La Stimulation Cardiaque: de plus en plus physiologique

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CARDIORUN 2021

De quoi parle-t-on ?

- La stimulation physiologique / système de conduction cardiaque :
  - Stimulation Hisienne
  - Stimulation de la branche gauche du faisceau de His

Pourquoi s'intéresser à la stimulation du système de conduction cardiaque?

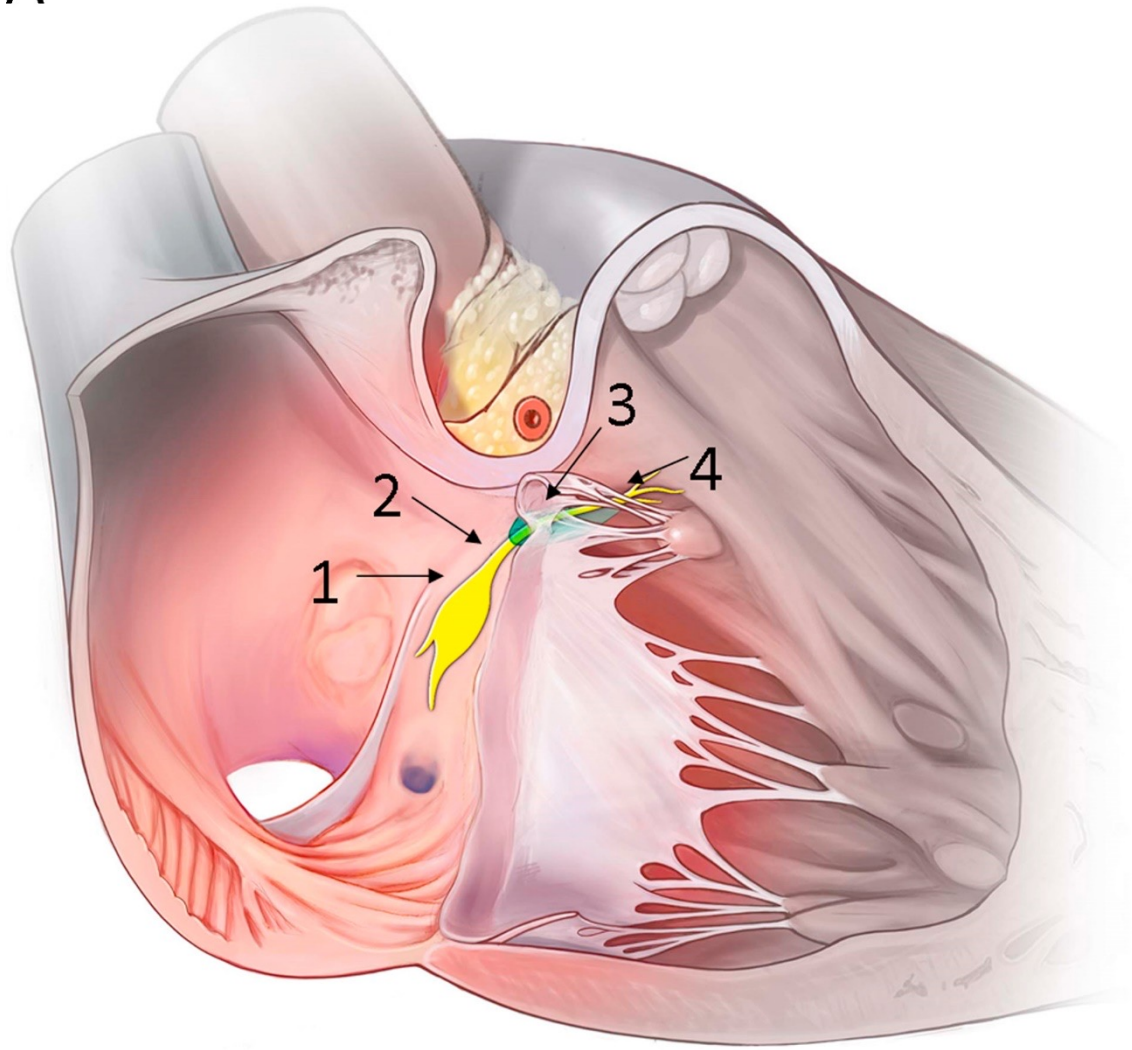
- Eviter les effets délétères de la stimulation VD au long cours

- Sur le long terme, la stimulation VD augmente :
  - L'incidence de la FA
  - L'incidence des hospitalisations pour insuffisance cardiaque
    - X 2.6 si >40%; MOST trial
    - Cut off > 20% dans des études récentes
  - La mortalité (en cas de FEVG altérée et > 40% stim VD, DAVID)

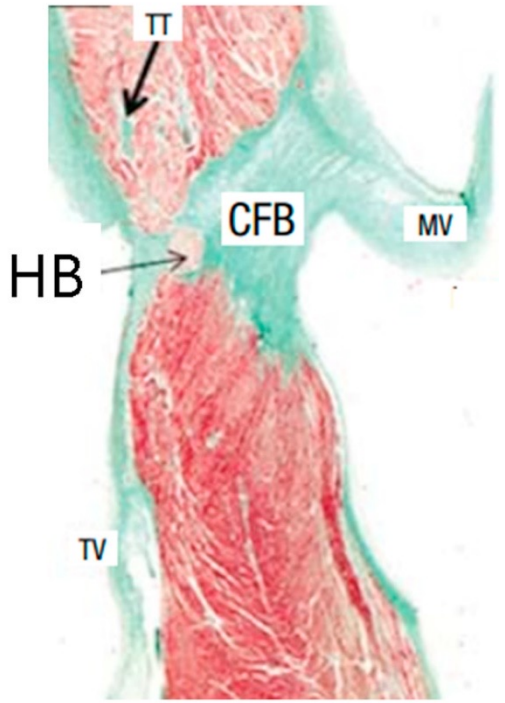
La stimulation du sytème de conduction cardiaque respecte la conduction physiologique intra-ventriculaire

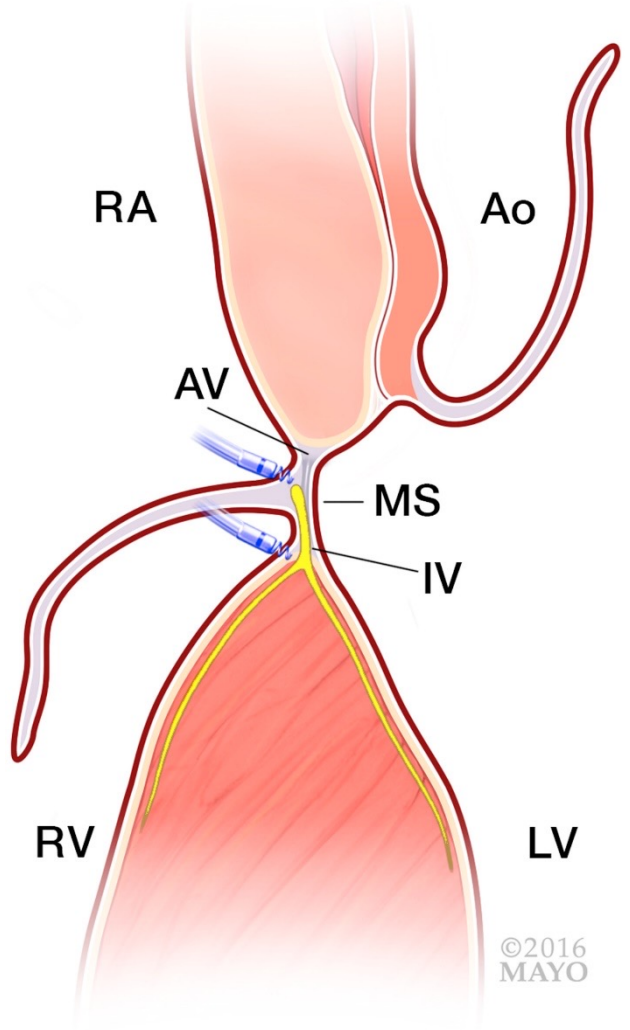
Anatomie

A

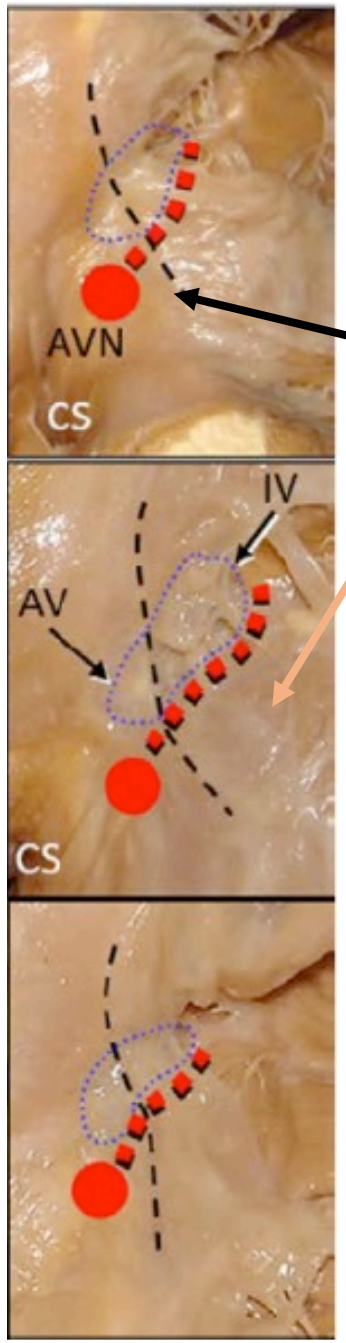


B





Variations anatomiques

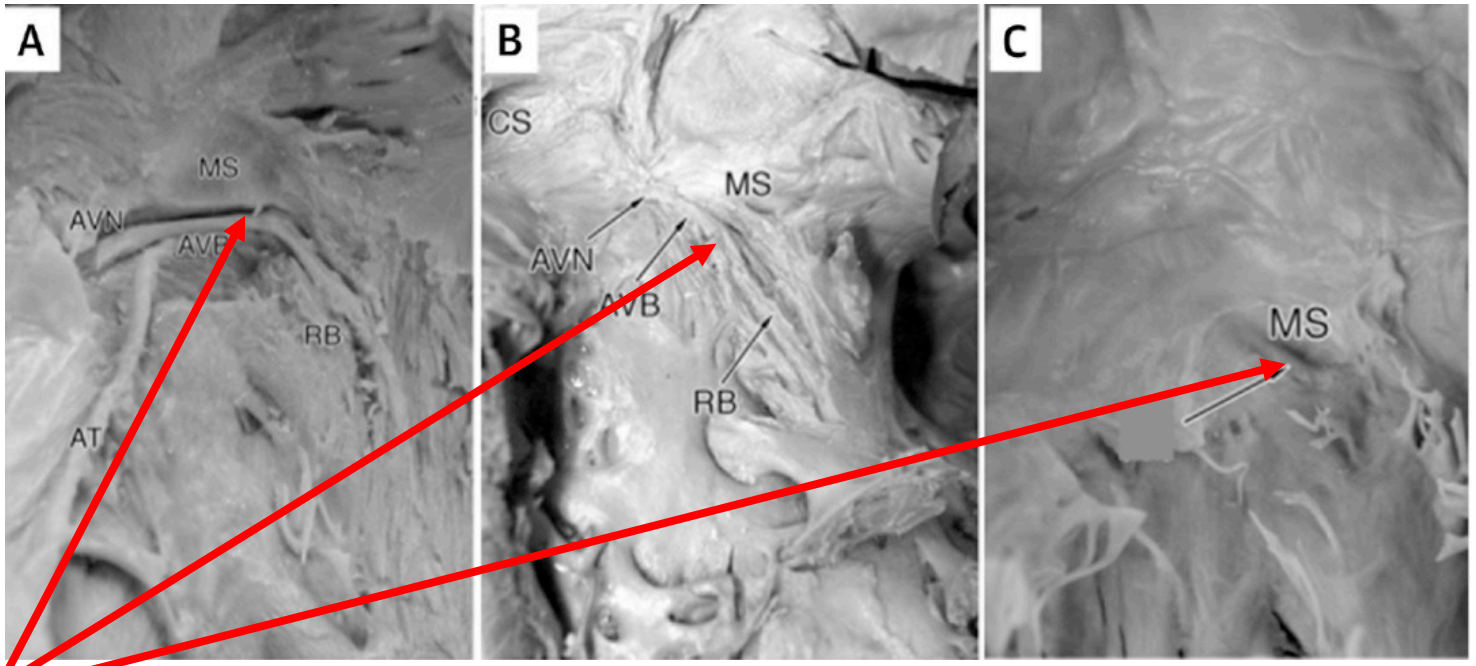


- Position

-de l'AT,

-de la valve septale/antérieure

-du His / septum membraneux



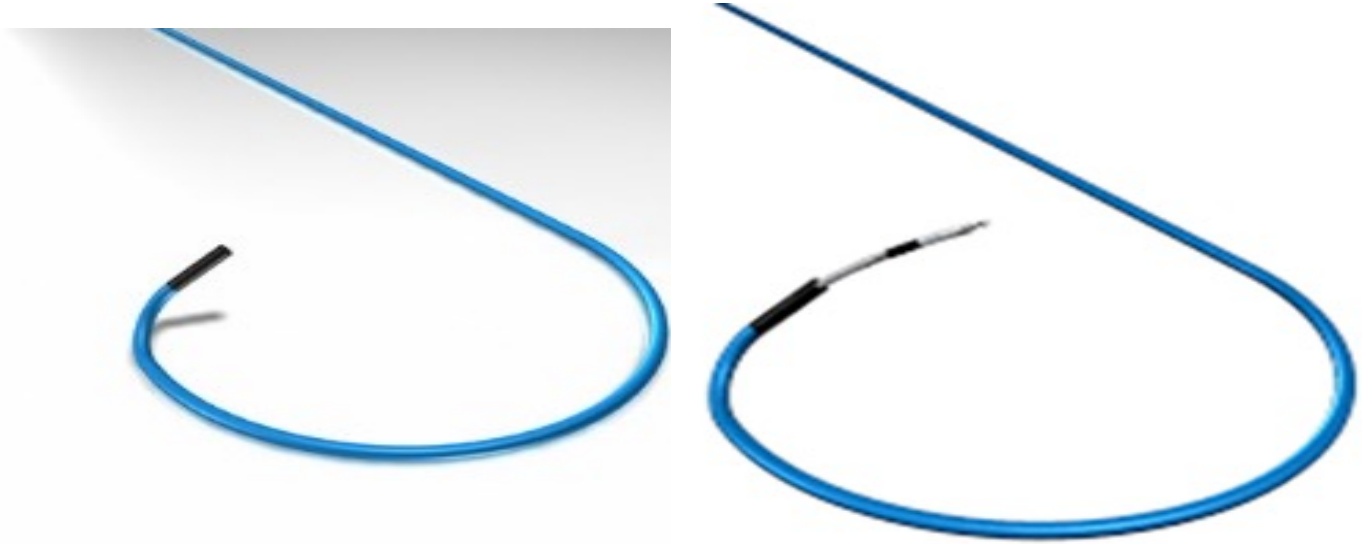
A- Type I: 46% à la bordure inf du septum membraneux recouvert d'une fine couche musculaire
B- Type II: 32% sous le septum membraneux dans le septum interventriculaire
C- Type III: 22% sur le septum membraneux non recouvert (His nu)

Nagarajan VD, et al Circ AE, 2019;12 e006897

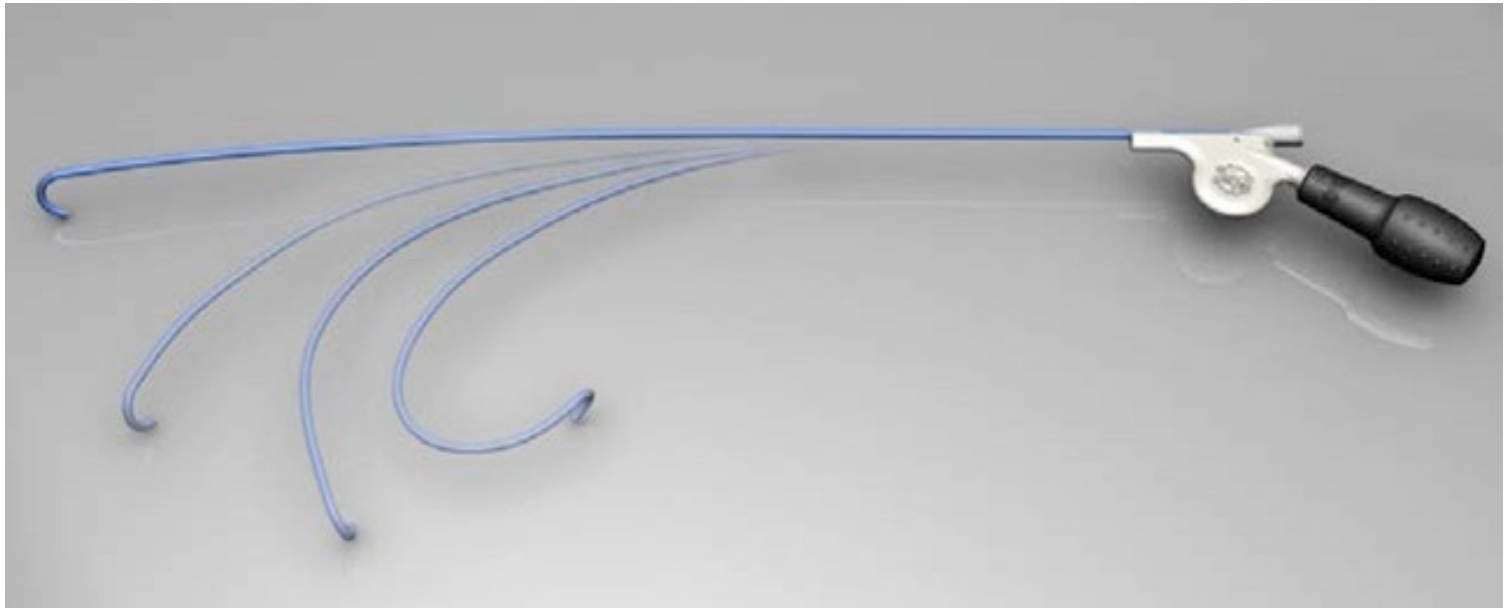
Kawashima T, et al Surg Radiol Anant 2005;27:206

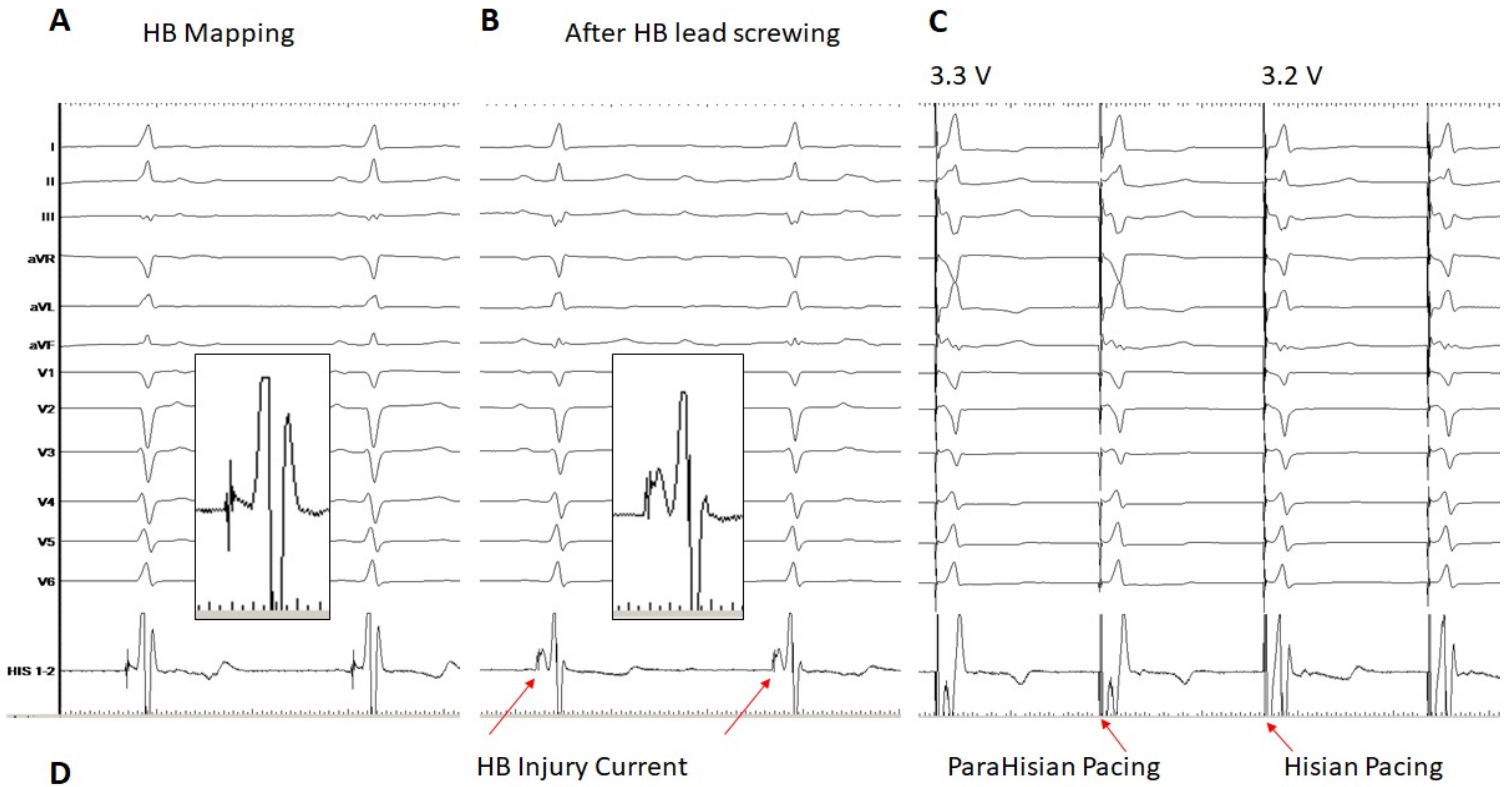
Sonde select secure de Medtronic

- Sonde fine sans lumière :
  - Pas de mandrin
  - Sonde souple avec gaine
  - -> Plus difficile à manipuler

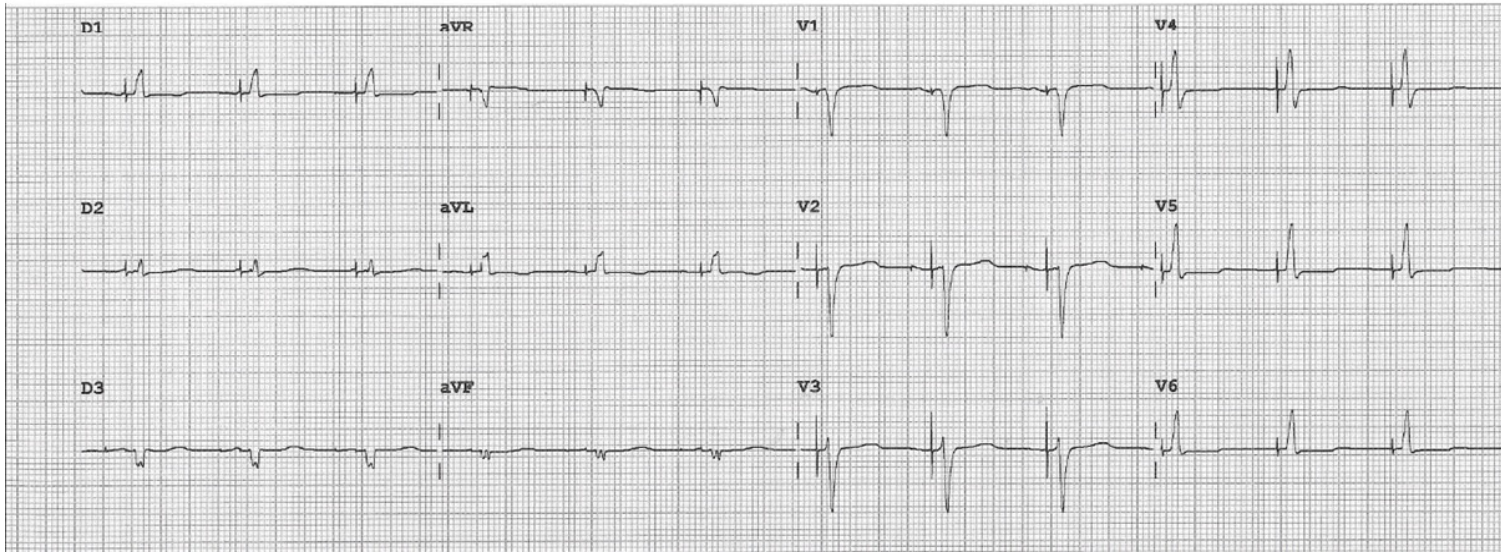


- Fixation par vis




A
HB Mapping
B
After HB lead screwing
C
3.3 V
3.2 V
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
HIS 1-2
HB Injury Current
ParaHisian Pacing
Hisian Pacing

D


D1
aVR
V1
V4
D2
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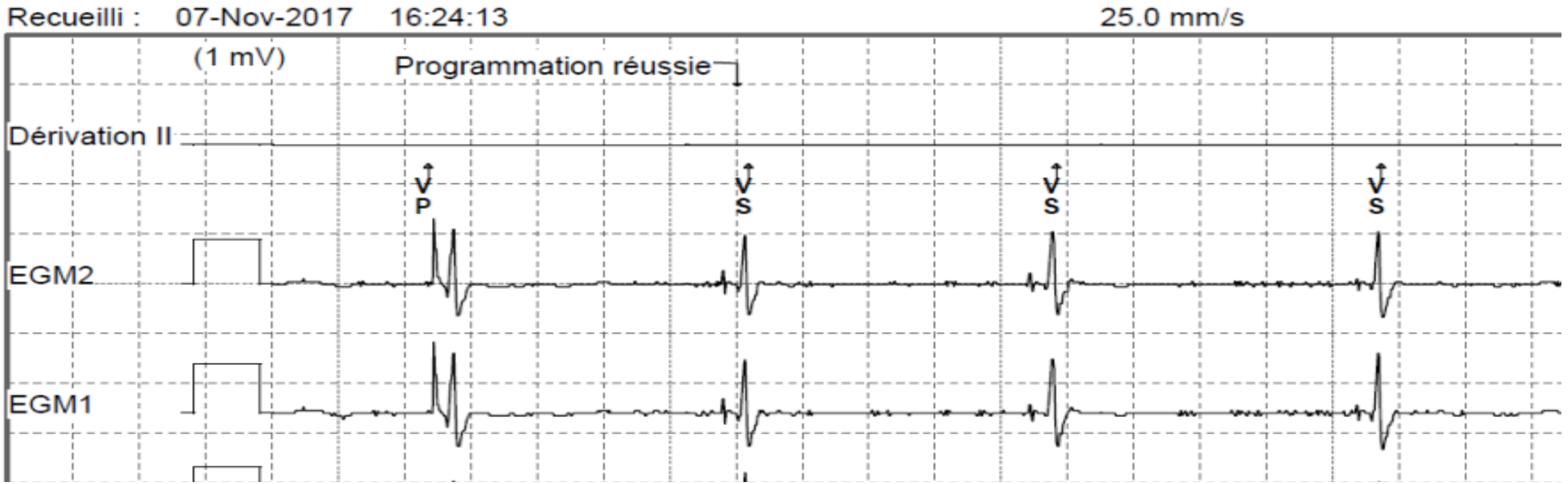
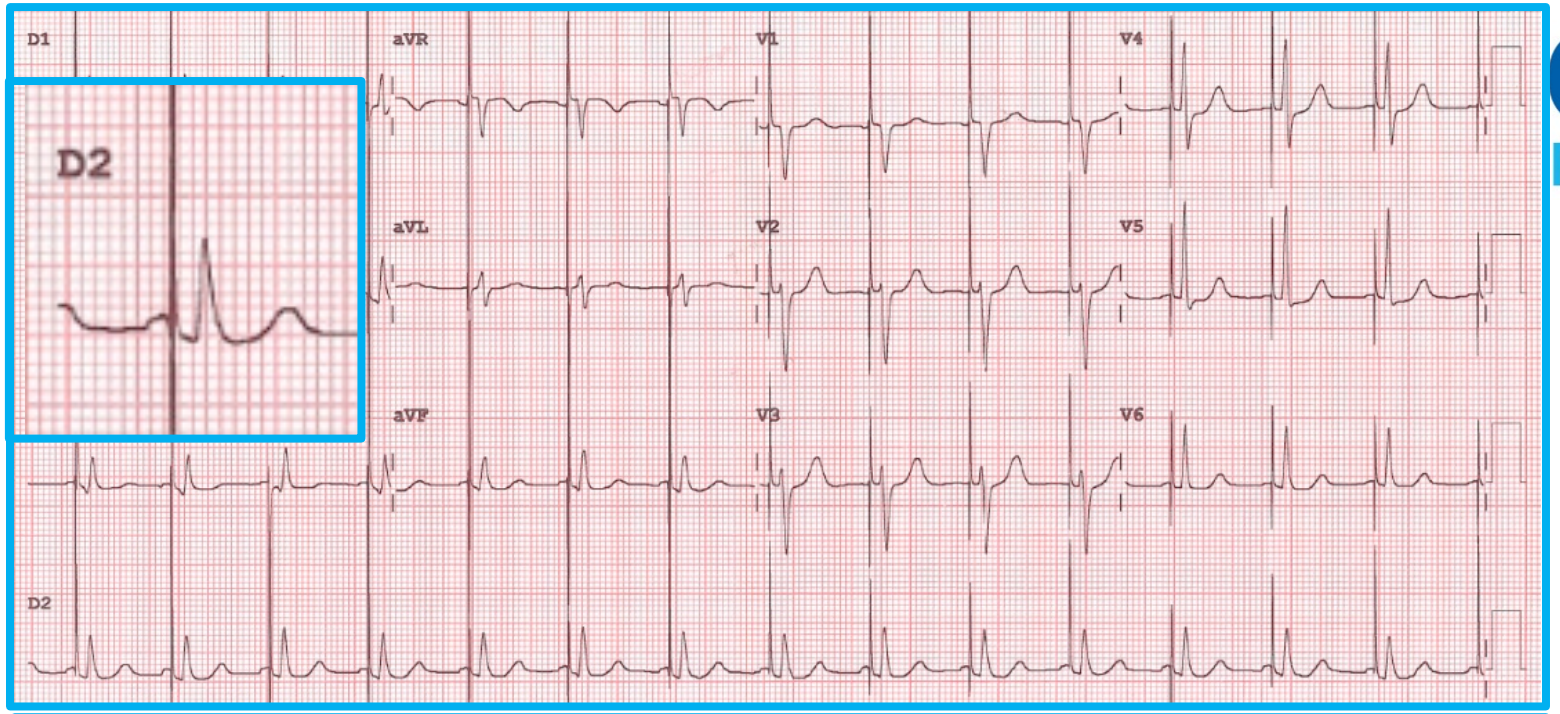
aVF
V3
V6

Enregistrement du His sur programmateur

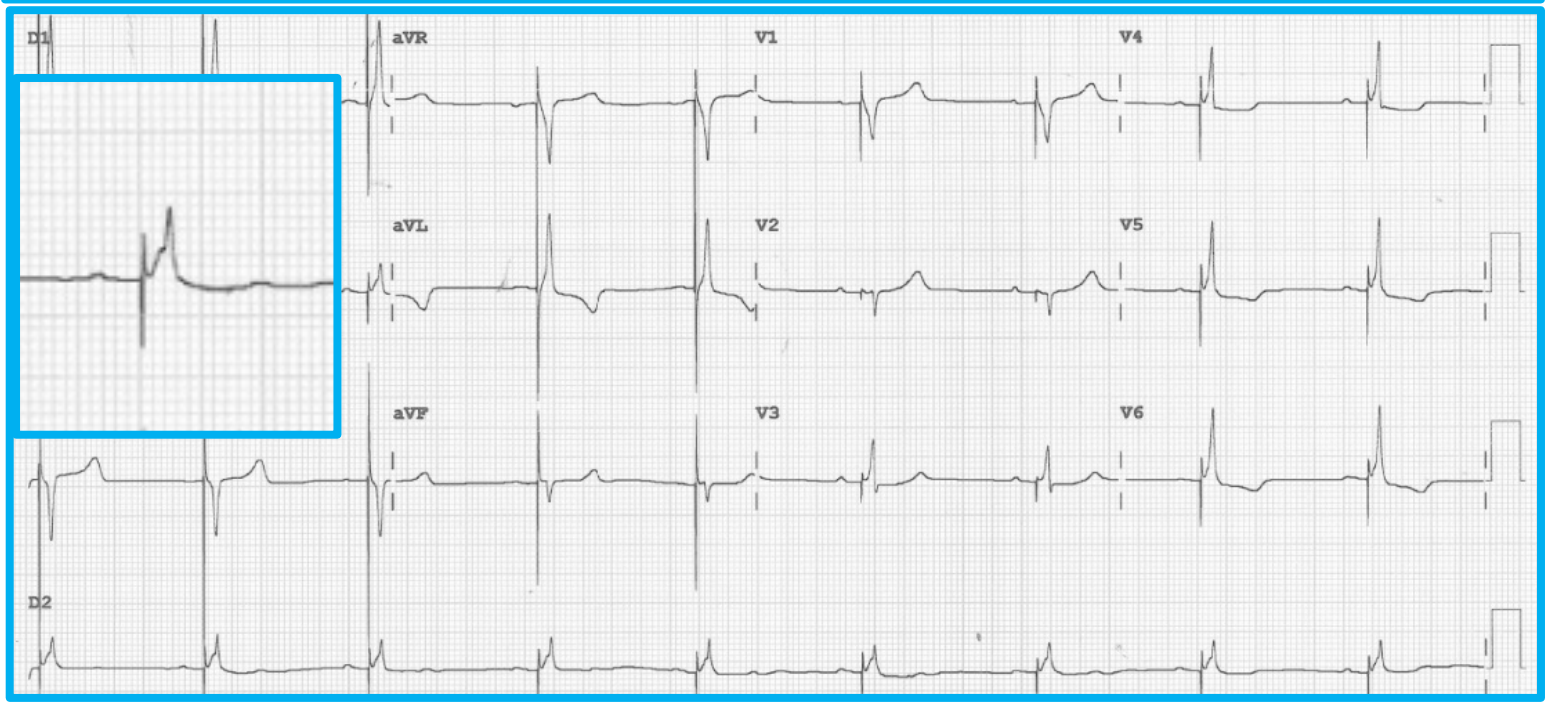


Stim. H
Sélective



Faible amplitude de stimulation

Stim. H
Non Sélective



Haute amplitude de stimulation

Pour quels patients?

- Stimulation « conventionnelle »
  - BAV de haut degré avec taux de stimulation ventriculaire anticipé important (> 40 %)
  - FA rapide non contrôlée + ablation du NAV

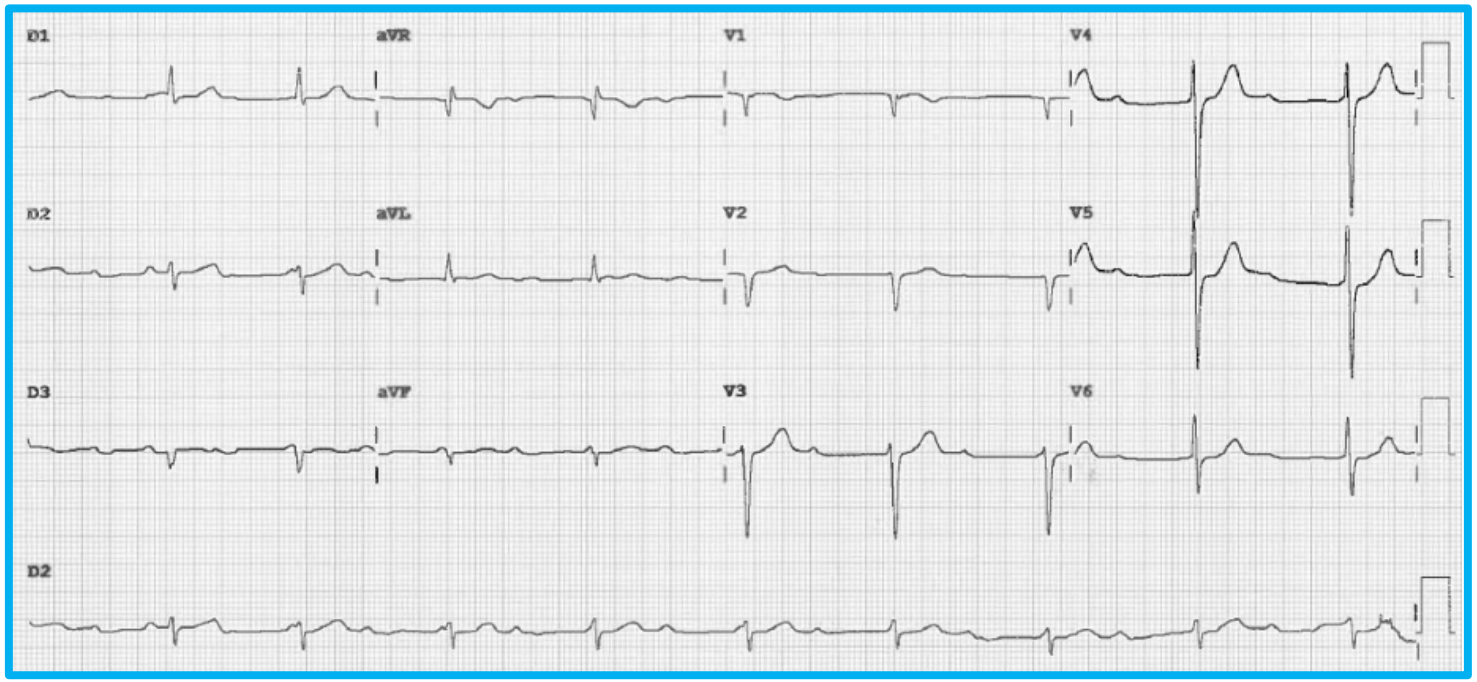
- Resynchronisation bi-ventriculaire

BAV de haut degré

Implantation success and clinical results

First Author, Year (Ref. #)	Design	Follow-up (Months)	N	Indication	Success (%)	Important Characteristics	Outcomes
Barba-Pichardo et al., 2010 (41)	Prospective	>3	91	AV nodal 65 Infranodal 26	68 57	182 patients with AV block mapped with EP catheter	5% lead failure
Kronborg et al., 2014 (40)	Randomized crossover HBP vs. RVSP	24	38	AV nodal block	84	AV block, baseline narrow QRS, LVEF >40%	Improvement in LVEF, no significant improvement in functional class, 6MWT, QOL
Pastore et al., 2015 (58)	Retrospective	12	148	AV nodal 100 Infranodal 48		High-grade AVB, Paroxysmal AF	HBP associated with lower risk of AF progression compared with RV pacing
Vijayaraman et al., 2015 (29)	Observational	19	100	AV nodal 46 Infranodal 54	93 76	High-grade AV block, no back-up RV pacing	High success in infranodal block. Lead failure 5%

Nodal AVB


D1
aVR
V1
V4
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aVL
V2
V5
D3
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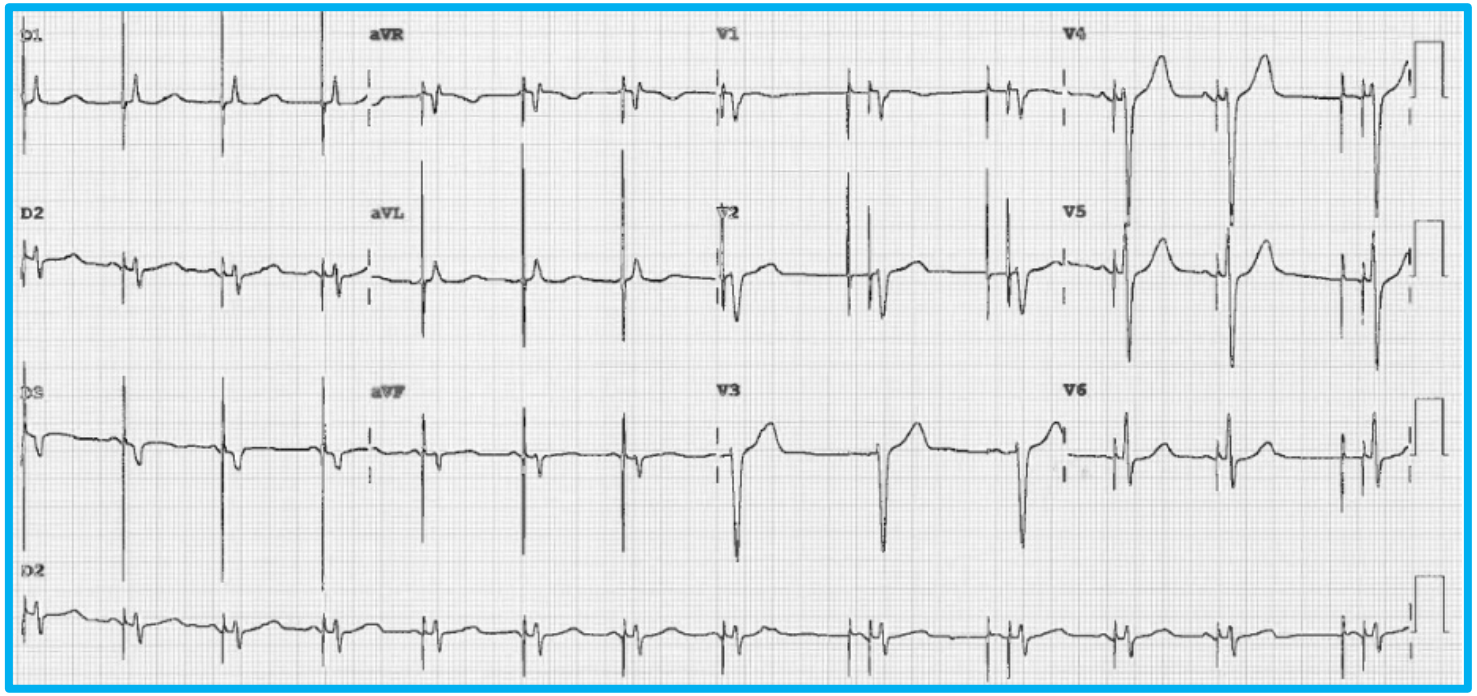
V3
V6
D2


D1
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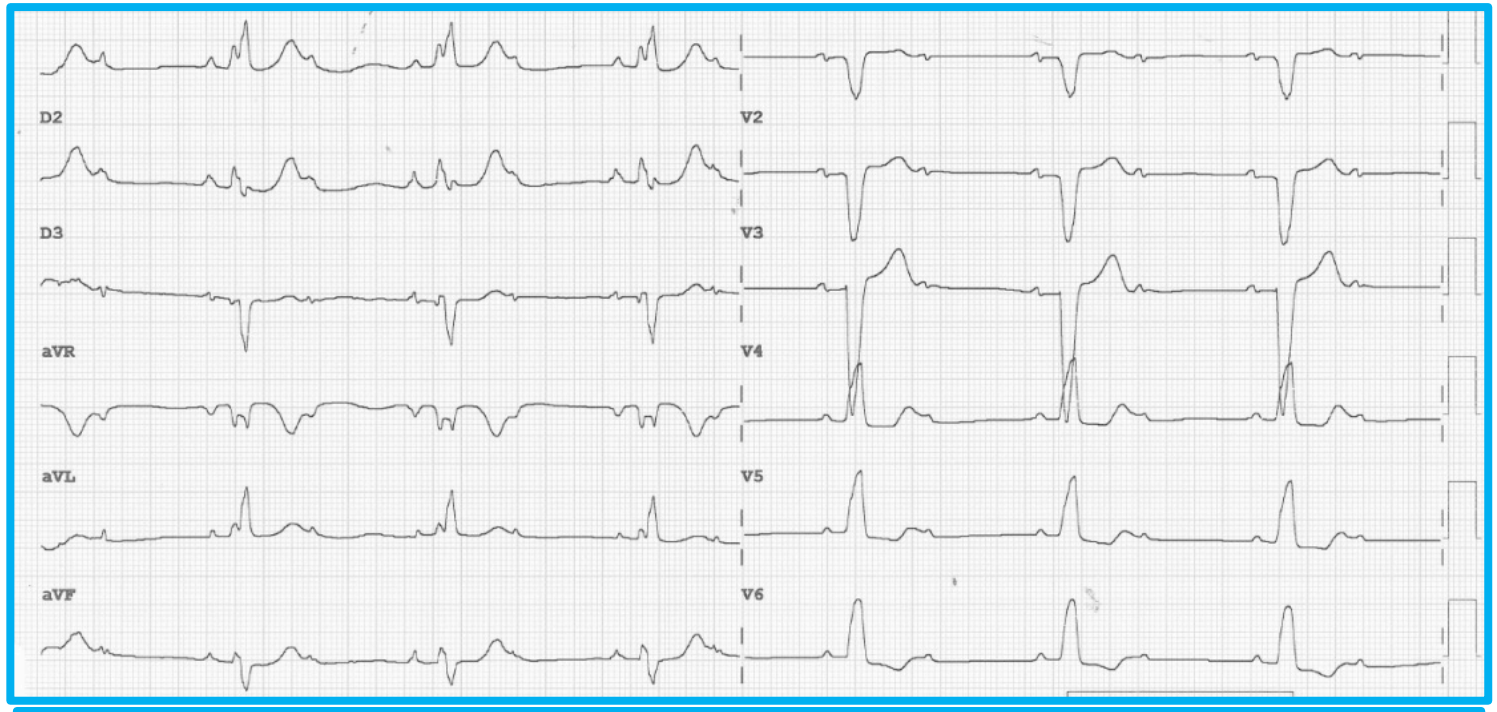
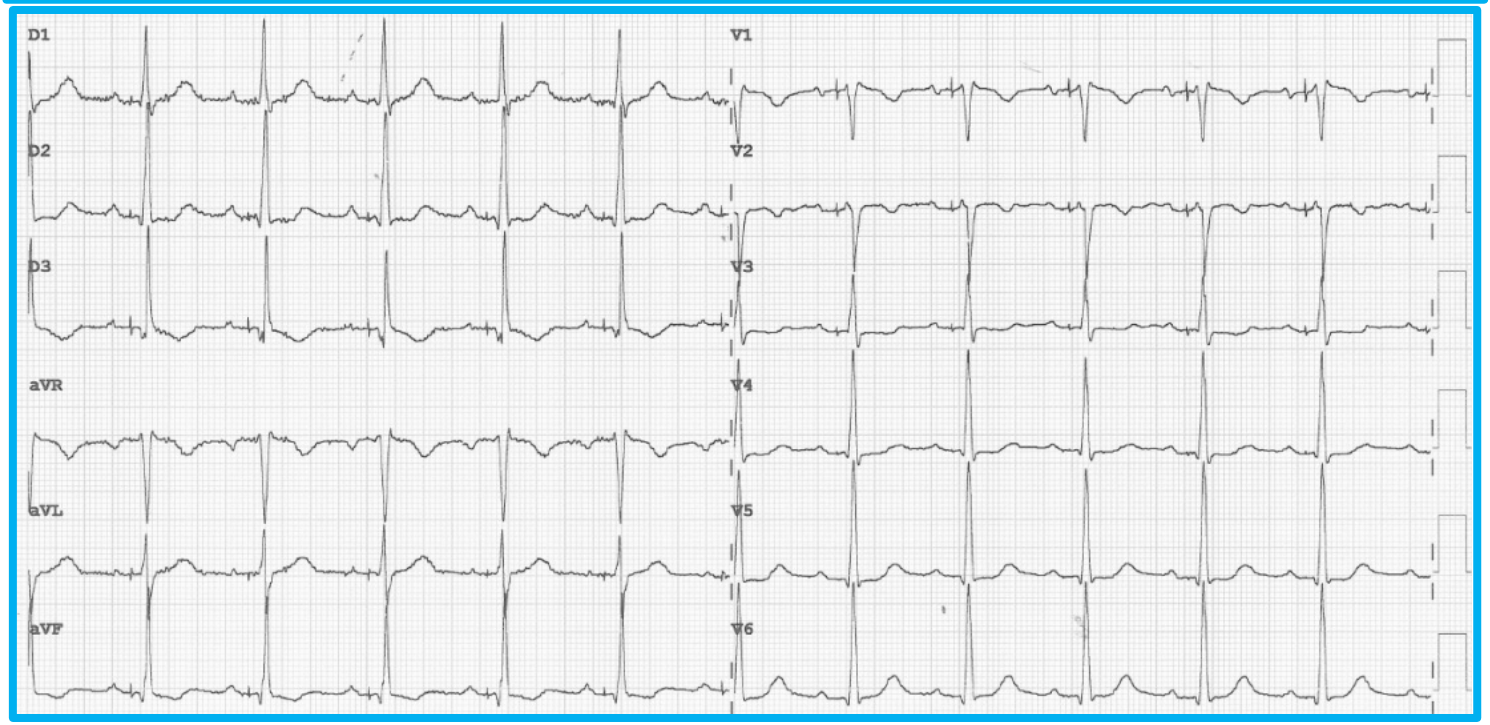
V5
D3
aVF
V3
V6
D2

Infra nodal AVB





Clinical Outcomes of His Bundle Pacing Compared to Right Ventricular Pacing

Mohamed Abdelrahman, MD, Faiz A. Subzposh, MD, Dominik Beer, DO, Brendan Durr, DO, Angela Naperkowski, RN, CEPS, CCDS, FHRS, Haiyan Sun, MS, Jess W. Oren, MD, Gopi Dandamudi, MD, FHRS, Pugazhendhi Vijayaraman, MD, FACC

- Systematic HBP at 1 institution
- RVP at the other
- 2013-2016
- Last FU 12/2017

	His Bundle Pacing (N=332)	RV pacing (N=433)	P-value
Age, mean (SD)	74.8 (11.0)	76.4 (11.3)	0.053
Race, White, N (%)	326 (98.2)	430 (99.3)	0.19
Gender, Male, N (%)	200 (60.2)	227 (52.4)	**0.03**
Active Smoking	22 (6.6)	20 (4.6)	0.23
Baseline Ejection Fraction %, mean (SD)	54.9 (8.5)	54.2 (10.2)	0.28
Baseline QRS duration in ms, mean (SD)	104.5 (24.5)	110.5 (28.4)	**< 0.01**
Ventricular pacing burden, mean (SD)	54.5 (45.2)	58.3 (43.8)	0.24
Sinus Node Dysfunction, N (%)	118 (36)	152 (35)	0.90
AV conduction Disease, N (%)	214 (64)	283 (65)	0.80
Dual Chamber PPM (DDD), N (%)	270 (81.3)	369 (85.2)	0.15
Single Chamber PPM (VVI), N (%)	51 (15.4)	64 (14.8)	0.82

JACC 2018

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		His Bundle Pacing (N=304)	RV pacing (N=433)	P-value
	Procedure duration (min), mean (SD)	70.21 (34)	55.02 (25)	**< 0.01**
	Fluoroscopy duration (min), mean (SD)	10.27 (6.5)	7.40 (5.1)	**< 0.01**
Measurements at implant	**QRS duration (ms),** mean (SD)	104.5 (24.5)	110.5 (28.4)	**< 0.01**
	Capture threshold (V @ ms), mean (SD)	1.30 (0.85) @ 0.79 (0.26)	0.59 (0.42) @ 0.5 (0.03)	**< 0.01**
	R wave amplitude (mV), mean (SD)	4.93 (3.46)	11.24 (6.37)	**< 0.01**
	Ventricular impedance (Ohms), mean (SD)	550 (126)	723 (162)	**< 0.01**
Measurements at last follow-up	**QRS duration (ms),** mean (SD)	128 (27.7)	166 (21.8)	**< 0.01**
	Capture threshold (V @ ms), mean (SD)	1.56 (0.95) @ 0.78 (0.30)	0.76 (0.29) @ 0.46 (0.09)	**< 0.01**
	R wave amplitude (mV), mean (SD)	5.54 (5.0)	11.7 (5.5)	**< 0.01**
	Ventricular Impedance (Ohms), mean (SD)	456 (68)	517 (116)	**< 0.01**
	Change in threshold (V), mean (SD)	0.28 (1.1)	0.16 (0.5)	0.09

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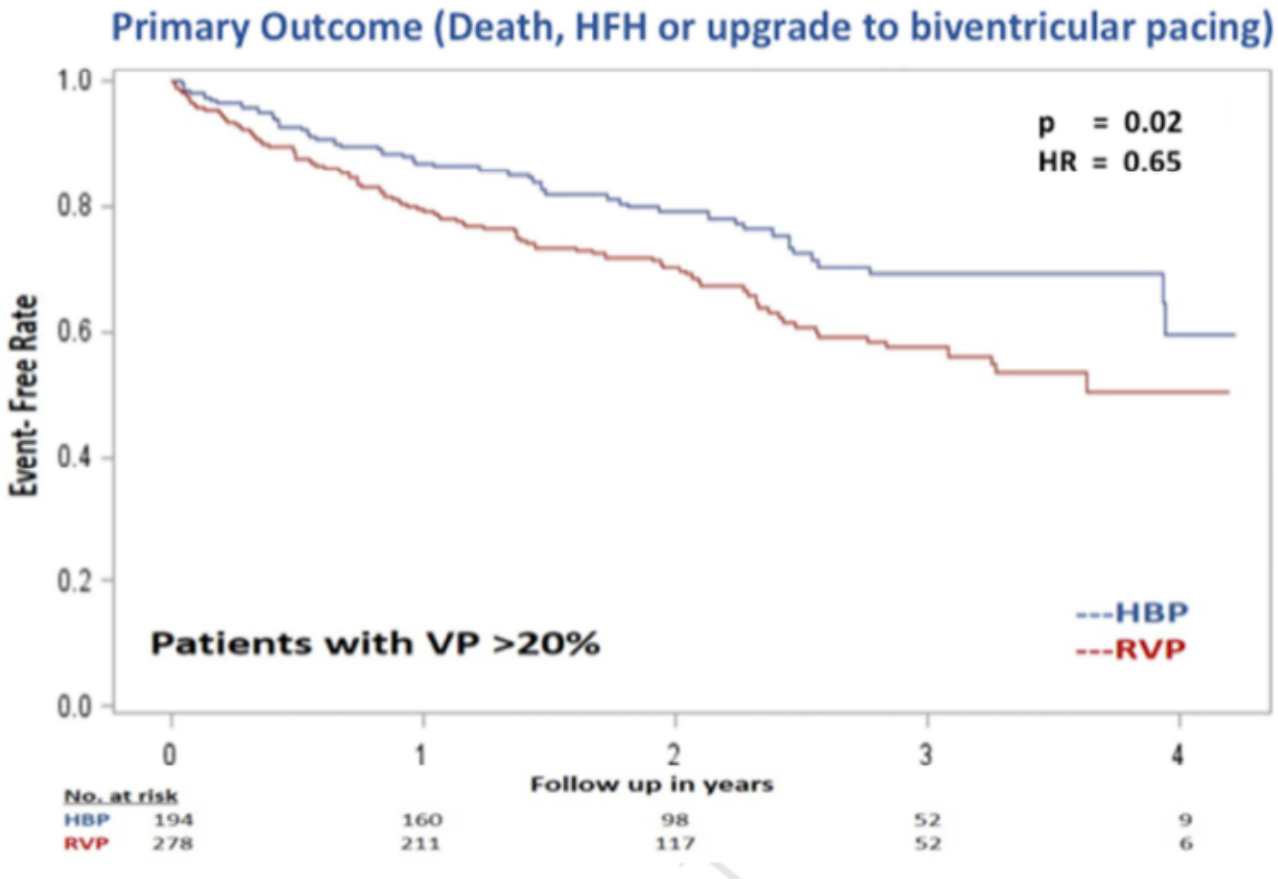

	Multivariate analysis		
	HR	CI	P value
HBP vs RVP	0.71	0.534-0.944	0.02
Age	1.022	1.007-1.037	< 0.01
Male gender			
Hypertension			
Diabetes			
Hyperlipidemia			
Coronary Artery Disease requiring intervention			
Chronic Kidney Disease	1.747	1.317-2.317	< 0.01
Ischemic Stroke			
Heart Failure	2.087	1.57-2.763	< 0.01
Atrial Fibrillation			
ACE or ARB			
Beta Blockers			
Antiarrhythmic usage			
Baseline QRS duration			
Paced QRS duration			
Baseline Ejection Fraction	0.982	0.970-0.994	< 0.01
Ventricular pacing percentage			

Mean FU duration : 725±423 d

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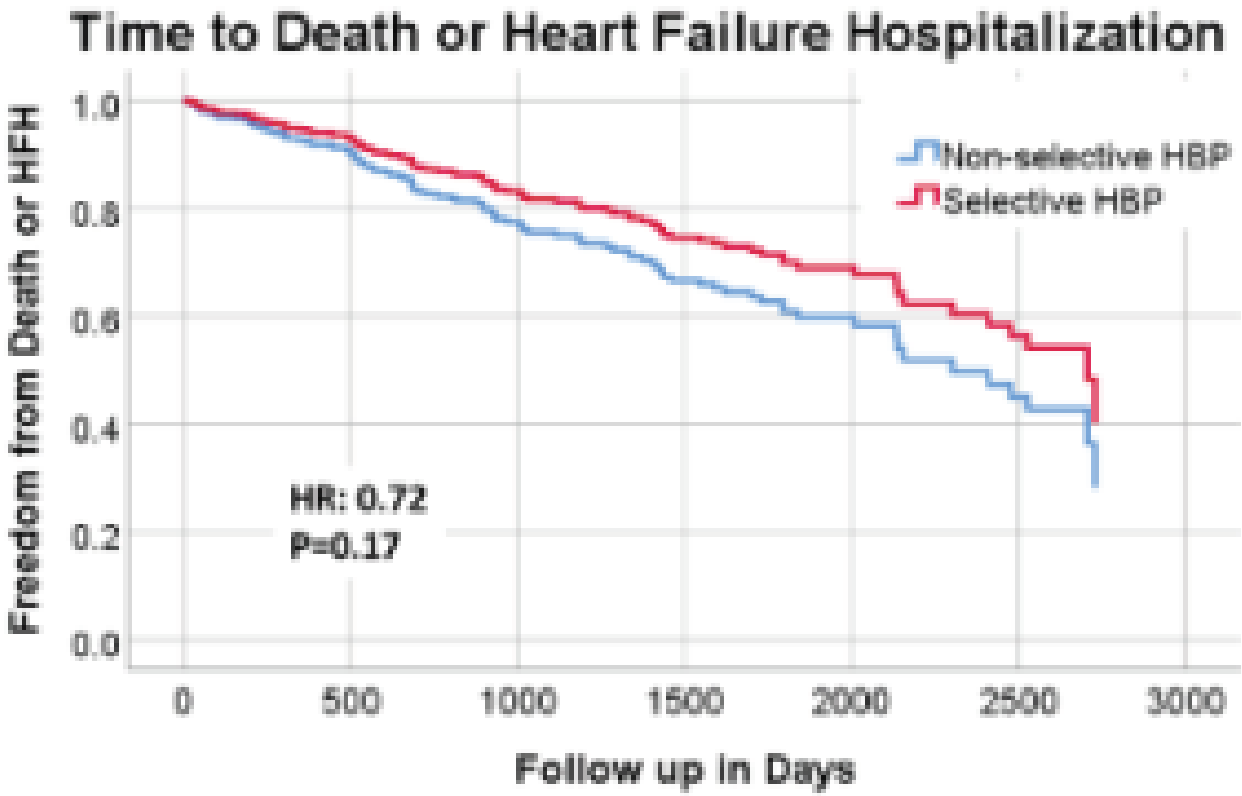
Selective vs Non selective HB Pacing

- 350 patients
  - sHBP = 118
  - nsHBP = 232
- Mean FU=1022 d



- Similar outcome
- Battery consumption ?

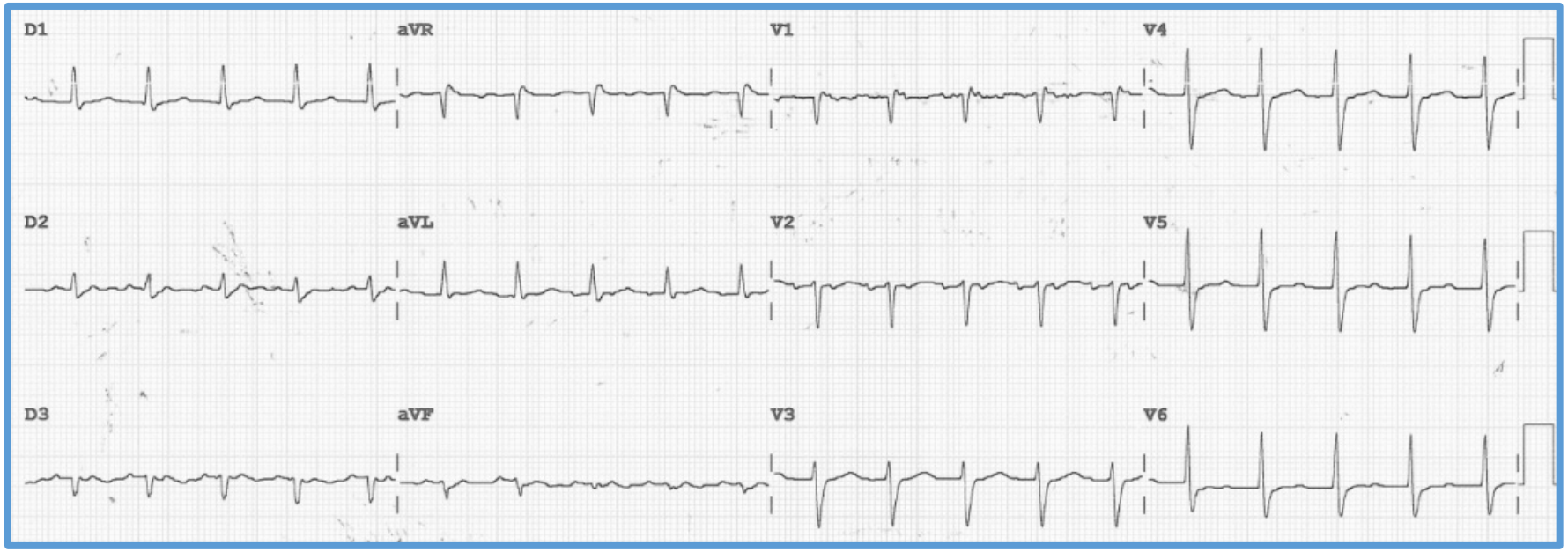
Beer D, et al. LBT HRS 2019

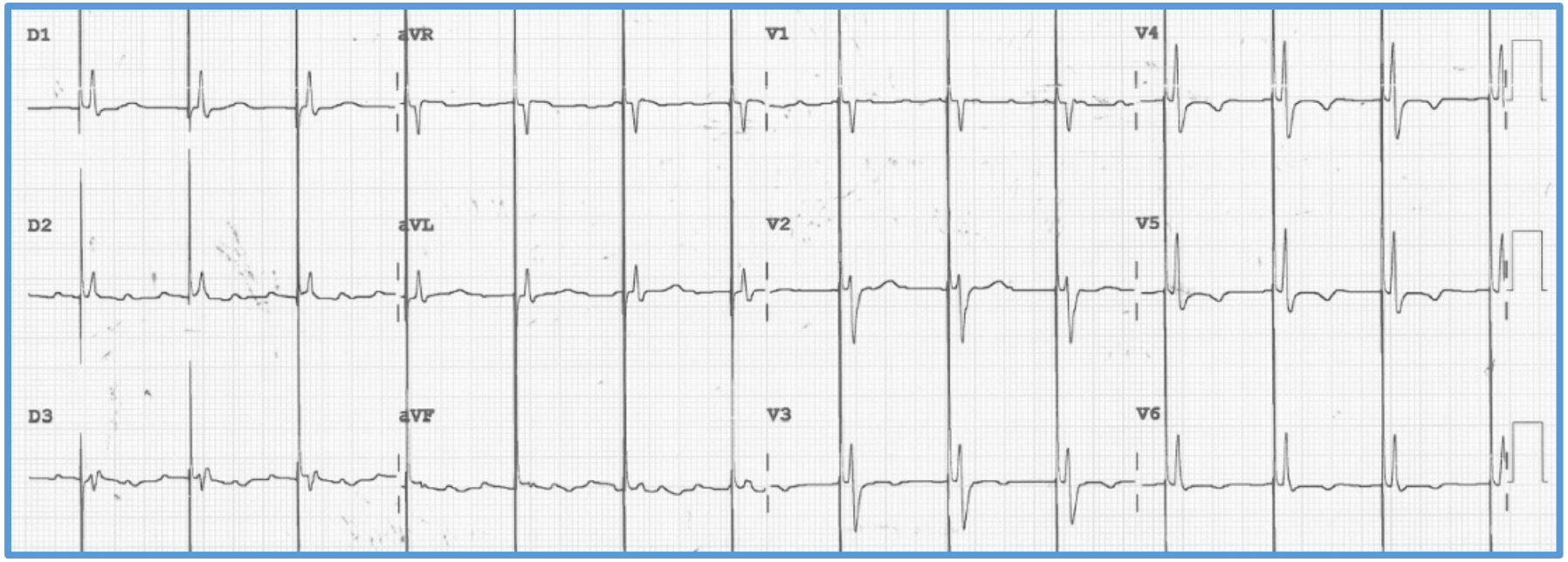
FA rapide et ablation du NAV

Implantation success and clinical results

TABLE 2 Permanent His Bundle Pacing in AV Node Ablation/AV Block

First Author, Year (Ref. #)	Design	Follow-up (Months)	N	Indication	Success (%)	Important Characteristics	Outcomes
Deshmukh et al., 2000 (5)	Observational	36	18	AV node ablation	66	Chronic AF, LVEF <40%, QRS duration <120 ms	Improvement in LV dimensions, NYHA functional class, and LVEF
Deshmukh et al., 2004 (35)	Observational	42	54	AV node ablation	72	Chronic AF, LVEF <40%, QRS duration <120 ms	Improved LVEF, NYHA functional class, peak VO_2
Occhetta et al., 2006 (36)	Randomized, 6 months, crossover RVP vs. HBP	12	18	AV node ablation	94	Chronic AF, QRS <120 ms	Improvement in NYHA functional class, 6MWT, QOL, and hemodynamics


D1
aVR
V1
V4
D2
aVL
V2
V5
D3
aVF
V3
V6


D1
aVR
V1
V4
D2
aVL
V2
V5
D3
aVF
V3
V6

2019 ESC recommendations for SVT management

Recommendation	Class[a]	Level[b]
Acute therapy		
Treatment of an underlying condition is recommended as a first step, if feasible.[209]	I	C
i.v. beta-blockers, or i.v. non-dihydropyridine calcium channel blockers (verapamil or diltiazem) should be considered.[213,214]	IIa	B
Chronic therapy		
Oral verapamil or diltiazem should be considered for patients with recurrent symptomatic multifocal AT in the absence of HFrEF.[217,218]	IIa	B
A selective beta-blocker should be considered for patients with recurrent symptomatic multifocal AT.[214,219]	IIa	B
AV nodal ablation followed by pacing (preferable biventricular or His-bundle pacing) should be considered for patients with LV dysfunction due to recurrent multifocal AT refractory to drug therapy.[216]	IIa	C

Long term Performance of HBP

Baseline characteristics	Total (n = 844)
Age at implant, y—mean ± SD	75 ± 9
Sex (Male)	59.1% (499)
Pacing indication	
Brady + atrial fibrillation	39.7% (335)
AV block	41.2% (348)
Sinus node disease	17.4% (147)
Heart failure	1.7% (14)
Ischemic cardiomyopathy	16.0% (135)
Previous myocardial infarction	20.0% (169)
Hypertension	83.3% (703)
Preimplant sinus rhythm	62.8% (530)
Presence of atrial fibrillation	54.5% (460)
History of heart failure	36.7% (310)
NYHA class	
I	40.4% (216/534)
II	42.9% (229/534)
III	16.1% (86/534)
IV	0.5% (3/534)
LVEF (%)—mean ± SD	56 ± 10
LVEF < 45%	12.1% (102)
Diabetes	30.6% (258)
Anticoagulation therapy	44.2% (371)

- 2 centers retrospective study
- 2004-2016 (mean FU= 3.9±3.2 y)
- A large majority of conventional pacing indications

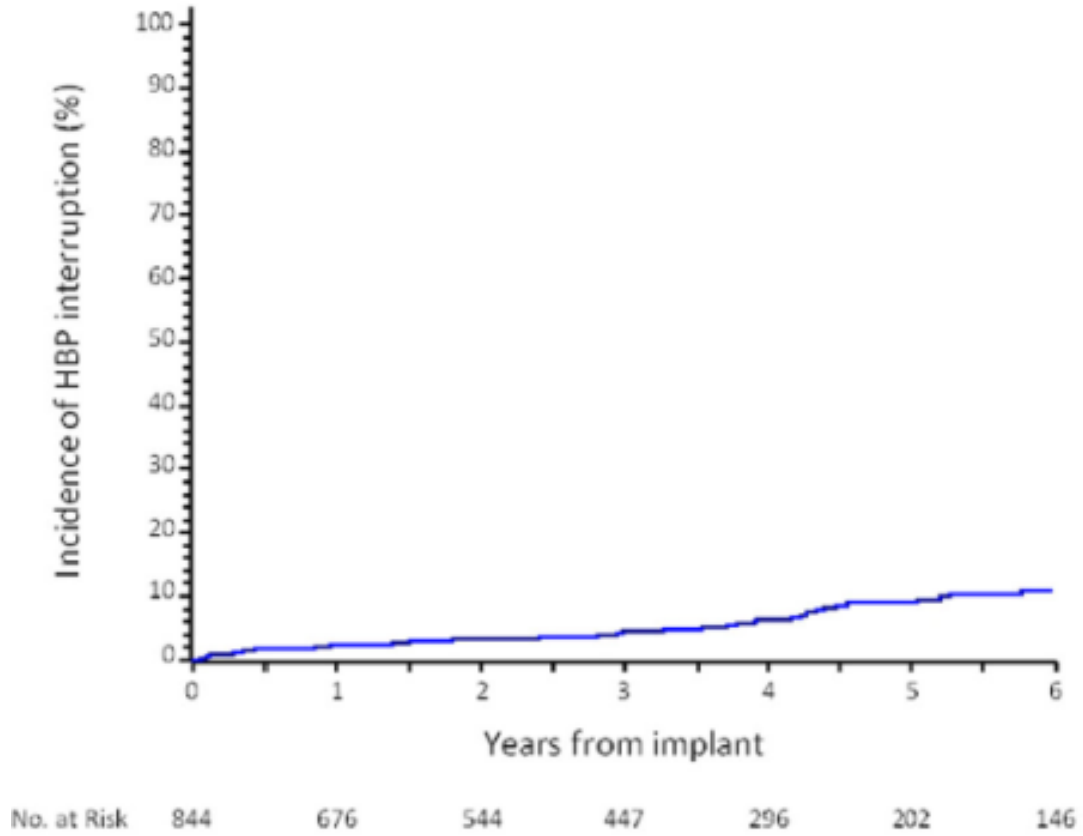
		Implant (844 patients)	Last follow-up (844 patients)
	Mean ± SD	123 ± 25	123 ± 29
Paced QRS (ms)	Median (IQR)	120 (100-140)	120 (100-140)
Pacing threshold, V	Mean ± SD	1.6 ± 1.0	2.0 ± 1.4
	Median (IQR)	1.4 (1-2)	1.5 (1-3)
Duration, ms	Mean ± SD	0.8 ± 0.4	0.8 ± 0.4
	Median (IQR)	0.5 (1-1)	0.5 (0-1)
Sensing, mV	Mean ± SD	4.5 ± 3.5	5.1 ± 4.8
	Median (IQR)	3.5 (2-6)	3.8 (2-6)
Impedance, ohm	Mean ± SD	582 ± 146	483 ± 103
	Median (IQR)	550 (490-638)	463 (427-520)

- Mean time to generator change for EOL: 5.9±2.1 y

Zanon F, et al. JCE 2019;30:1594

Long term Safety of HBP

- ~ 8% of HBP interruption at 6 year FU



Capture threshold ≥ 2.5 V	27.6% (233/844)
Capture threshold > 2.5 V	23.3 (197/844)
Capture threshold = 2.5 V	4.3% (36/844)
Interruption of HIS pacing	7.6% (64/844)
Capture threshold ≥ 5 V	2.6% (22/844)
Capture threshold ≥ 3.5 V and < 5 V	3.4% (29/844)
Sensing issues	0.2% (2/844)
Infection	0.5% (4/844)
Upgrading to biventricular device	0.6%(5/844)
Lead fracture	0.1% (1/844)
Lead dislodgement	0.1% (1/844)

Zanon F, et al. JCE 2019;30:1594

Expérience Normande (>nov. 2017)

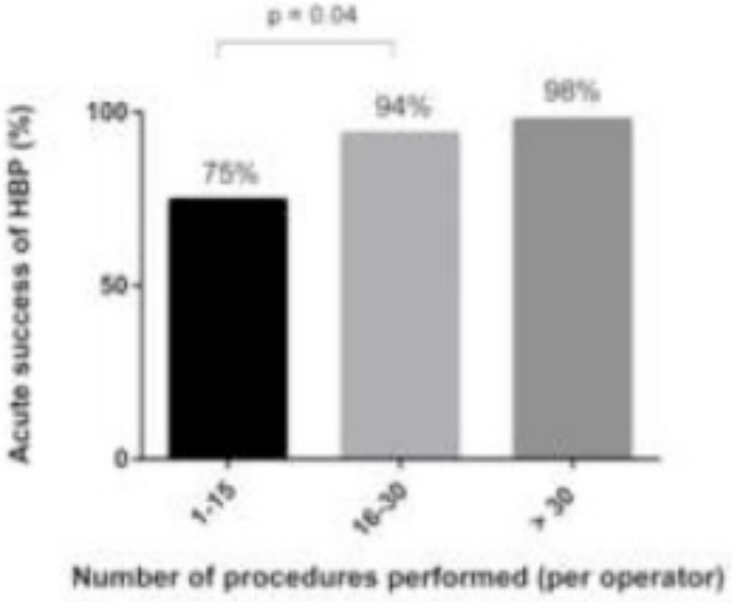
- HBP was successful in 147 of 170 patients (86.5%);
  - selective HBC was obtained in 96 patients
  - nonselective HBC occurred in 45 patients.
- Procedure:
  - mean procedure duration was 67.0±28.8 min
  - mean fluoroscopy duration was 7.3±8.1 min

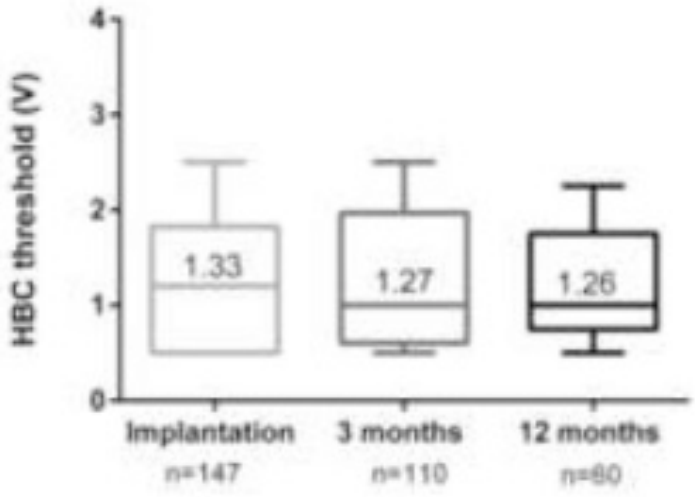
Pacing indication	
High degree AV block	62 (36.5%)
Slowly conducted AF	27 (15.9%)
Sinus node dysfunction	30 (17.6%)
AV node ablation for non controlled atrial arrhythmia	51 (30.0%)

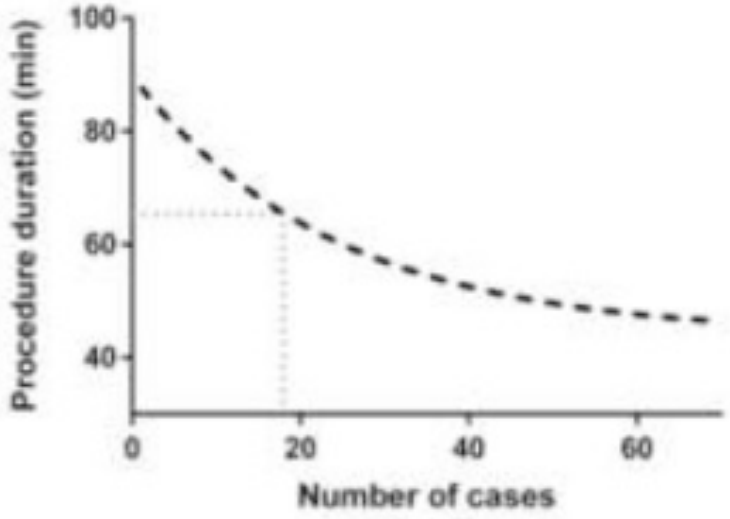
- Only 15 patients (10.6%) had HBP threshold > 2V/0.5ms (initial phase).
- There was no pericardial effusion, no pneumothorax and no device infection. Ventricular lead revision was required in 5 patients; for threshold increase, without obvious dislodgement in 3 patients, and dislodgment occurred in 2 patients.
- RA enlargement, infra nodal AV block as technical obstacles

Expérience Normande (>nov. 2017)

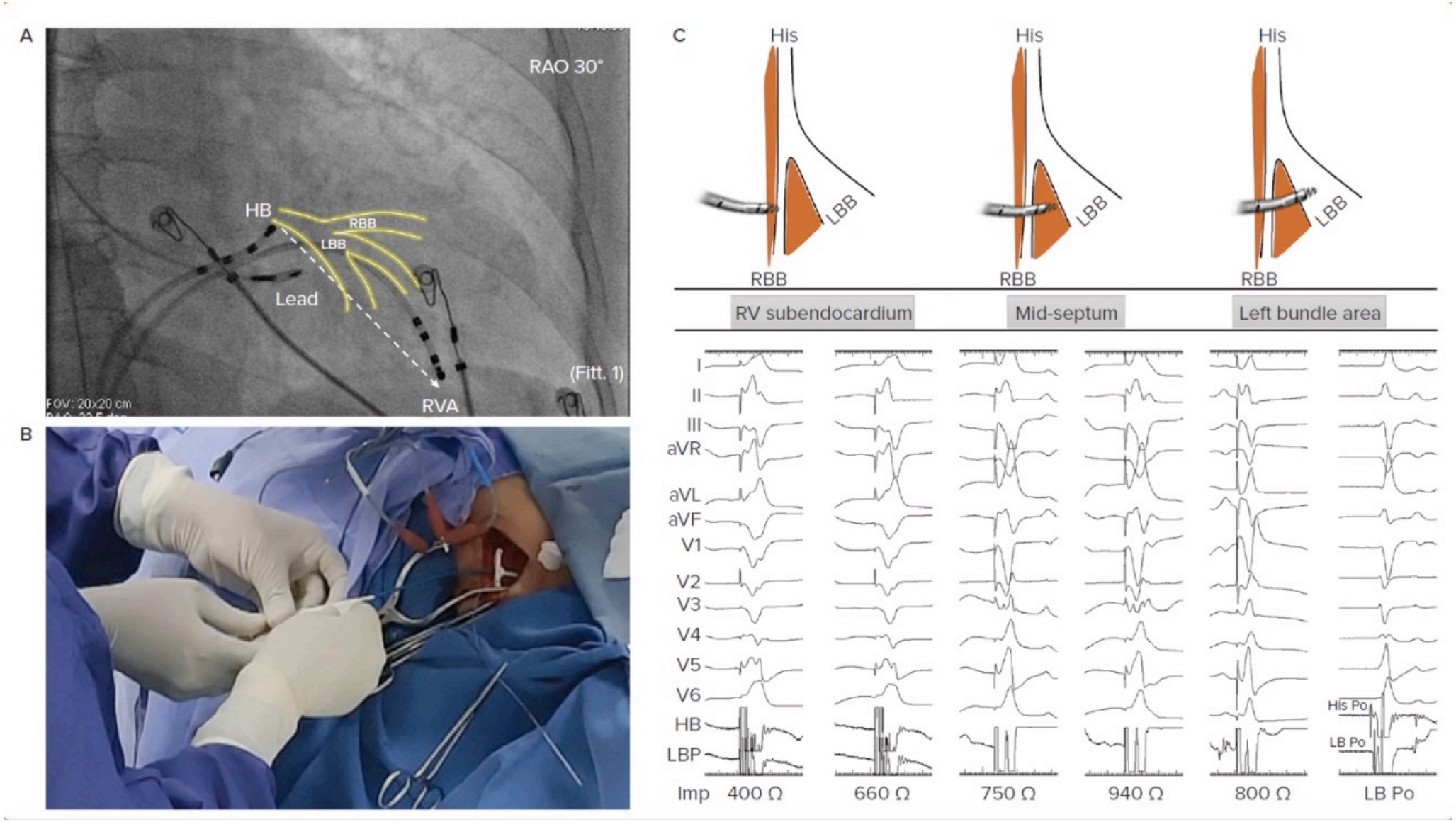
- Efficacité, sécurité et courbe d'apprentissage



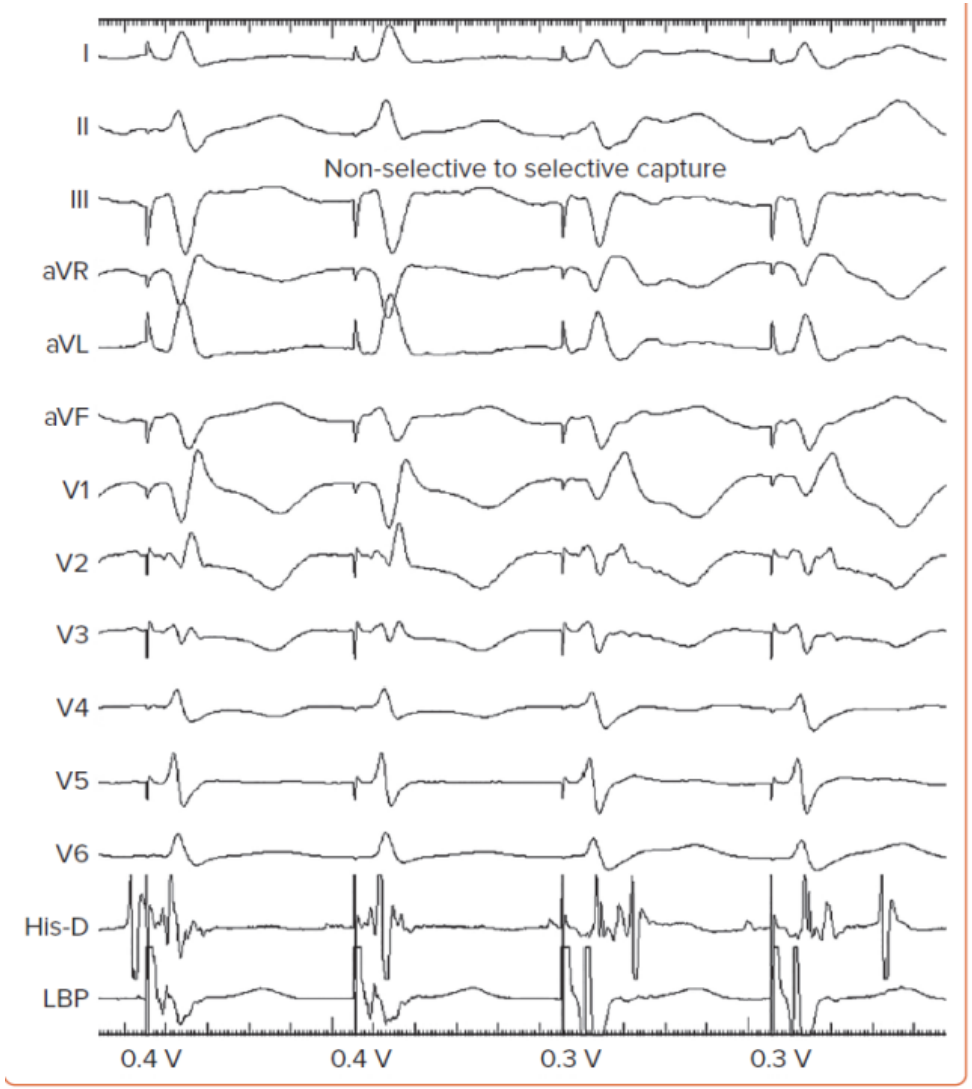




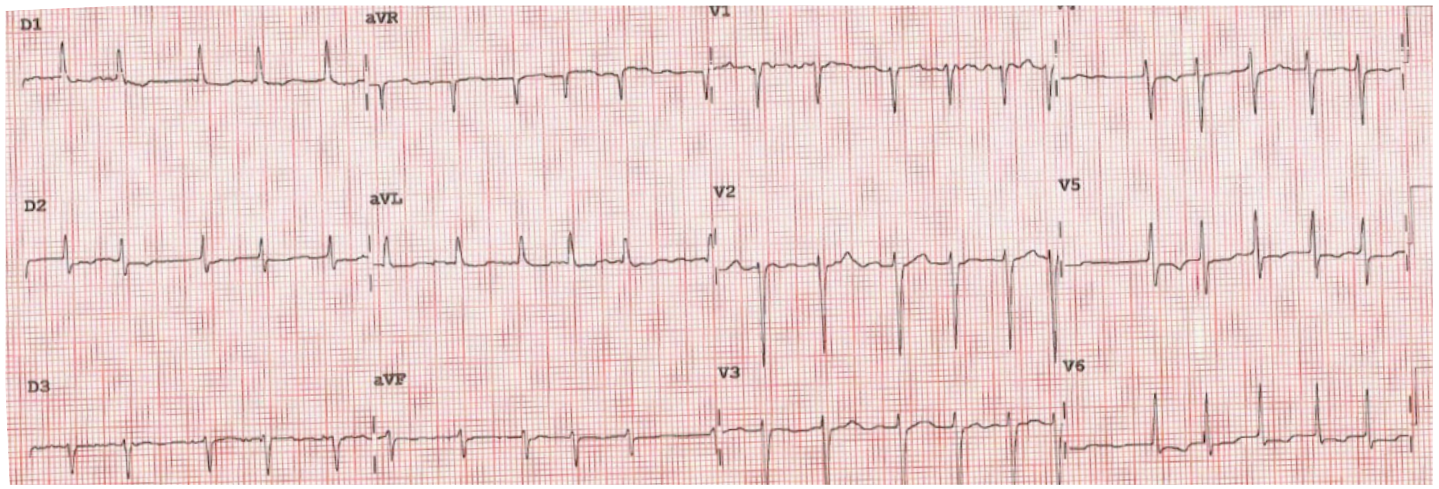
Technique de Stim. Br. Gche

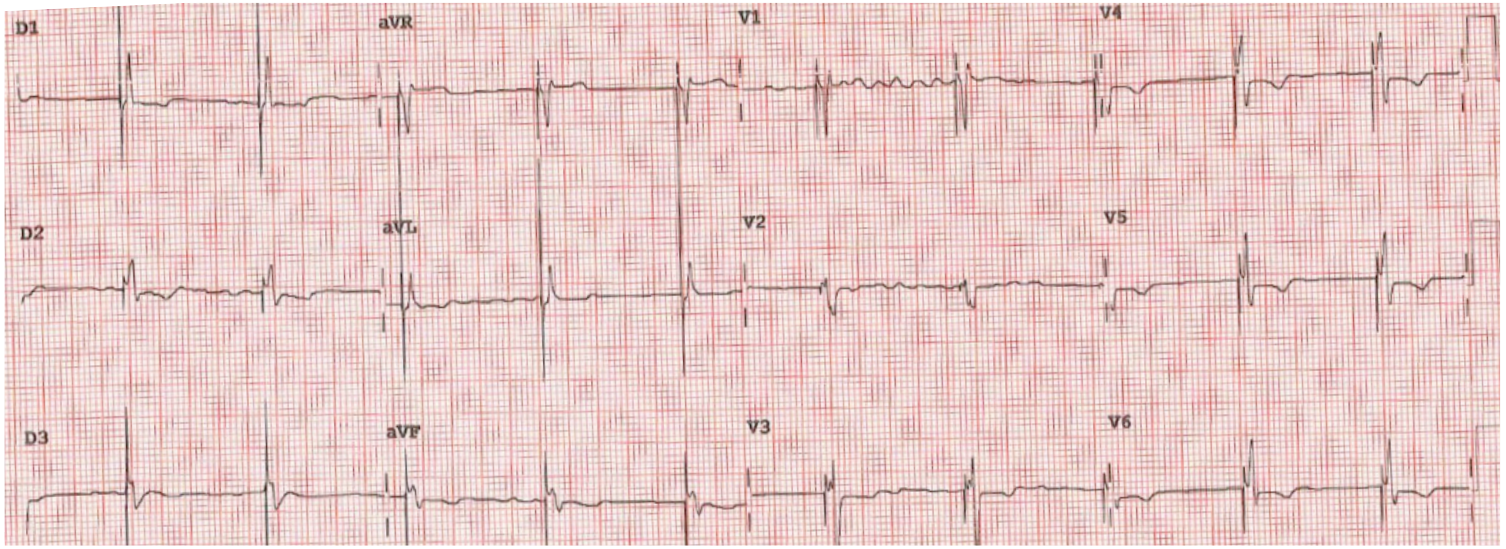


Stimulation de Br. Gche

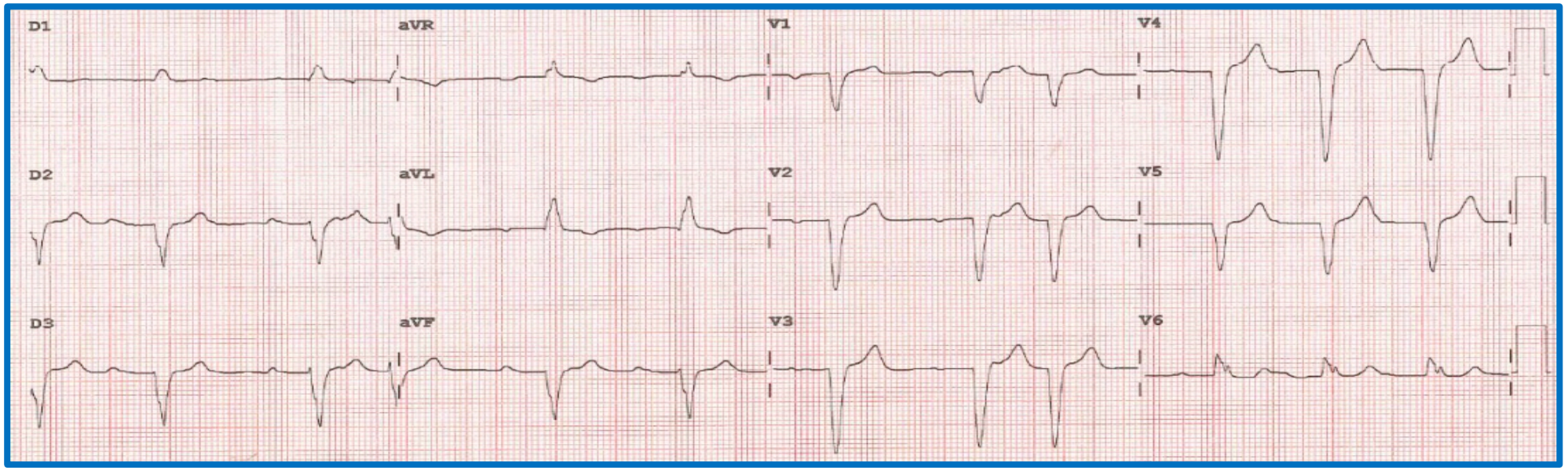


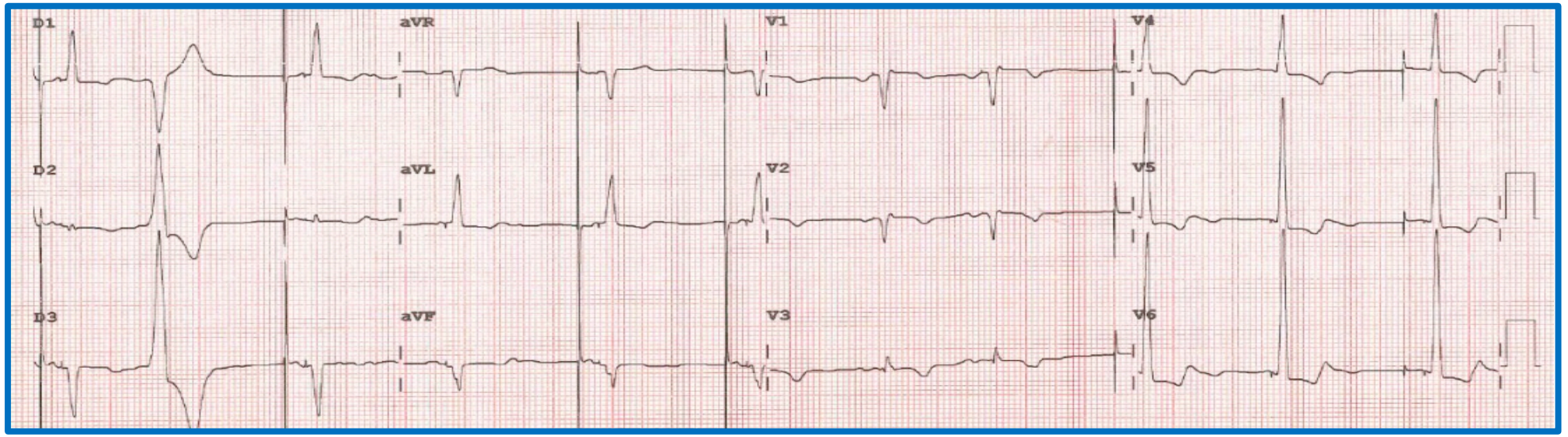
Ablate and LBB Pace



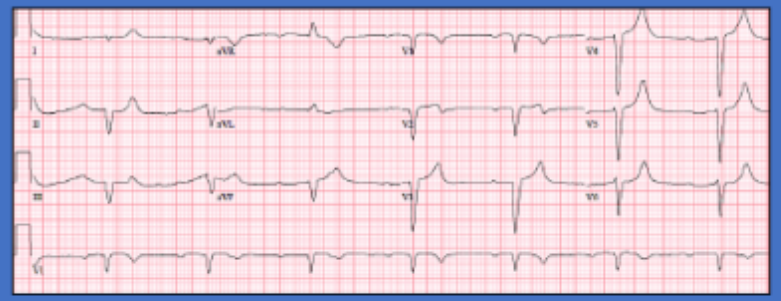


LBBP to correct LBBP

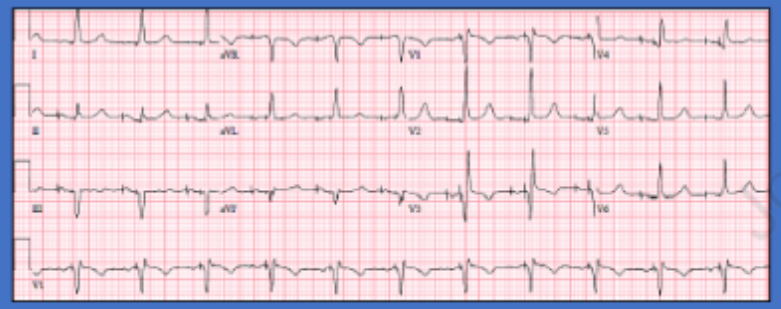


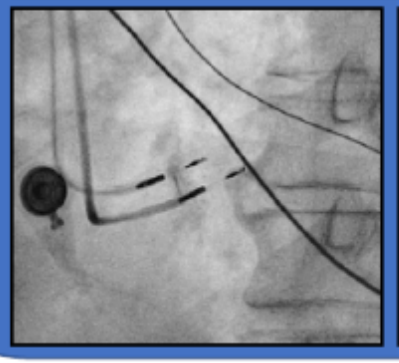


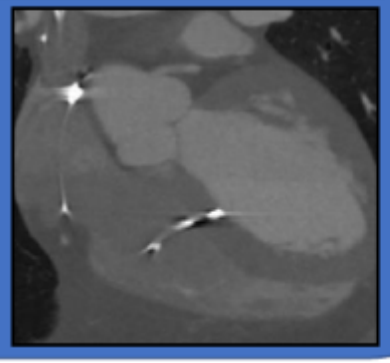
Clinical Outcomes Of Left Bundle Branch Area Pacing Compared To Right Ventricular Pacing: Results From The Geisinger-Rush Conduction System Pacing Registry



Left Bundle Branch Area Pacing

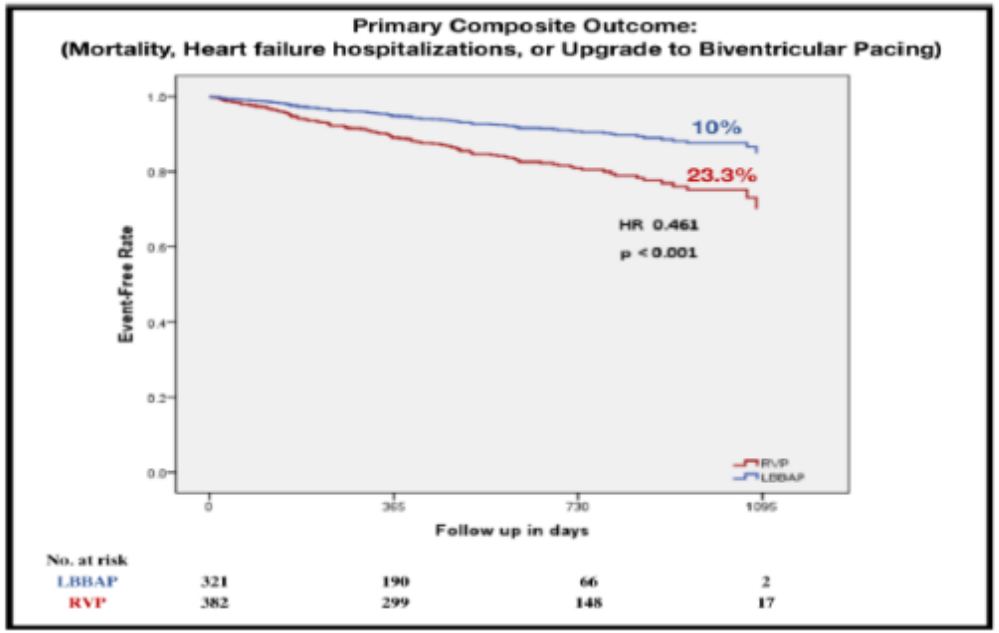






703 patients with pacemaker implantations met inclusion criteria

LBBAP	RVP
(321 pts)	(382 pts)



Sharma P, Vijayaraman P. HR in press

Stim. B. Gche : Expérience Rouennaise

	Total population (n = 163)	Successful procedure (n = 145)	Unsuccesful procedure (n = 18)	p
Age (year)	76 ± 10	77 ± 10	74 ± 12	0.35
BMI (Kg/m²)	27.5 ± 4.8	27.2 ± 4.7	29.5 ± 4.7	0.04
Atrial fibrillation	66 (40.5%)	58 (40.0%)	8 (44.4%)	0.80
Cardiopathy				
Valvulopathy	58 (35.6%)	51 (35.2%)	7 (38.9%)	0.79
Valvular heart surgery	28 (17.2%)	22 (15.2%)	6 (33.3%)	0.09
TAVI	27 (16.6%)	26 (17.7%)	1 (6.3%)	0.48
Coronary disease	22 (13.5%)	17 (11.7%)	5 (27.8%)	0.08
Dilated cardiomyopathy	11 (6.7%)	9 (6.2%)	2 (11.1%)	0.35
Hypertrophic cardiomyopathy	1 (0.6%)	1 (0.7%)	0 (0%)	
Amyloidosis	2 (1.2%)	2 (1.4%)	0 (0%)	
Electrocardiogram				
Mean QRS Duration (ms)	119 ± 28	119 ± 29	126 ± 29	0.59
Left bundle branch block	54 (33.1%)	51 (35.2%)	3 (16.7%)	0.19
Right bundle branch block	42 (25.8%)	39 (26.9 %)	3 (16.7%)	0.57
Echocardiography				
LVEF (%)	57 ± 12	57 ± 12	55 ± 11	0.38
LVEF 35-50 %	24 (14.7%)	21 (14.5%)	3 (16.7%)	0.74
LVEF ≤ 35 %	14 (8.6%)	11 (7.6%)	3 (16.7%)	0.19
Left ventricular dilatation	22 (13.5%)	19 (13.1%)	3 (16.7%)	0.72
Left ventricular hypertrophy	42 (25.8%)	36 (24.8%)	6 (33.3%)	0.41
Left atrial dilatation	108 (66.3%)	95 (65.5%)	13 (72.2%)	0.80
Right atrial dilatation	46 (28.2%)	37 (25.5%)	9 (50.0 %)	0.05
Right ventricular dilatation	7 (4.3%)	3 (2.1%)	4 (22.2%)	0.003
Right ventricular dysfunction	7 (4.3%)	4 (2.8%)	3 (16.7%)	0.03
Pacemaker indication				
High degree AVB	132 (81.0%)	119 (82.1%)	13 (72.2%)	0.34
Sinus node dysfunction	6 (1.8%)	5 (3.4%)	1 (5.6%)	0.51
Uncontrolled atrial fibrillation	21 (12 .9%)	19 (13.1%)	2 (11.1%)	1.0
Others	3 (0.6%)	2 (1.4%)	2 (11.1%)	0.07

Stim. B. Gche : Expérience Rouennaise

	Successful procedure n = 145
Single chamber PM	34 (23.4 %)
Total procedure time (min)	40 ± 15
Total fluoroscopic time (min)	4.1 ± 3.6
Total fluoroscopic dose (Gy/cm²)	1.5 ± 1.8
Dual chamber PM	107 (73.8%)
Total procedure time (min)	46 ± 11
Total fluoroscopic time (min)	3.4 ± 2.8
Total fluoroscopic dose (Gy/cm²)	1.2 ± 1.1
Unipolar impedance (Ohms)	556 ± 121
Bipolar impedance (Ohms)	760 ± 119
Detection (mV)	11.9 ± 5.3
Unipolar threshold (V @ 0,4 ms)	0.57 ± 0.20
Bipolar threshold (V @ 0,4 ms)	0.63 ± 0.26

Electrical and mechanical consequences of LBBP

	Total population (n=145)		p	LBBB (n=51)		p	RBBB (n=39)		p	Narrow QRS (n=55)		p
	Spontaneous rhythm	Ventricular pacing		Spontaneous rhythm	Ventricular pacing		Spontaneous rhythm	Ventricular pacing		Spontaneous rhythm	Ventricular pacing	
QRS duration (ms)	119 ± 29	105 ± 12	<0.001	142 ± 19	107 ± 13	<0.001	130 ± 18	107 ± 13	<0.001	91 ± 18	103 ± 11	<0.001
IVD (ms)	34 ± 23	15 ± 12	<0.001	51 ± 14	14 ± 12	<0.001	50 ± 16	17 ± 14	<0.001	12 ± 11	13 ± 11	0.90
LIV delay in A3C *(strain)*	67 ± 51	43 ± 29	<0.001	116 ± 65	47± 32	<0.001	42 ± 29	47 ± 24	0.83	49 ± 22	40 ± 31	0.13
LIV delay in A4C *(strain)*	64 ± 57	57 ± 30	0.31	124 ± 72	66 ± 28	<0.001	36 ± 19	56 ± 31	0.09	44 ± 29	54 ± 30	0.42
LIV delay in A2C *(strain)*	48 ± 36	45 ± 30	0.99	67 ± 49	57 ± 37	0.75	38 ± 24	40 ± 22	0.38	42 ± 26	41 ± 29	0.86

Synthèse

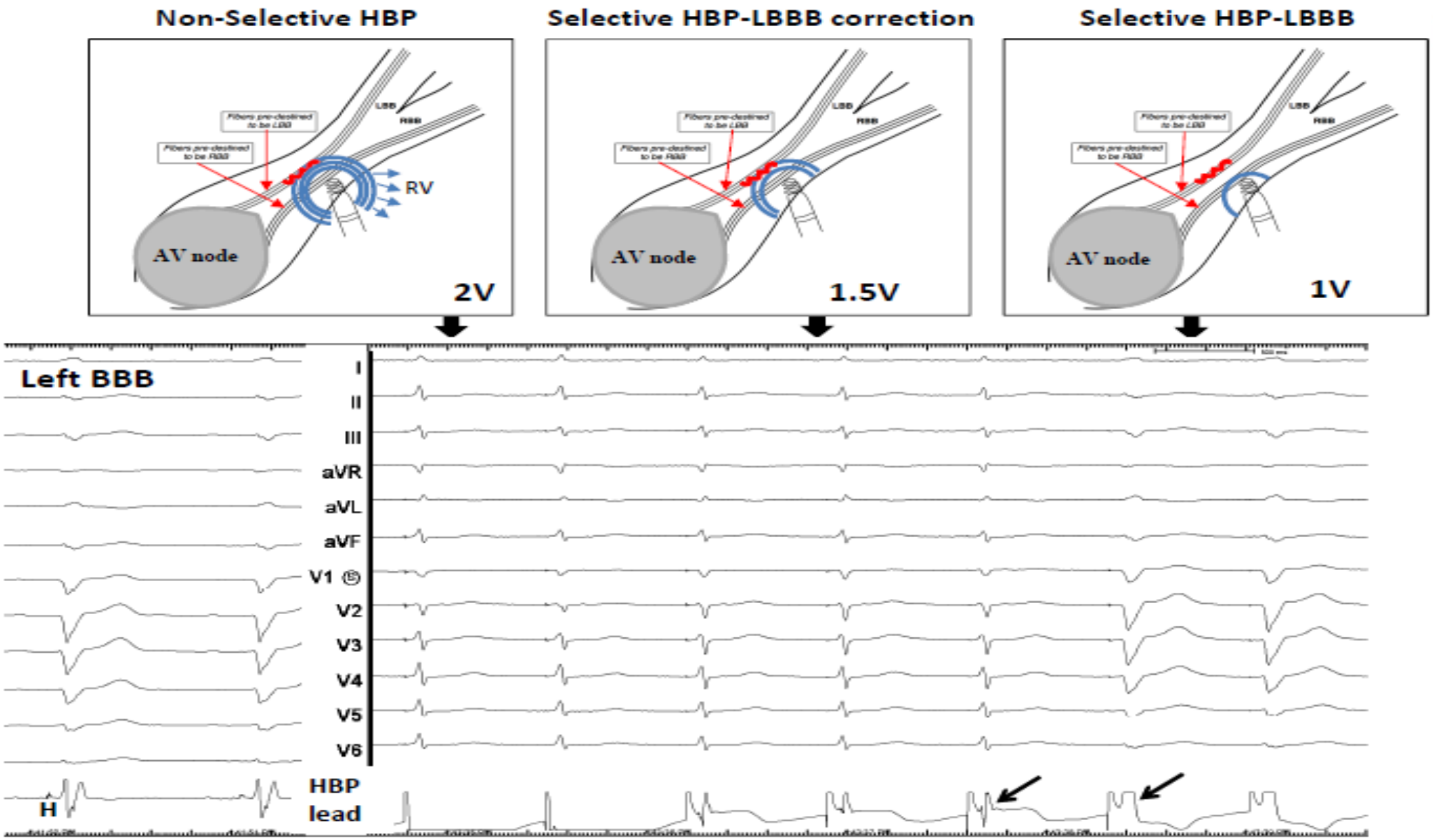
- Pour les patients avec un taux de stimulation ventriculaire anticipé élevé - ablation du nœud AV (maintenant dans les recos !)
  - BAV III de siège nodal (HBP) ou infranodal (LBBP)

- Diminution escomptée de l'incidence d'insuffisance cardiaque au long cours

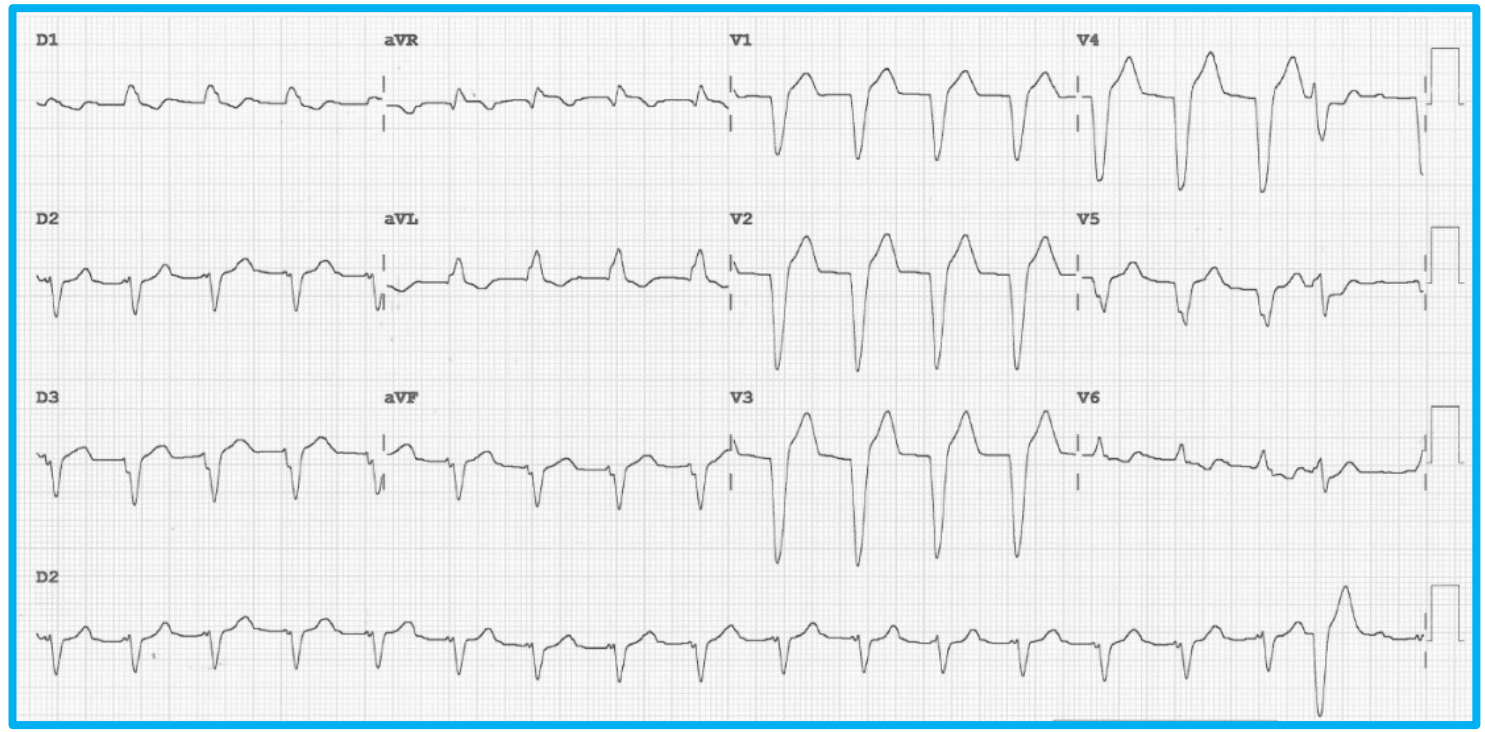
- Au prix:
  - Procédure plus longue
  - Ecoute ventriculaire moins bonne (HBP)
  - Consommation électrique plus élevée (Seuils et impédances; HBP)
  - Quid de la longévité de la sonde en position transeptale (LBBP)

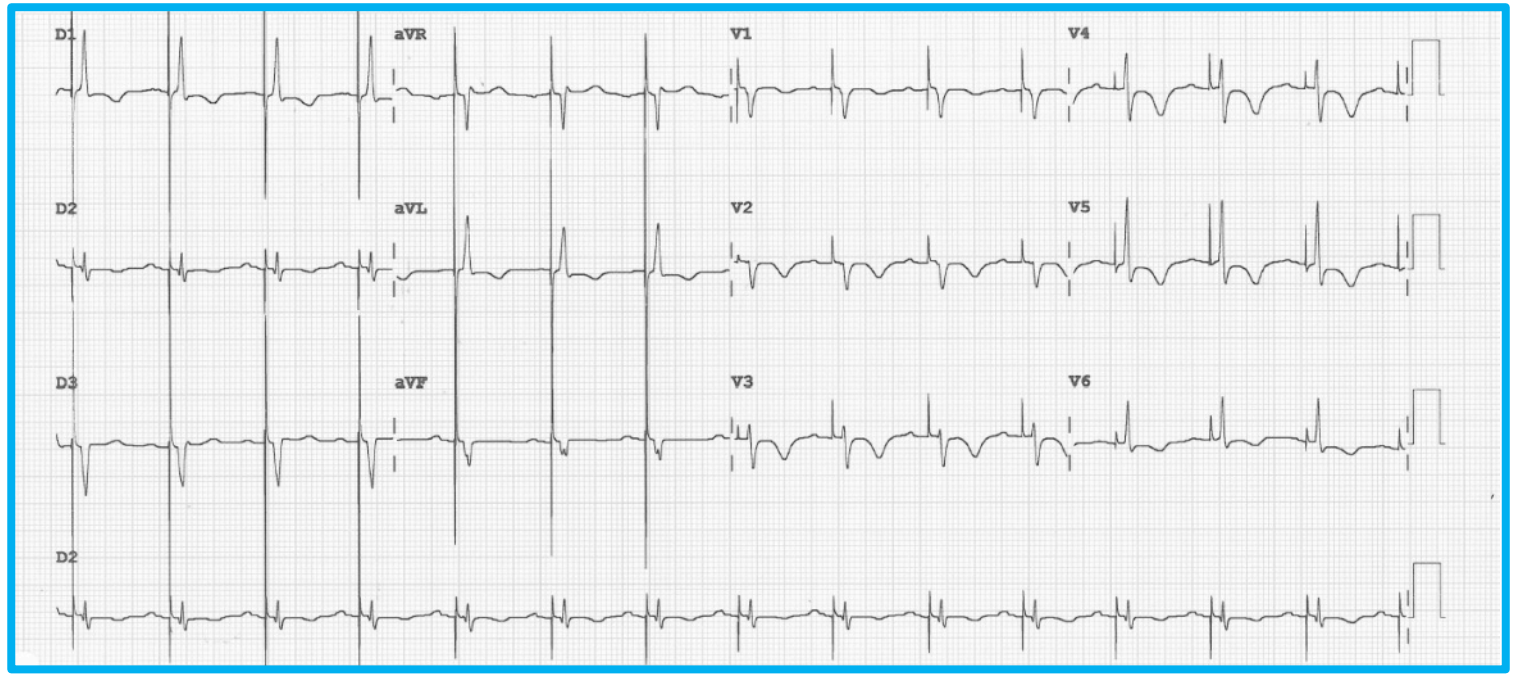
- Alternative à la synchronisation cardiaque dans certaines situations particulières

Resynchronisation bi-ventriculaire



Sharma PS, Dandamudi G, Herweg B, Wilson D, Singh R, et al. 2017. Permanent His Bundle Pacing as an Alternative to Biventricular Pacing for Cardiac Resynchronization Therapy: A Multi-Center Experience. *Heart rhythm : the official journal of the Heart Rhythm Society*


D1
aVR
V1
V4
D2
aVL
V2
V5
D3
aVF
V3
V6
D2


D1
aVR
V1
V4
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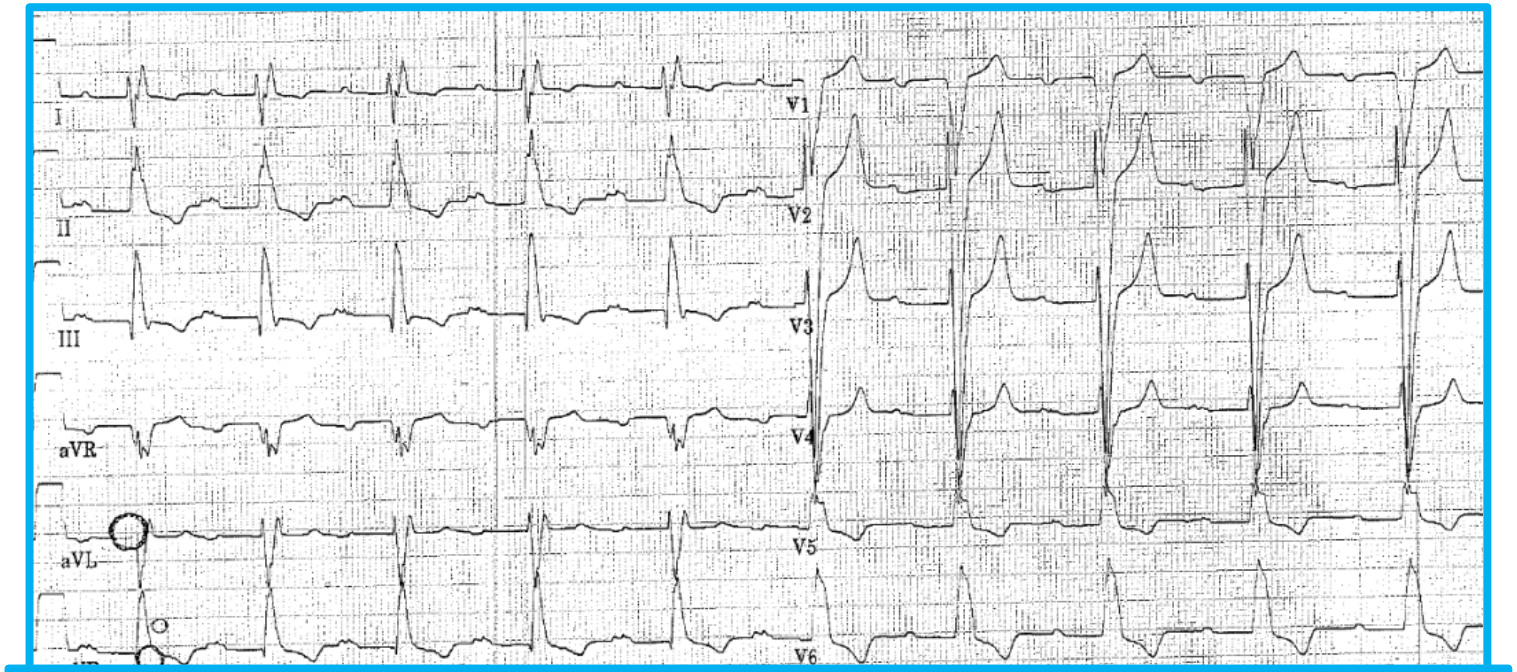
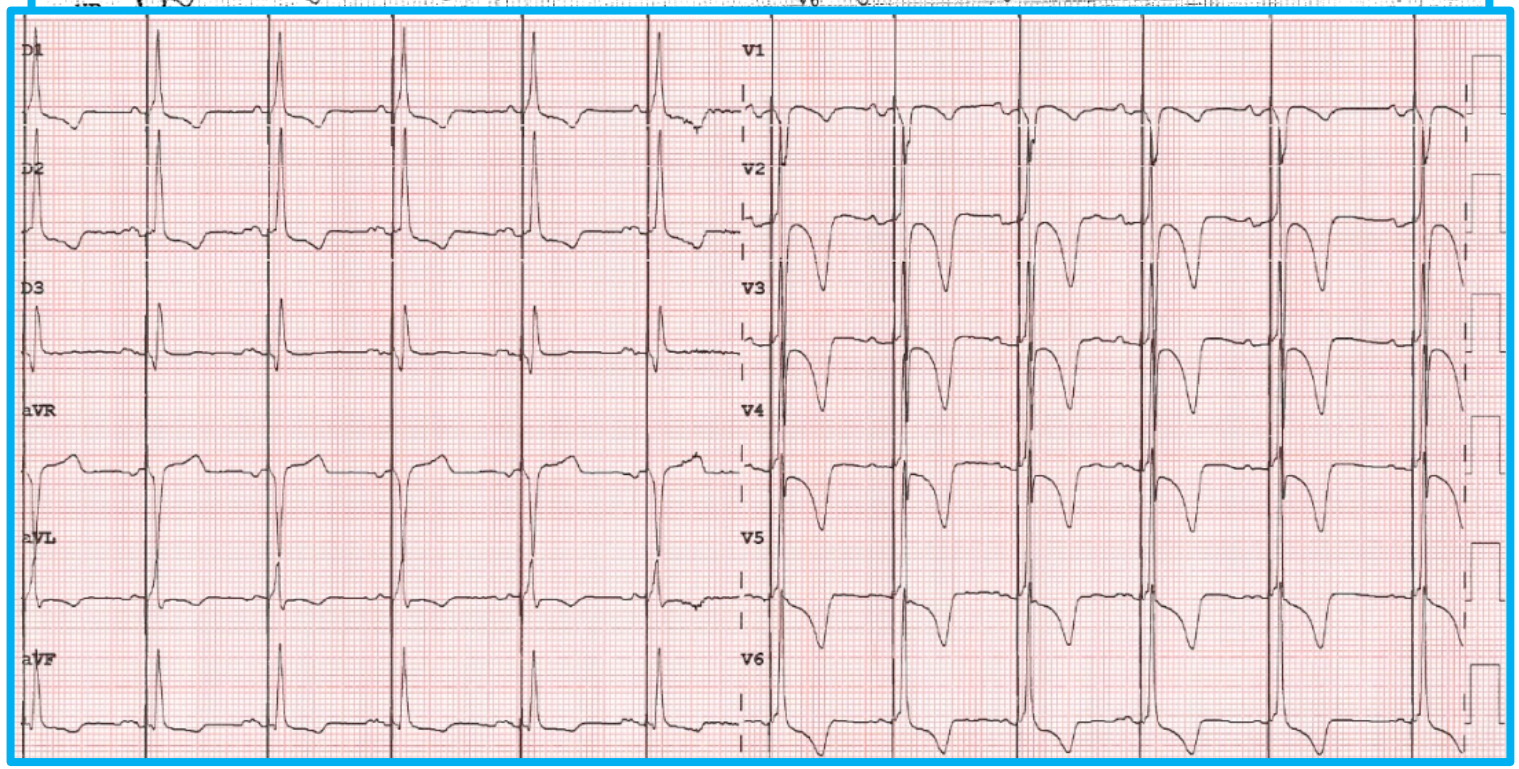
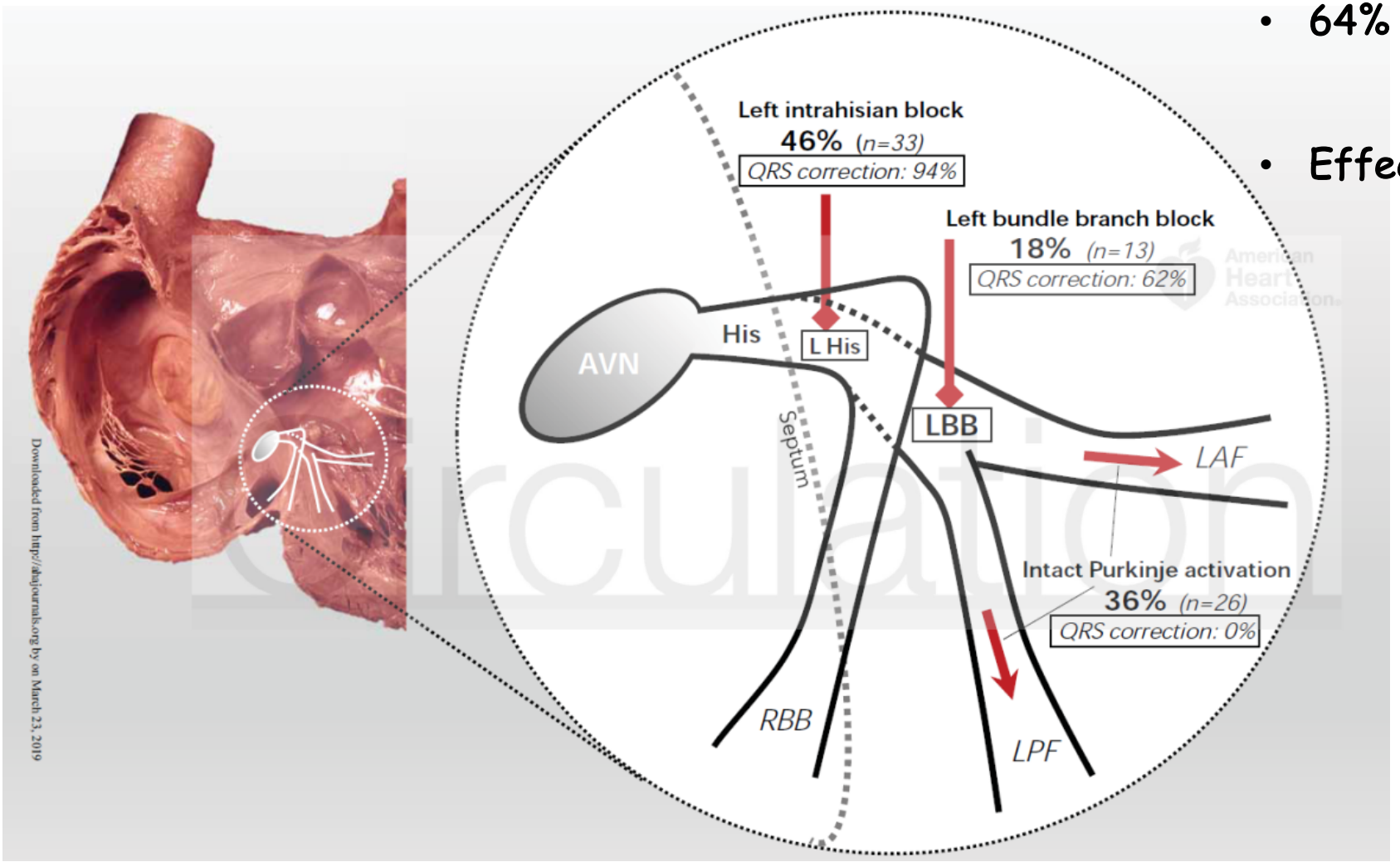
aVL
V2
V5
D3
aVF
V3
V6
D2


I
II
III
aVR
aVL
V1
V2
V3
V4
V5
V6


D1
D2
D3
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Mapping of the Left His-Purkinje system in LBBB patients: Response to HBP



- 64% accessible to correction (proximal complete block)
- Effective correction in 85% of those

Upadhyay G, et al. Circulation 2019

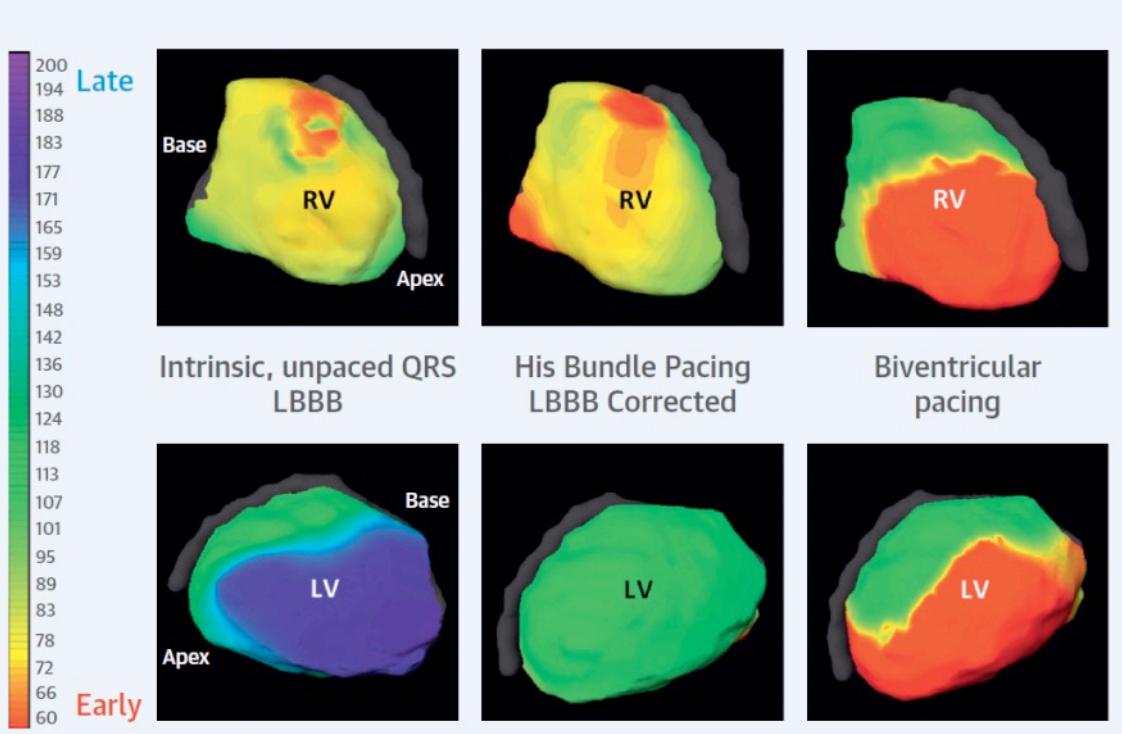
Criteria to predict corrective HBP ?

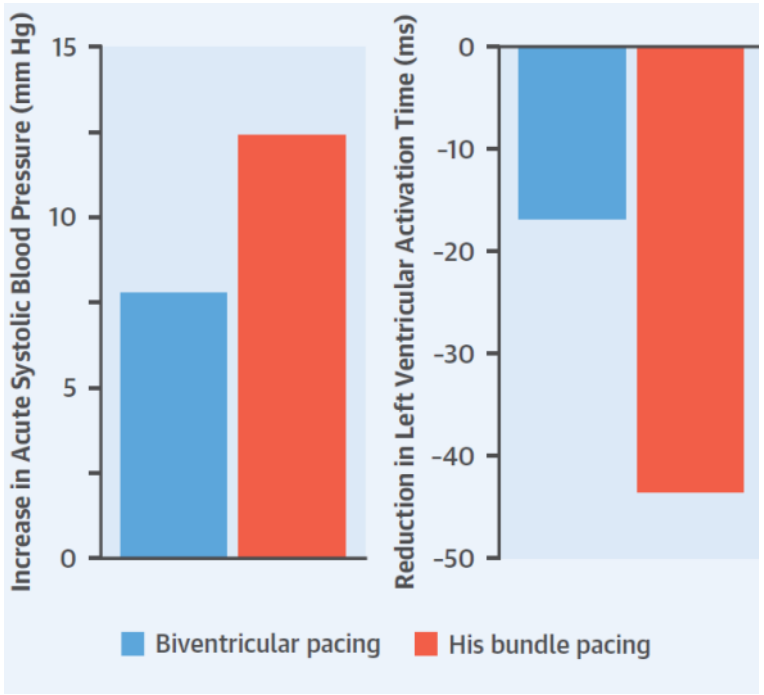
Characteristic	IPA (n=26)	CCB (n=46)	p-value
Electrocardiographic characteristics			
QRS duration (ms)—mean±SD	*152±19*	*171±23*	*0.001*
QRS duration > 140 msec (men) or >130 msec (women)—no. (%)	*23 (88.5)*	*44 (95.7)*	*0.34*
R-wave amplitude in V1 (mV)—median(IQR)	0.08 (0.00-0.13)	0.07 (0.00-0.15)	0.91
R-wave in V1 < 0.1 mV—no. (%)	15 (57.7)	29 (63.0)	0.65
Presence of QRS notching in V1, V2, V5, V6, I, or aVL—no. (%)	*14 (53.9)*	*44 (95.7)*	*<0.0001*
Overall Strauss criteria met—no. (%)	*10 (38.5)*	*42 (91.3)*	*<0.0001*

	Sensitivity	Specificity	NPV	PPV
All Strauss criteria	95%	55%	90%	71%
Mid QRS notching	100%	42%	100%	67%
Intracardiac CCB	100%	79%	100%	85%

Upadhyay G, et al. Circulation 2019

HBP vs BiV: LVAT and Hemodynamic response





- 23 CRT-indicated patients, 17 analyzed (No LVAT reduction > 10 ms in 4)
- ECGi (252 electrodes vest)
- Invasive or Finapress blood pressure analysis
- Temporary HBP from subclavian or femoral approach

Arnold AD, et al. JACC 2018;72(24):3112

HBP as an suitable alternative for cardiac resynchronization

High right ventricular (RV) pacing burden			
Sharma et al. [28•]	192 patients with indication for pacemaker. Patients at one center receiving HBP and patients at another center receiving RVP	Case control study 2-year follow-up	Asses feasibility, safety, and clinical outcomes of permanent HBP in an unselected population as compared to RVP	75/94 (80%) successful; 107 patients (> 60%) had RV pacing burde > 40%. HFH was significantly reduced; no difference in mortalit
Vijayaraman et al. [29]	192 patients with indication for pacemaker. Patients at one center receiving HBP and patients at another center receiving RVP	Case control study 5-year follow-up	Assess long-term performance and compare the clinical outcomes of permanent HBP vs RVP	Higher incidence of PICM (2% vs 22%) in HBP vs RVP. Death o HFH was significantly lower in HBP compared to RVP patients the need for lead revisions was higher in the HBP group
Abdelrahman-an et al. [30•]	765 patients with an indication for pacemaker. Patients at one center receiving HBP and patients at another center receiving RVP	Case control study	Assess primary outcome of combined endpoint of death, HFH, or upgrade to BiVP	304/332 (92%) successful; primary endpoint was significantly reduced in the HBP group; observed primarily in patients with ventricular pacing > 20%; a trend toward reduced mortality in HBP
Deshmukh et al. [10]	18 patients with AF, DCM. 10 patients underwent AV node ablation	Prospective observational	Assess HBP feasibility in humans	12/18 (60%) successful; significant improvement in LVEDD, LVESD, LVEF, cardiothoracic ratios
Deshmukh et al. [43]	54 patients; narrow QRS complex of ≤120 ms, persistent AF requiring AV nodal ablation and DCM	Prospective observational	Long-term outcomes with HBP	39/54 (72%) successful; improved EF (23 to 33%), increased cardiopulmonary reserve
Kronborg et al. [44]	38 patients with high-grade AV block, narrow QRS and EF > 40%	Prospective, randomized, crossover design	Primary outcome, LVEF	32/38 (84%) successful; significantly lower after 12 months with RVP. No difference in functional class, 6-min walk test
Huang et al. [31•]	52 patients with CHF (HFpEF and HFrEF), persistent AF and AV node ablation	Prospective observational	Assess clinical outcomes	42/52 (80%) successful; improved echocardiographic measurements, functional class and reduced diuretics use

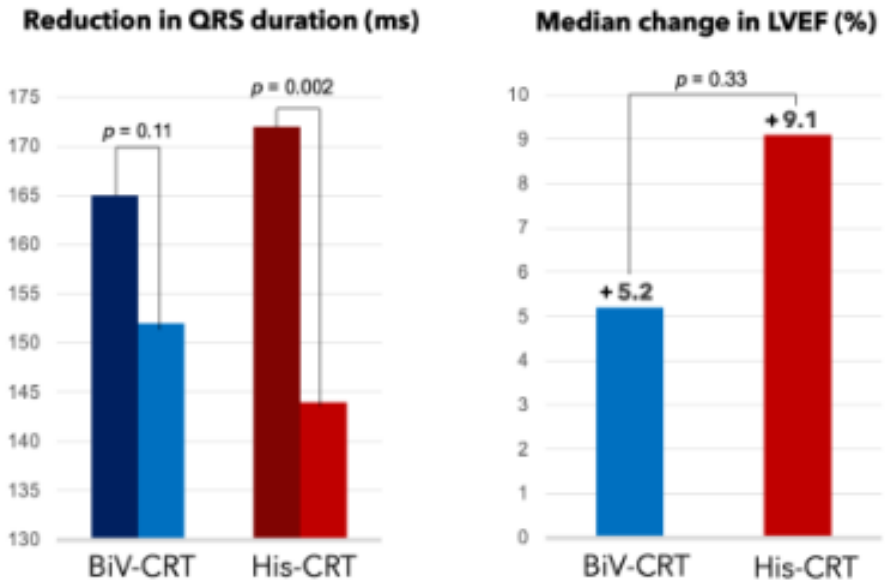
						and LVEF improved from 29%→36% (<0.05)
Su et al. (50)	2015	16	CRT implant failure	Select-Secure 3830	100	Specific degree of QRS narrowing not reported, but correction achieved for all patients. They found that His bundle tip-RV coil configuration demonstrated better capture thresholds than bipolar configuration

His-SYNC study

- First multicenter randomized study comparing HBP vs BiV pacing
- 20 patients in each group
- 1 year FU
- No difference in ECG / Echo parameters

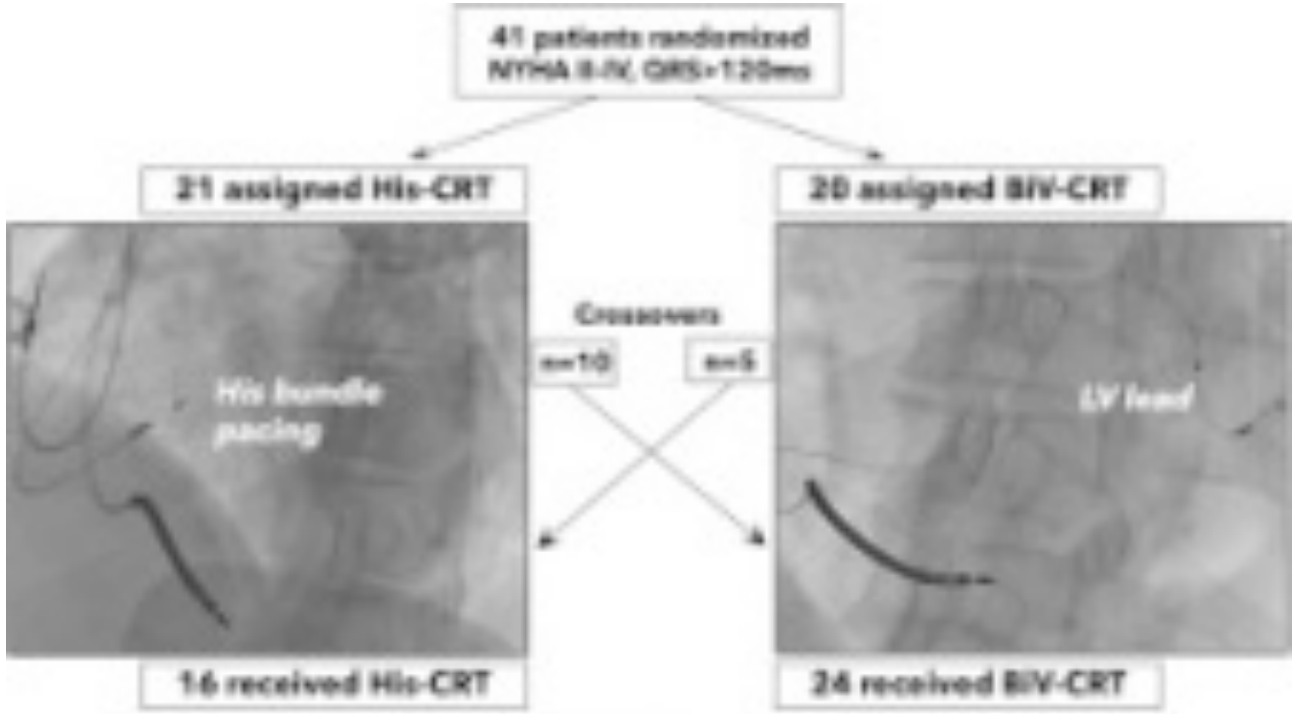
- Lot of cross-over (48% HBP, 26% BiV)
- Lot of IVCD (50% !)

ITT analysis



Upadhyay G et al, JACC.2019.04.026

His-SYNC per protocol analysis



	HB pacing (n=16)	BiV pacing (n=24)	p
QRS duration (ms)	125±22	164±25	<0.001
Echo response (>5%, %)	91	54	0.078

Upadhyay G et al, HRthm.2019.05.009