Dysfonction VD
- Comorbidités (Ins. rénale, BPCO...)
- Autre pathologie de mauvais pronostic

...



Le poids des comorbidités

Survival curves according to Charlson comorbidity index



Stimulation bi-ventriculaire: quand ?

Recommandations ESC 2021

Resynchronisation cardiaque - Patients en rythme sinusal - FEVG ≤ 35%

Recommendations		Class	Level
LBBB QRS morphology			
	CRT is recommended for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration ≥150 ms, and LBBB QRS morphology despite OMT , in order to improve symptoms and reduce morbidity and mortality.	I	A
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Recommendations		Class	Level
Non-LBBB QRS morphology			
Non BBG QRS ≥ 150 ms	CRT should be considered for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration ≥150 ms, and non-LBBB QRS morphology despite OMT , in order to improve symptoms and reduce morbidity.	IIa	B
Non BBG QRS 130-149 ms	CRT may be considered for symptomatic patients with HF in SR with LVEF ≤35%, QRS duration 130–149 ms, and non-LBBB QRS morphology despite OMT , in order to improve symptoms and reduce morbidity.	IIb	B

Stimulation bi-ventriculaire: quand ?

- OMT: lequel ?
- Quel délai pour l'optimisation ?

Le traitement médical optimal (optimisé)

Management of patients with HFrEF



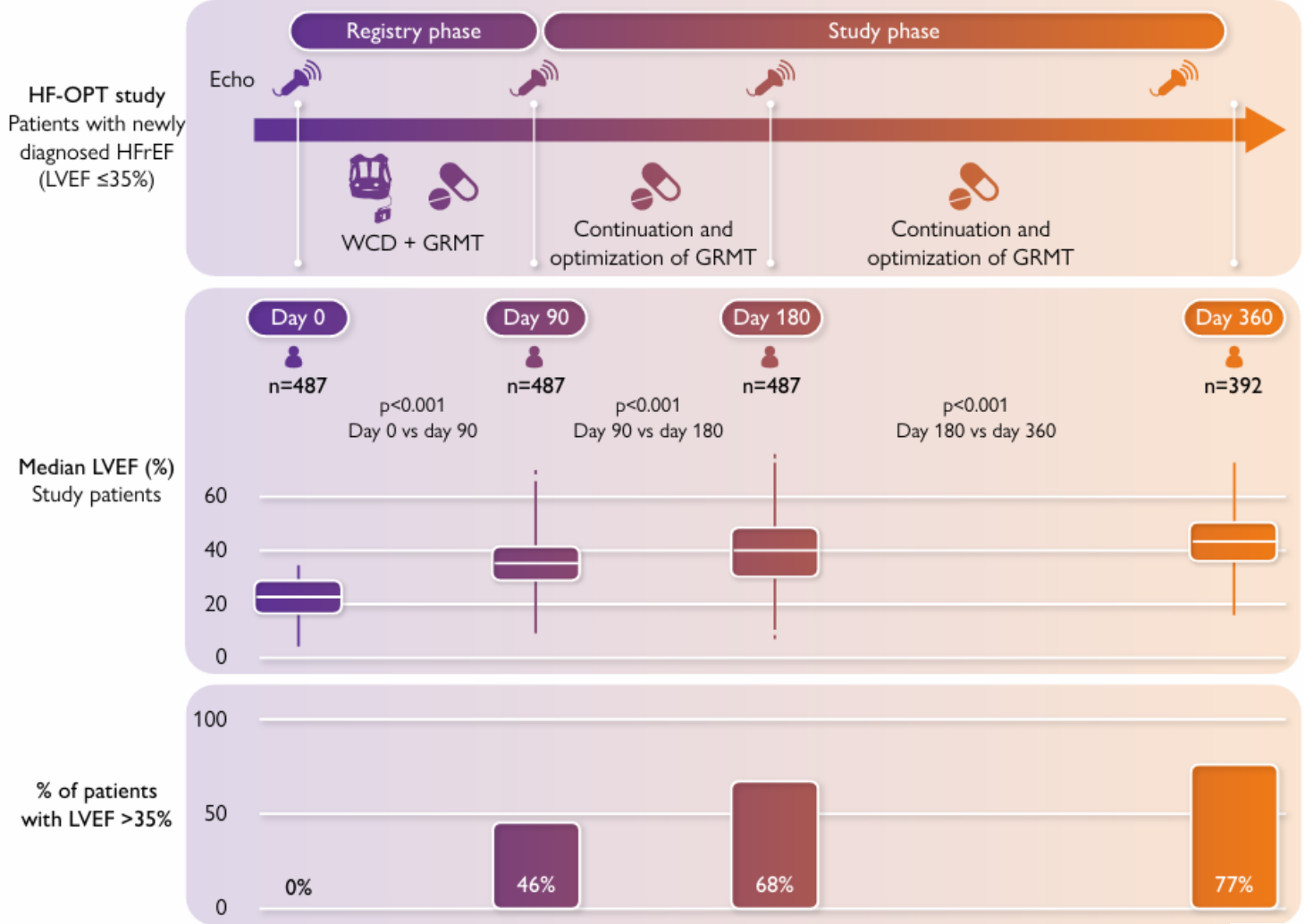
- ACE-I/ARNI^a
- Beta-blocker
- MRA
- Dapagliflozin/Empagliflozin
- Loop diuretic for fluid retention
(Class I)

Stimulation bi-ventriculaire: quand

Quel délai pour l'optimisation ?

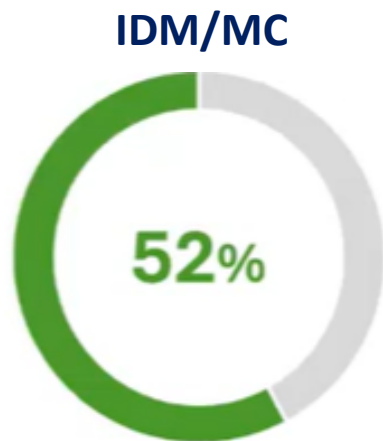
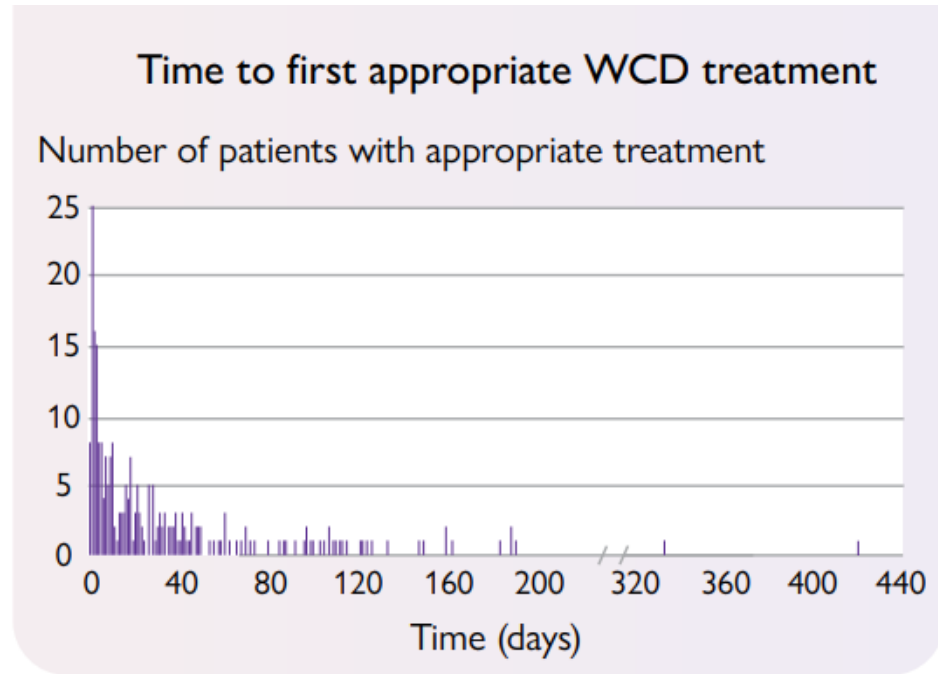
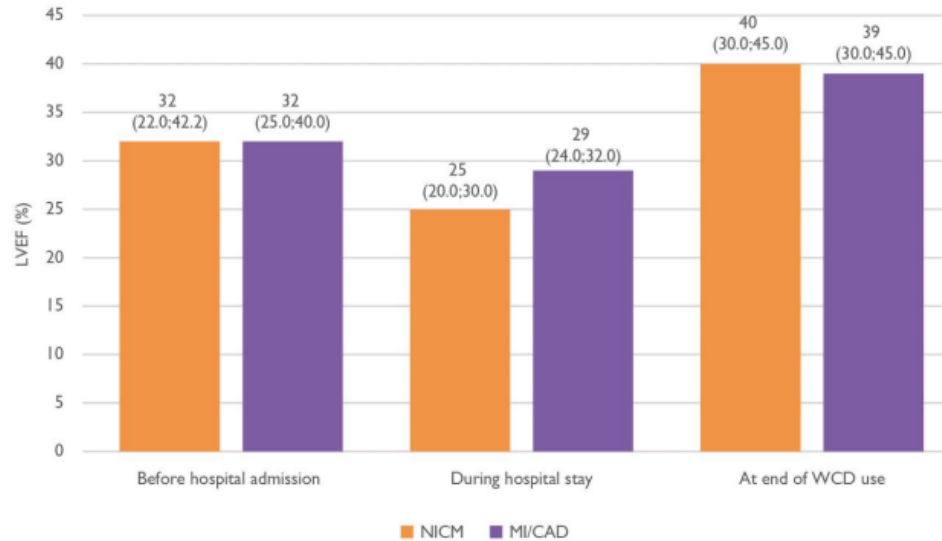
Therapy duration and improvement of ventricular function in *de novo* heart failure: the Heart Failure Optimization study

Christian Veltmann ^{1,2*}, David Duncker ^{1†}, Michael Doering ³, Siva Gummadi ⁴, Michael Robertson ⁵, Thomas Wittlinger ⁶, Byron J. Colley ⁷, Christian Perings ⁸, Orvar Jonsson ⁹, Johann Bauersachs ¹, Robert Sanchez ¹⁰, and Lars S. Maier ¹¹; for the Heart Failure Optimization Study (HF-OPT) Investigators



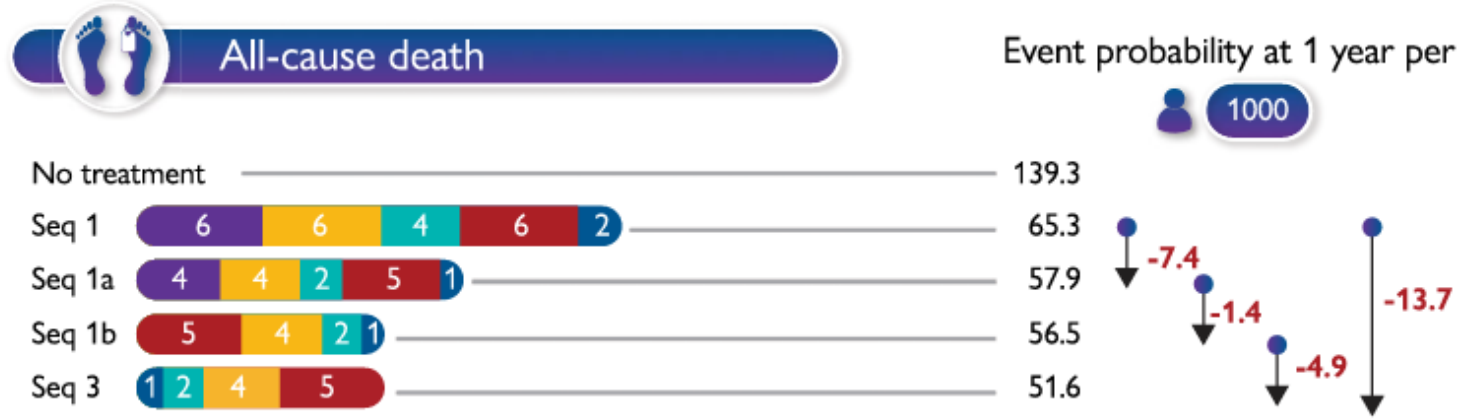
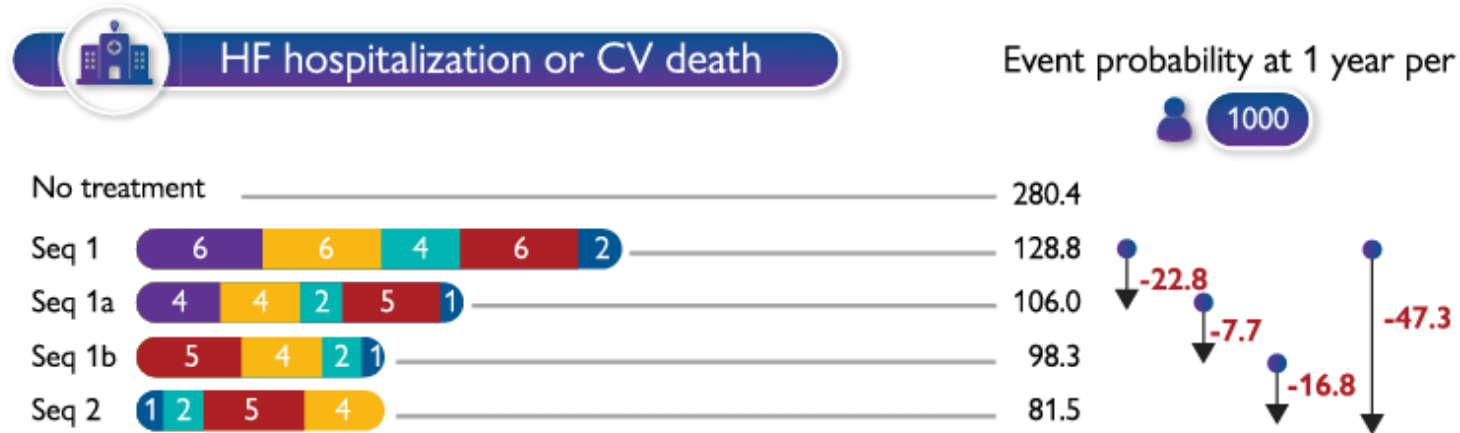
SCD-PROTECT study

50 % des patients retrouvent une FEVG > 35 % à 3 mois



Accelerated and personalized therapy for heart failure with reduced ejection fraction

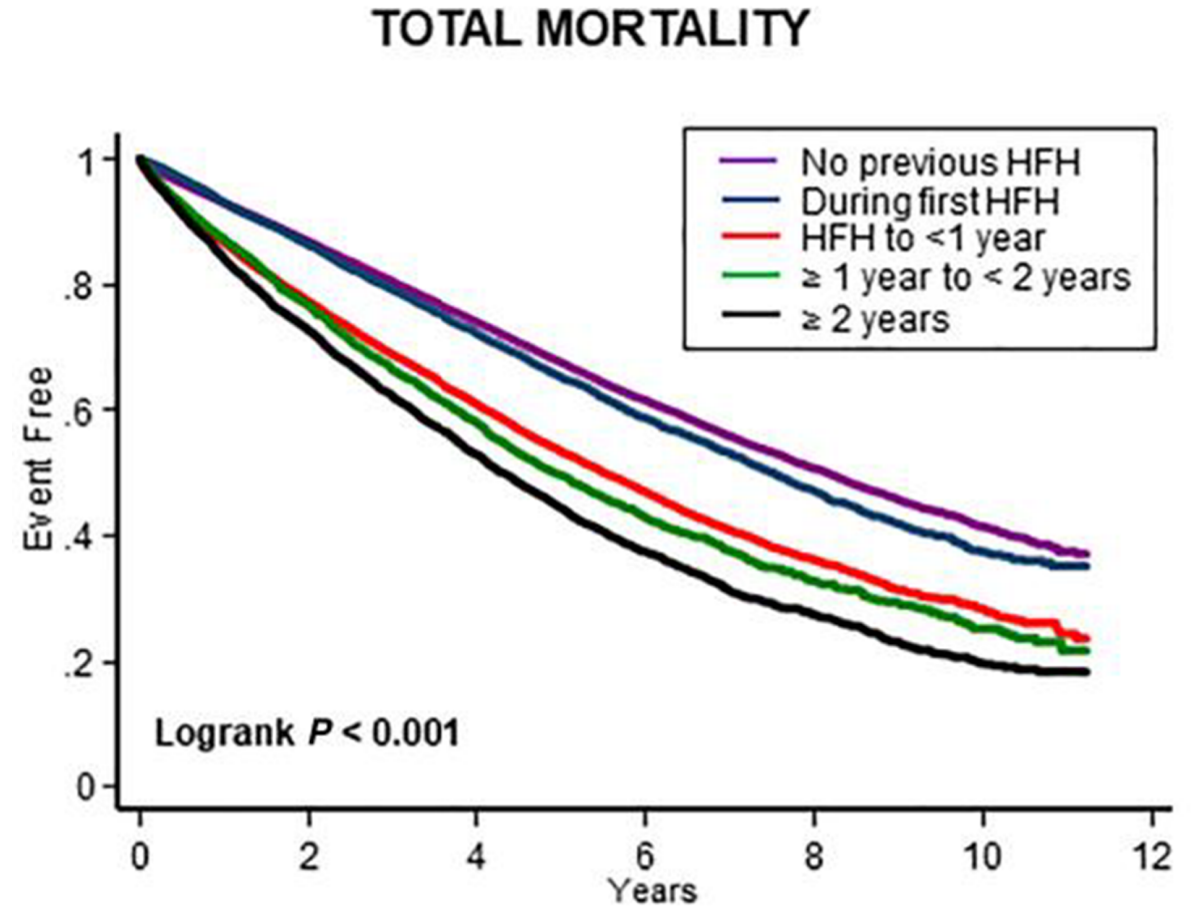
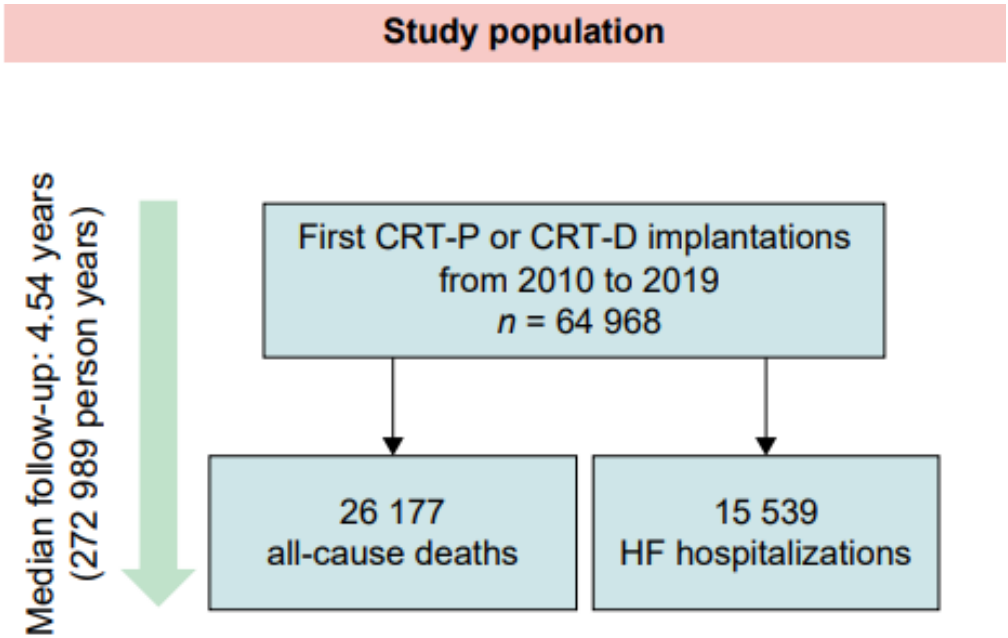
Li Shen^{1,2}, Pardeep Singh Jhund², Kieran Francis Docherty², Muthiah Vaduganathan³, Mark Colquhoun Petrie², Akshay Suvas Desai³, Lars Køber⁴, Morten Schou⁵, Milton Packer^{6,7}, Scott David Solomon³, Xingwei Zhang¹, and John Joseph Valentine McMurray^{2*}



● RASi
 ● Beta-blocker
 ● MRA
 ● ARNI
 ● SGLT2i

6 The numbers in the bars denote the duration of up-titration periods in weeks.

Quand ? Pas trop tard...



Stimulation bi-ventriculaire: quand ?

Quel délai pour l'optimisation ? **Au moins 3 mois**

Sous réserve d'une stratégie « agressive » d'optimisation du traitement

La stimulation bi-ventriculaire en chiffres

- **> 3 000 000 de CRT implantés dans le monde**
- **2021: 90 000 implantations aux USA, 80 000 en Europe**
- **Majorité de CRT-D**
USA 86%, Italie 77%, Allemagne 68%, France 60 %, UK 44%

CRT-D

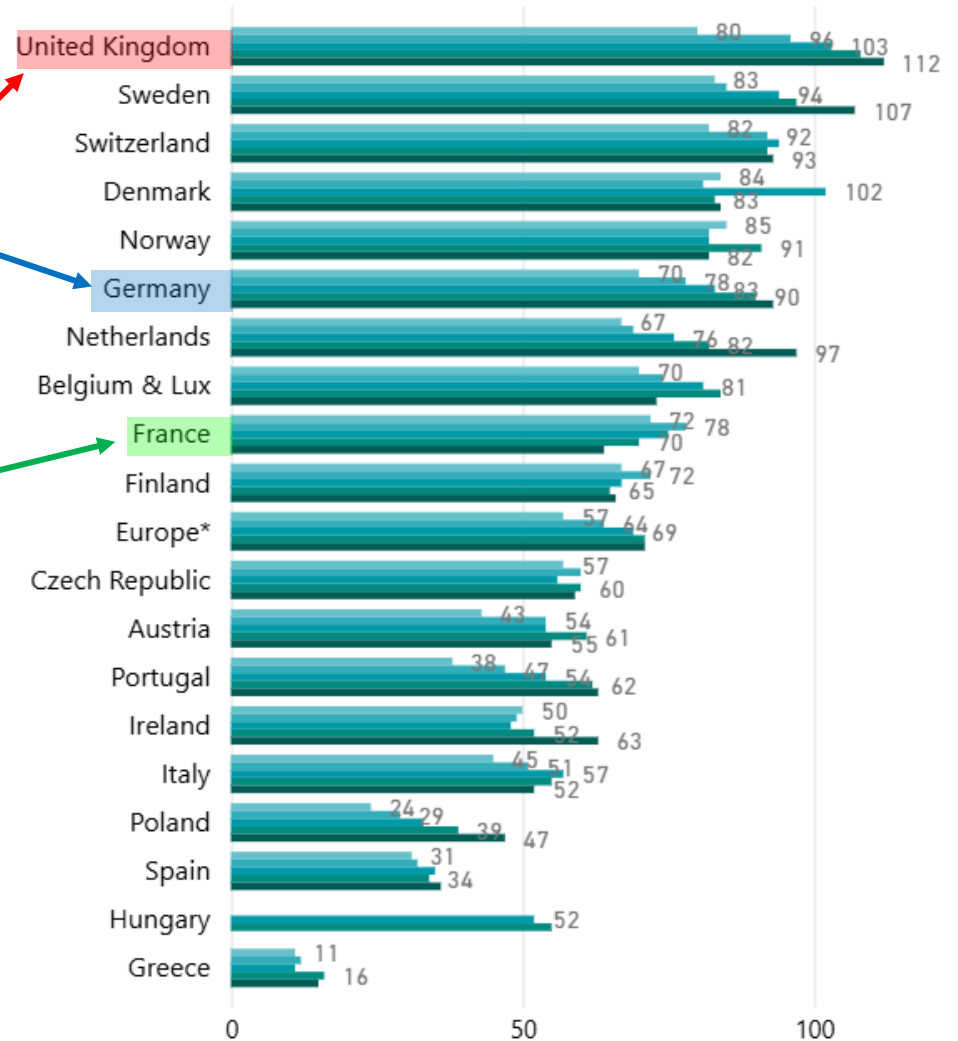
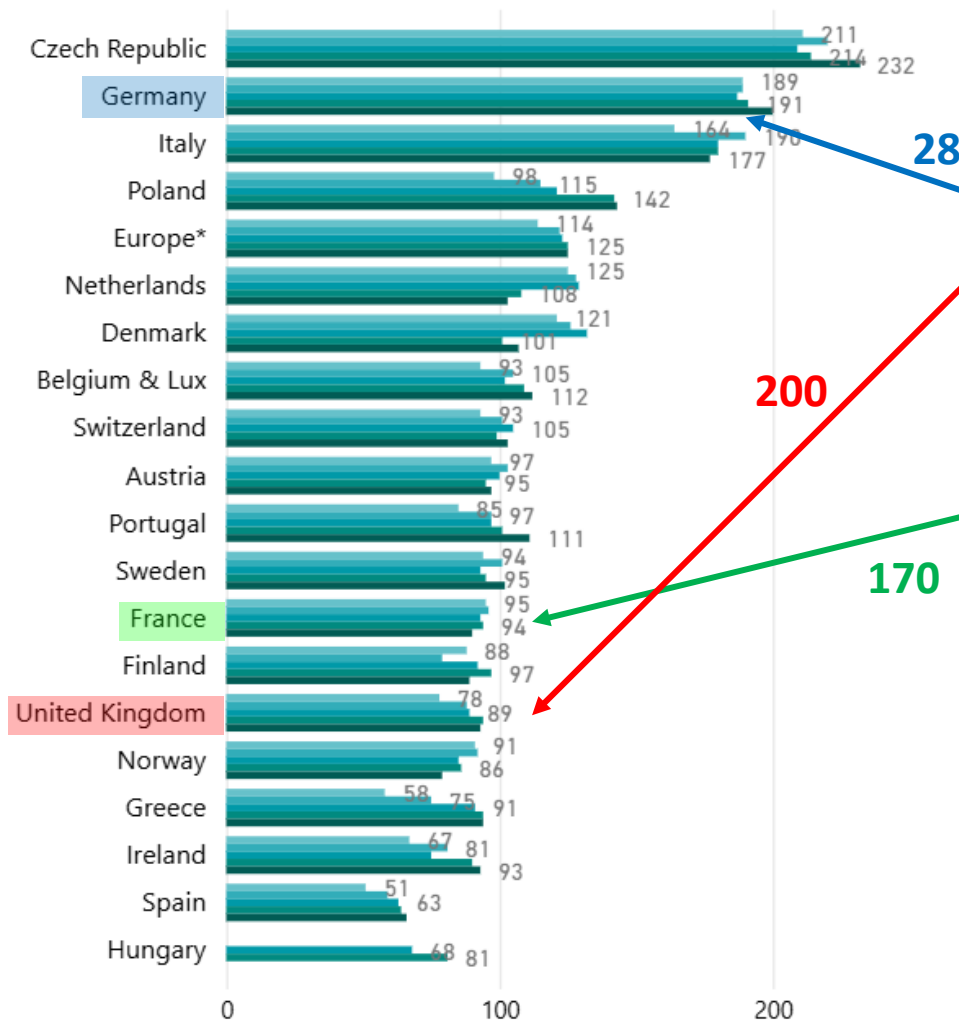
CRT-P

Units per million inhabitants

Units per million inhabitants

Year ● 2020 ● 2021 ● 2022 ● 2023 ● 2024

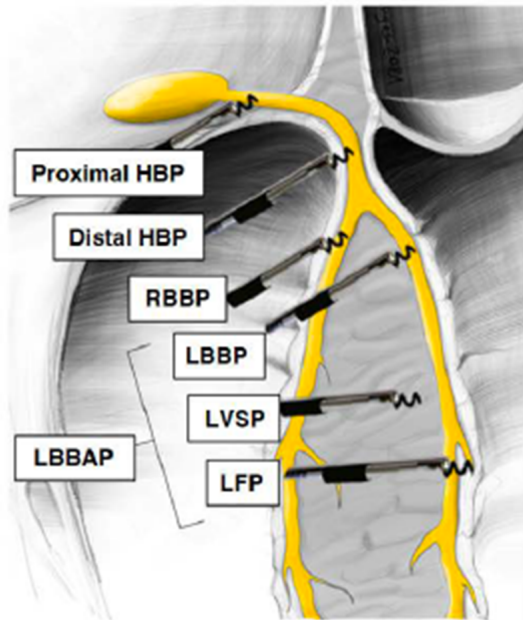
Year ● 2020 ● 2021 ● 2022 ● 2023 ● 2024



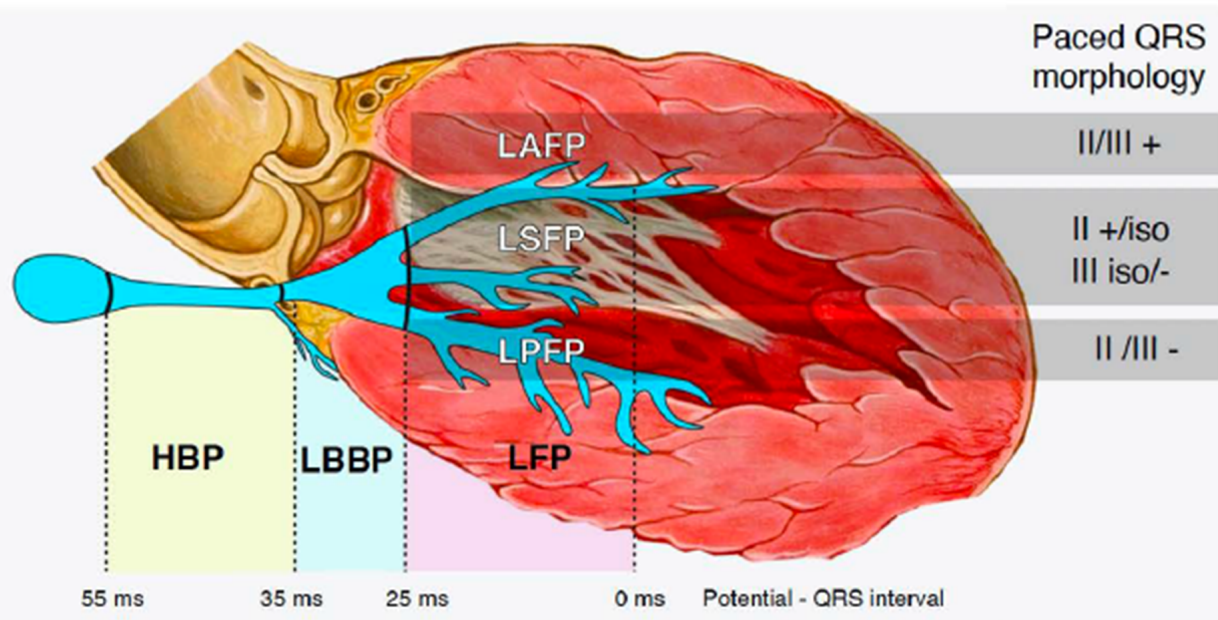
La stimulation bi-ventriculaire en chiffres

- **> 3 000 000 de CRT implantés dans le monde**
- **2021: 90 000 implantations aux USA, 80 000 en Europe**
- **Majorité de CRT-D**
 - USA 86%, Italie 77%, Allemagne 68%, France 60 %, UK 44%**
- **2024: 4,2 milliards \$**
- **Estimation 2032: 7,7 milliards \$**

Resynchronisation: stimuler le tissu de conduction une alternative à la stimulation BiV ?



HBP: His bundle pacing
RBBP: right bundle branch pacing



LBB(A)P: left bundle branch (area) pacing
LVSP: left ventricular septal pacing
L(P)FP: left (posterior) fascicular pacing

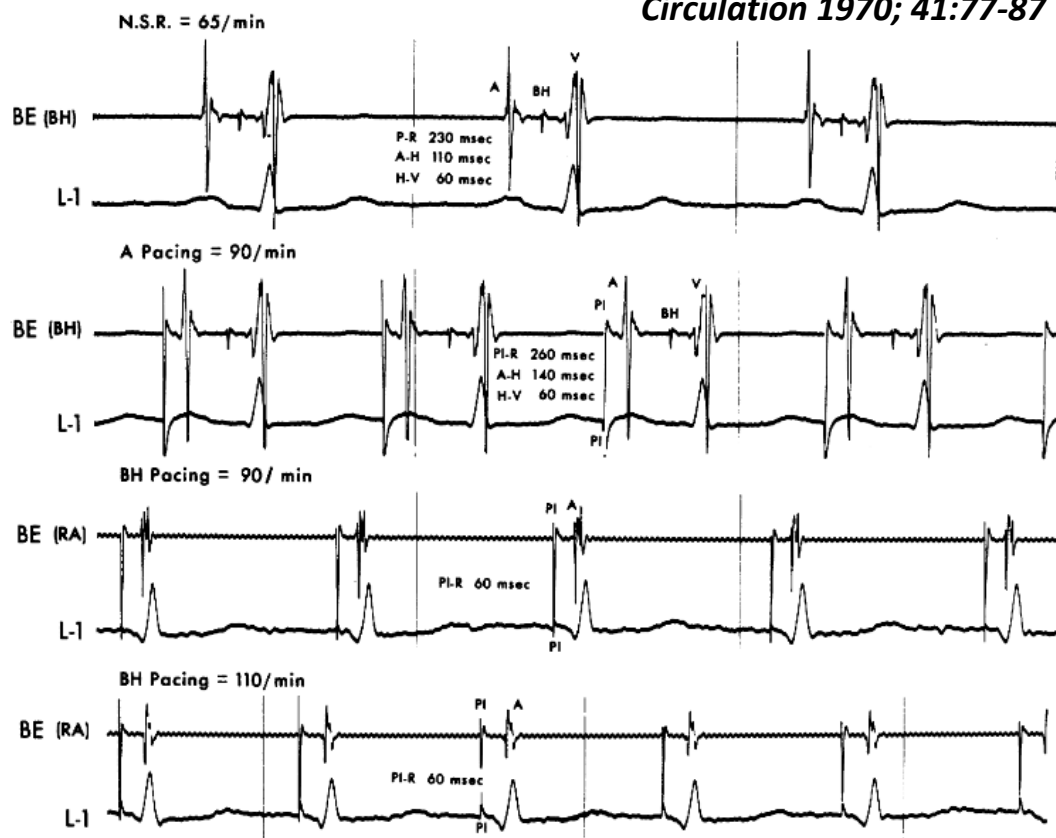
Stimuler le His: une idée pas si nouvelle...

Pervenous Pacing of the Specialized Conducting System in Man

His Bundle and A-V Nodal Stimulation

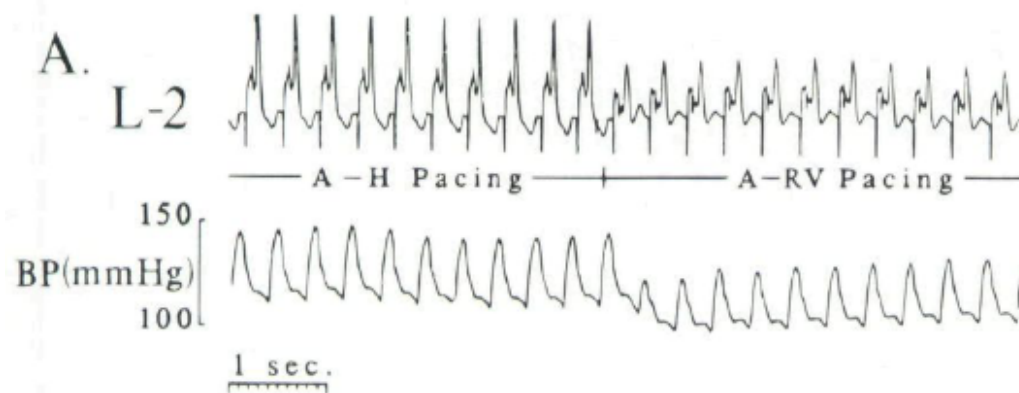
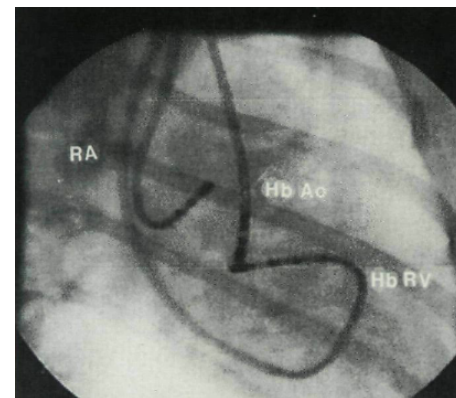
By ONKAR S. NARULA, M.D., BENJAMIN J. SCHERLAG, Ph.D.,
AND PHILIP SAMET, M.D.

Circulation 1970; 41:77-87



A Technique for Stable His-Bundle Recording and Pacing: Electrophysiological and Hemodynamic Correlates

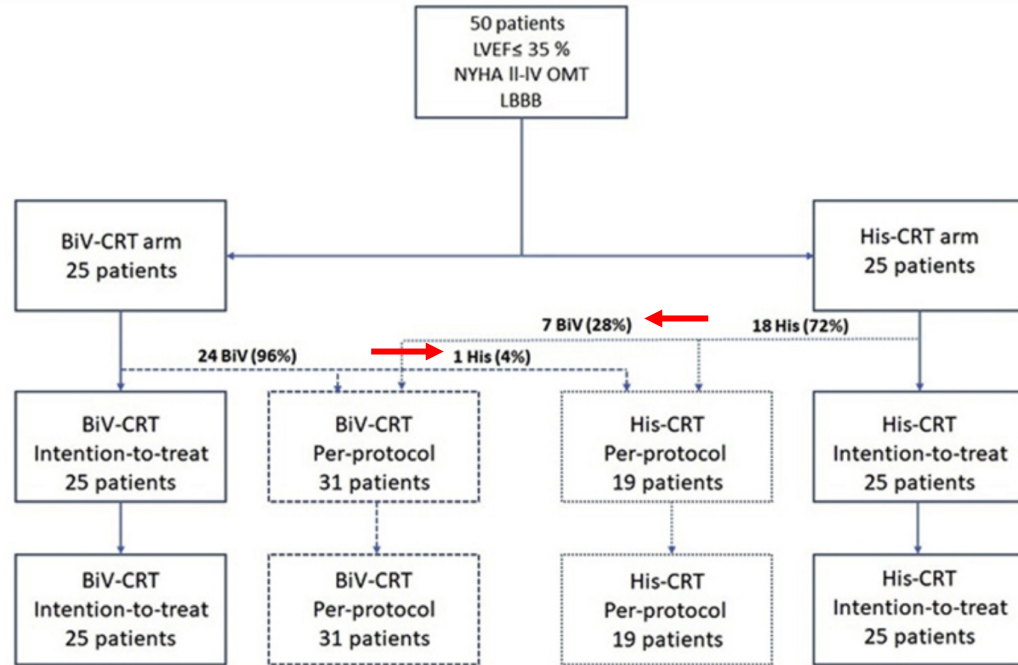
PHILIPPE MABO, BENJAMIN J. SCHERLAG, ANAND MUNSIF,
KENICHIRO OTOMO, and RALPH LAZZARA *PACE 1995; 18: 1894-1901*



A Randomized Trial of His pacing versus Biventricular pacing in Symptomatic Heart Failure Patients with left bundle branch block (His-Alternative)

Michael Vinther, Niels Risum, Jesper Hastrup Svendsen, Rasmus Møgelvang, and Berit Thornvig Philbert

J Am Coll Cardiol EP. Apr 25, 2021. Published DOI: 10.1016/j.jacep.2021.04.003



Match nul !

**Cross-over
H to BiV: 28%
BiV to H: 4%**

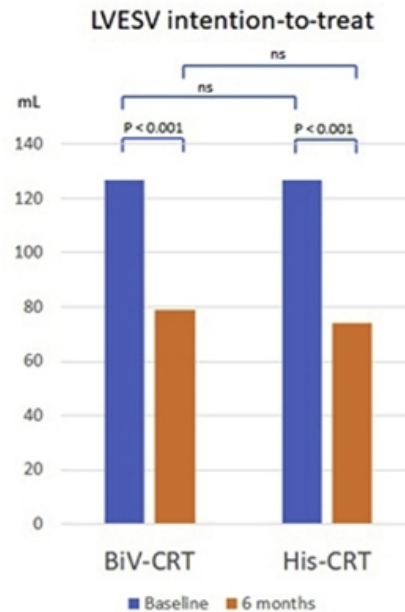
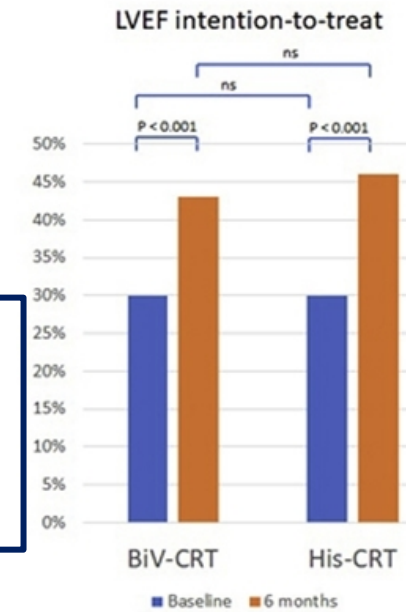
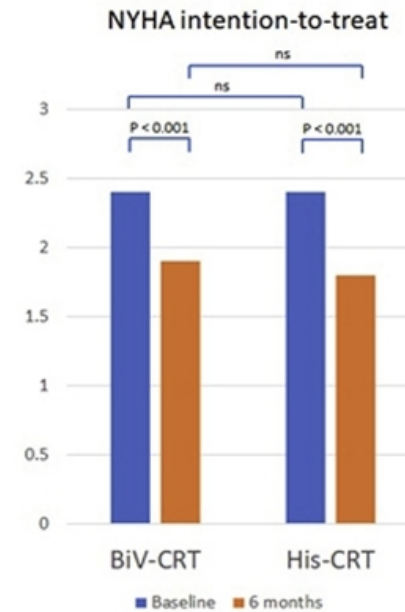
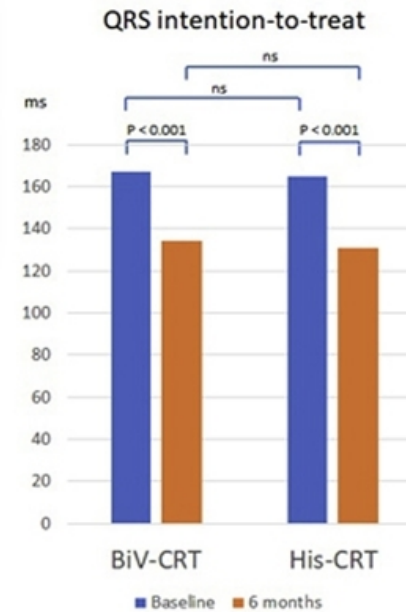
Pacing Thresholds	Implantation (V at 1 ms dur)	6-months FU (V at 1 ms dur)
LV-leads (n=31)	1.1 ± 0.7	1.5 ± 0.6 *
His-leads (n=19)	2.2 ± 1.2 *	2.4 ± 1.6 *

* P < 0.05 baseline vs 6-months FU

* P < 0.05 His-leads vs LV-leads

Limites:

- Echecs de stimulation sélective du His (7 à 10%)
- Seuils chroniques élevés



Left Bundle Branch Area Pacing

MELOS — MULTICENTER EUROPEAN LEFT BUNDLE BRANCH AREA PACING OUTCOMES STUDY



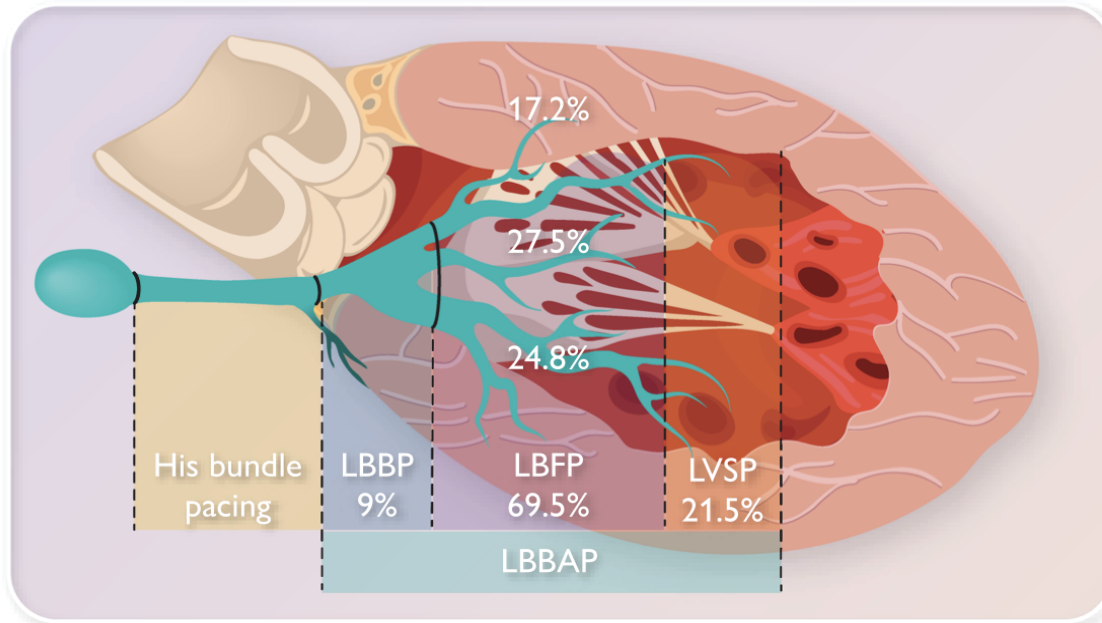
Prospective, multicenter,
registry-based observational study



2533
Participants



14
European centres



Independent predictors of LBBAP lead implantation failure

Heart failure indication	OR 1.49, 95% CI 1.01–2.21
Baseline QRS duration, per 10 ms	OR 1.08, 95% CI 1.03–1.14
LVEDD, per 10 mm increase	OR 1.53, 95% CI 1.26–1.86

LBBAP implantation success

Bradycardia indication success	92.4%
Heart failure indication success	82.2%

Courbe d'apprentissage (100 procédures)

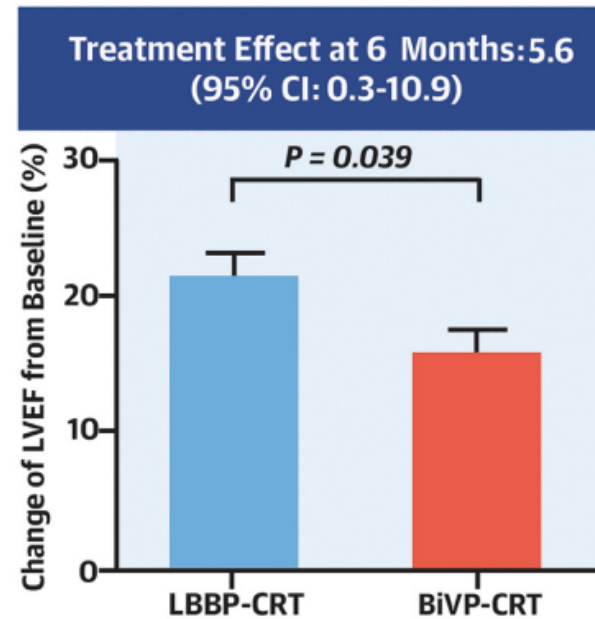
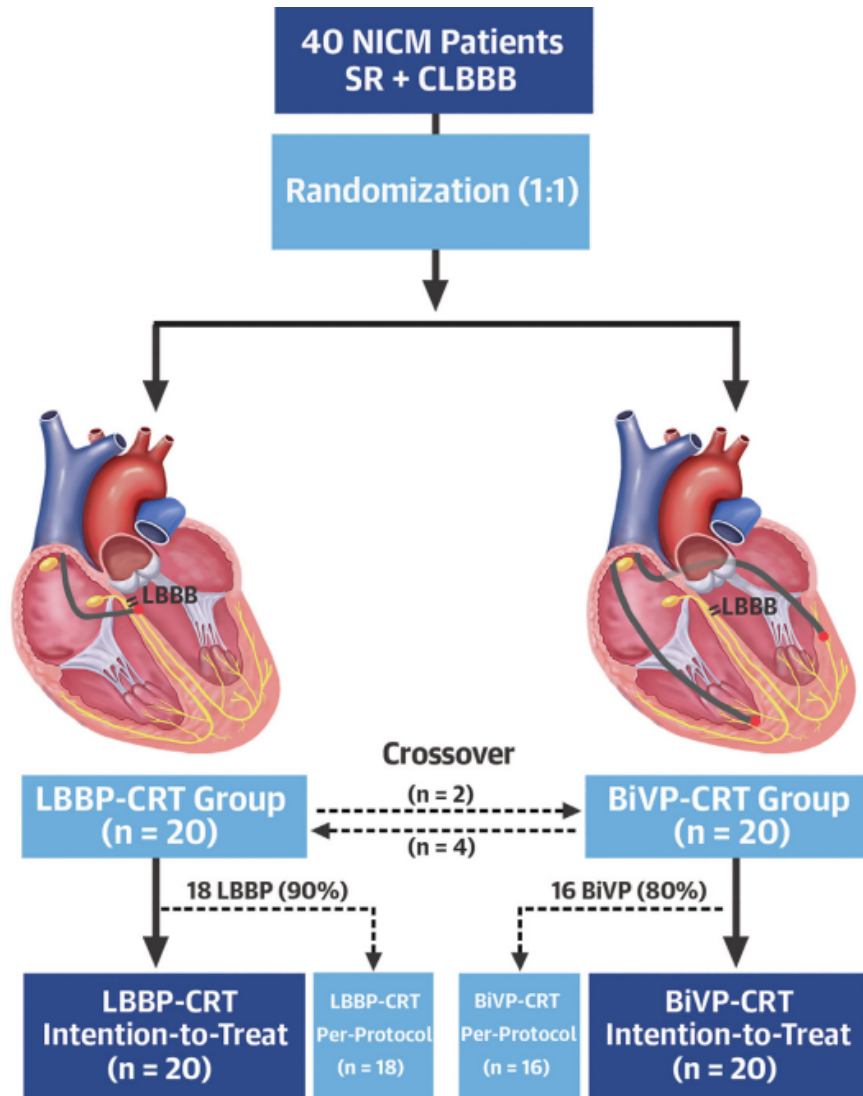
LBBAP lead complications 8.3%

• Acute perforation to LV	3.7%
• Lead dislodgement	1.5%
• Acute chest pain	1.0%
• Capture threshold rise	0.7%
• Acute coronary syndrome	0.4%
• Trapped/damaged helix	0.4%
• Delayed perforation to LV	0.1%
• Other	0.7%

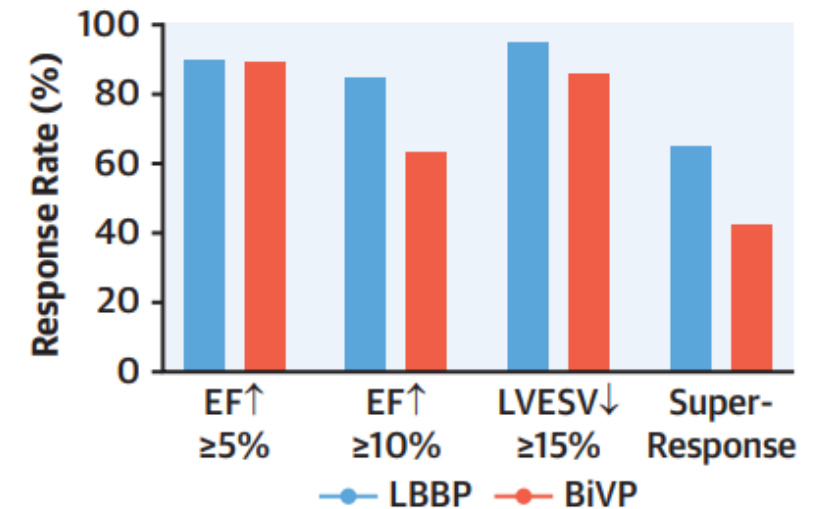
Randomized Trial of Left Bundle Branch vs Biventricular Pacing for Cardiac Resynchronization Therapy

Yao Wang, MD, PhD,^{a,*} Haojie Zhu, MD,^{b,*} Xiaofeng Hou, MD,^a Zhao Wang, MD, PhD,^b Fengwei Zou, MD,^c Zhiyong Qian, MD, PhD,^a Yongyue Wei, MD, PhD,^d Xiang Wang, BSc,^d Longyao Zhang, MD,^d Xiaofei Li, MD,^b Zhimin Liu, MD,^b Siyuan Xue, MD,^a Chaotong Qin, MD,^a Jiaxin Zeng, MD,^a Hui Li, MD,^b Hongping Wu, MD,^a Hong Ma, MD,^a Kenneth A. Ellenbogen, MD,^e Michael R. Gold, MD, PhD,^f Xiaohan Fan, MD, PhD,^b Jiangang Zou, MD, PhD,^{a,g} on behalf of the LBBP-RESYNC Investigators

JACC 2022; 80: 1205 – 1216



Amélioration FEVG
%age FEVG basale



Taux de répondeurs

Clinical Response to Resynchronization Therapy

Conduction System Pacing vs Biventricular Pacing: The CONSYST-CRT Trial

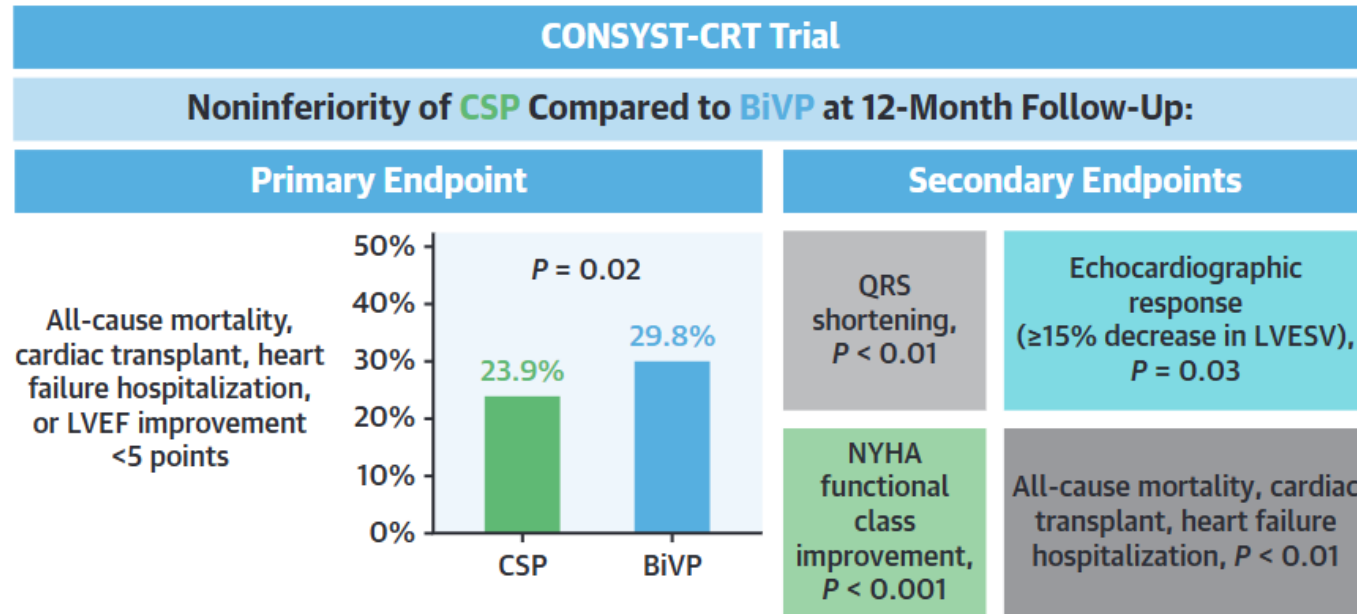
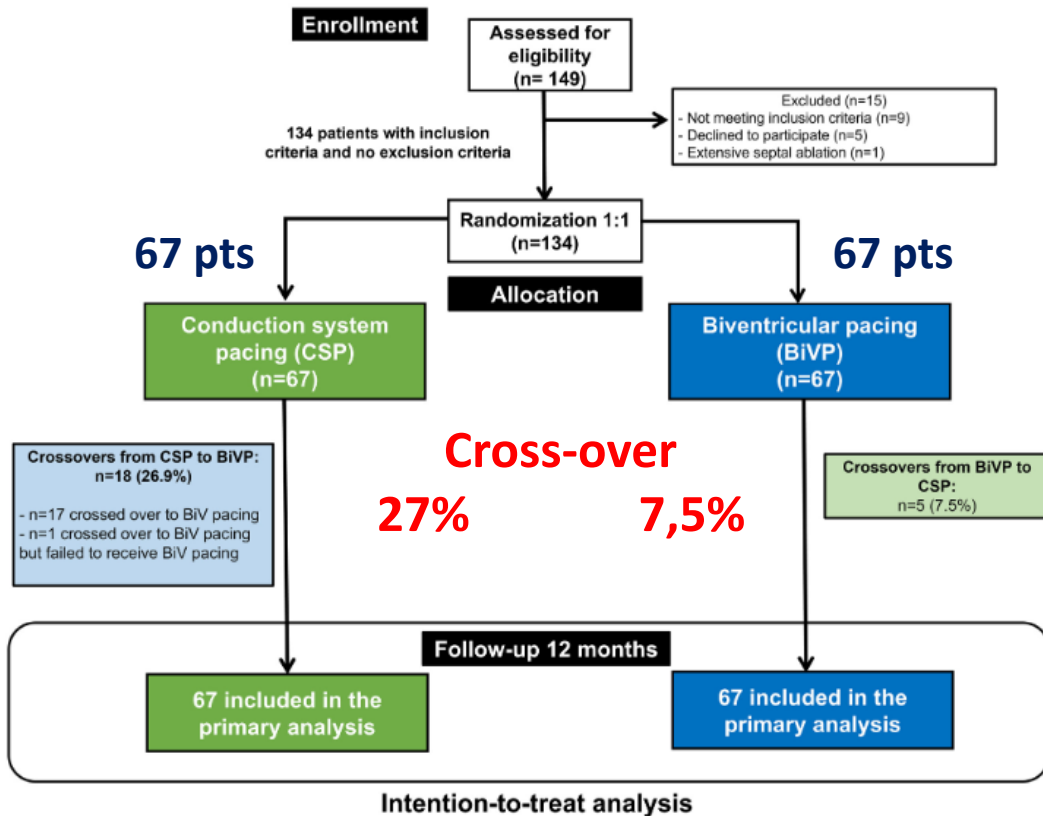
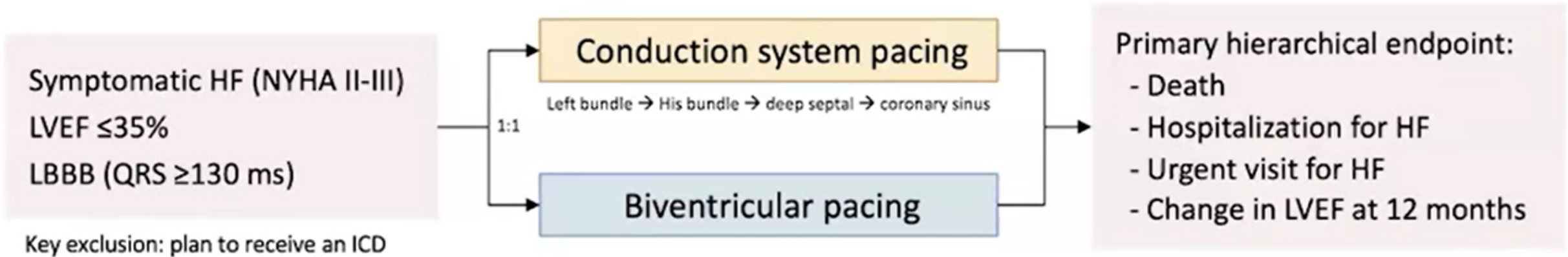


TABLE 2 Endpoints for Intention-to-Treat

	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

PHYSIOSYNC-HF trial



CSP: n = 87 ; age 61y ; QRS 180 ms ; LBBB 97% ; LVEF 26%

BiV: n = 86 ; age 63y ; QRS 180 ms ; LBBB 94% ; LVEF 27%

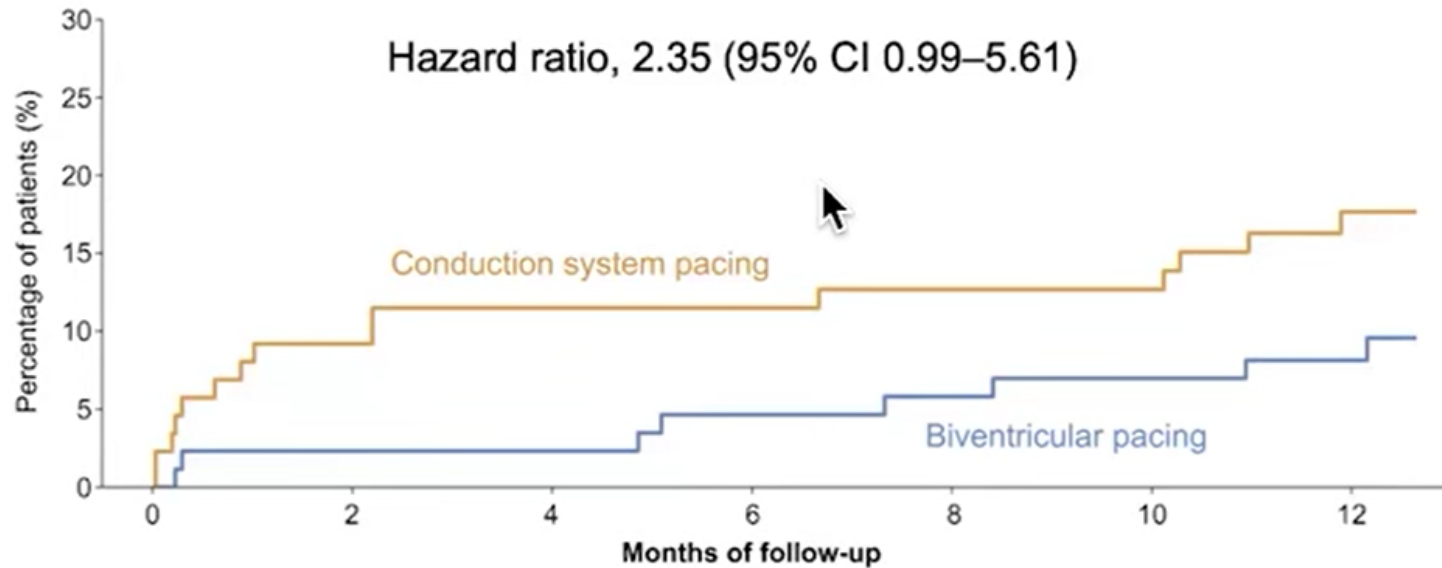
Treatment assignment was blinded to patients and non-electrophysiology personnel.
Endpoints were independently adjudicated by blinded committees.

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

PHYSIOSYNC-HF trial - Results

Death or HF events

Hazard ratio, 2.35 (95% CI 0.99–5.61)

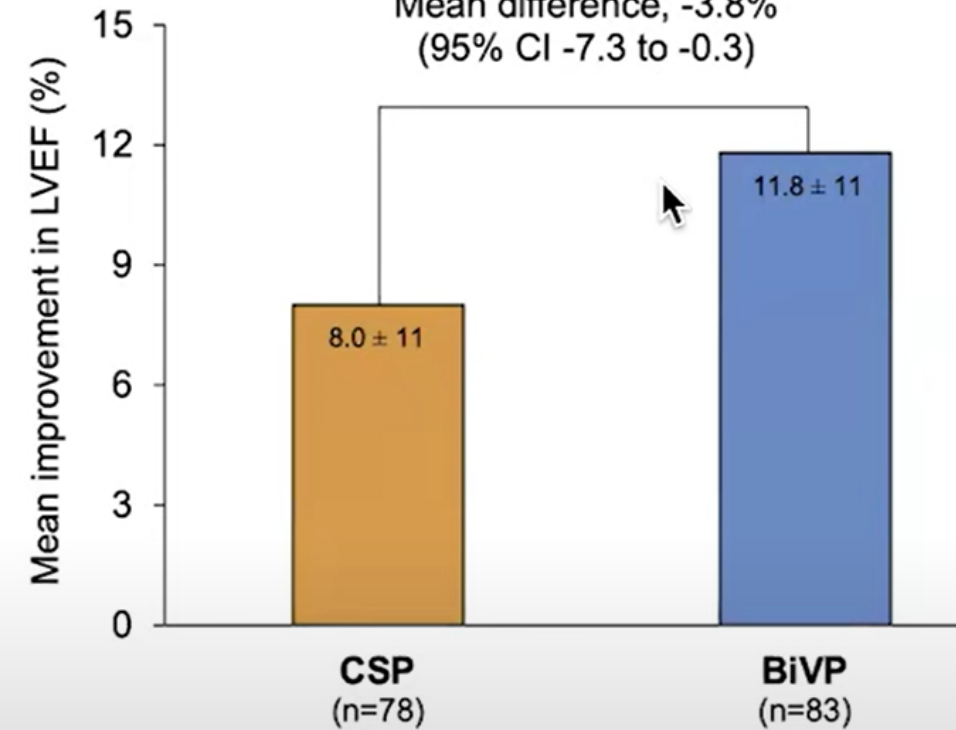


Number at risk

BiVP	86	84	84	82	81	80	69
CSP	87	79	79	76	73	73	52

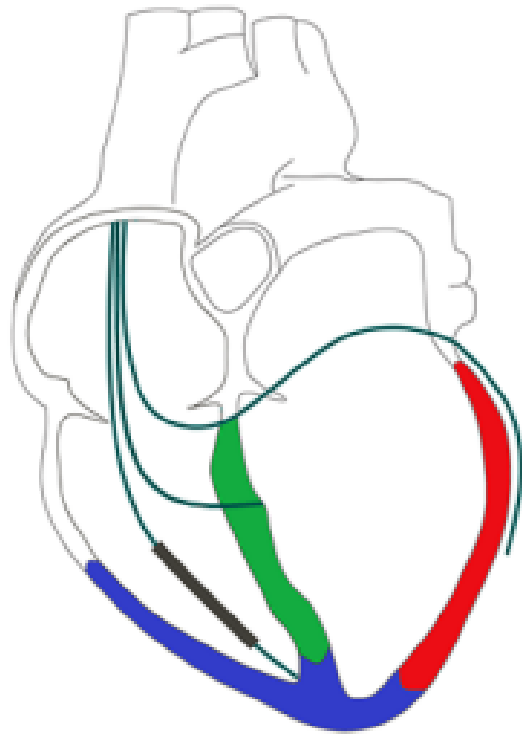
LVEF improvement

Mean difference, -3.8%
(95% CI -7.3 to -0.3)

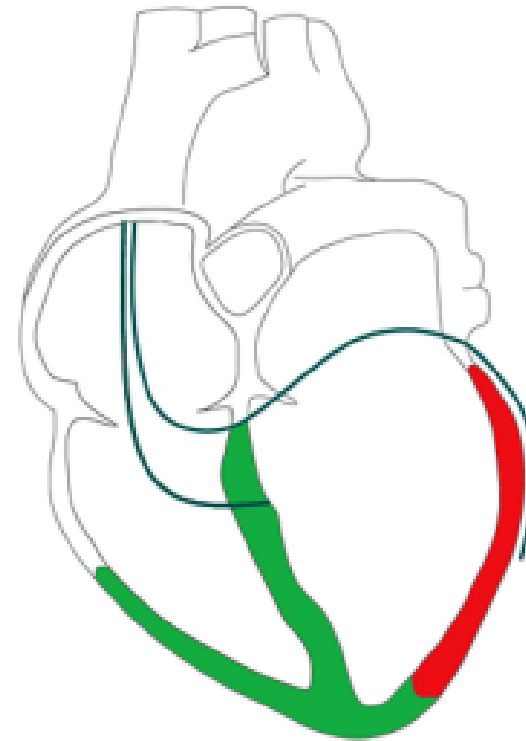


Combinaison BiV + LBBA pacing ?

LOT-CRT
(LBBAP + BiVP)



LOT-CRT
(LBBAP + CS)



Asynchronisme et resynchronisation

- Une longue route déjà réalisée



Asynchronisme et resynchronisation

- Une longue route déjà réalisée
- La suite de l'histoire reste à écrire

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