Insights into His Bundle Pacing

Data from PM and CRT-P Studies

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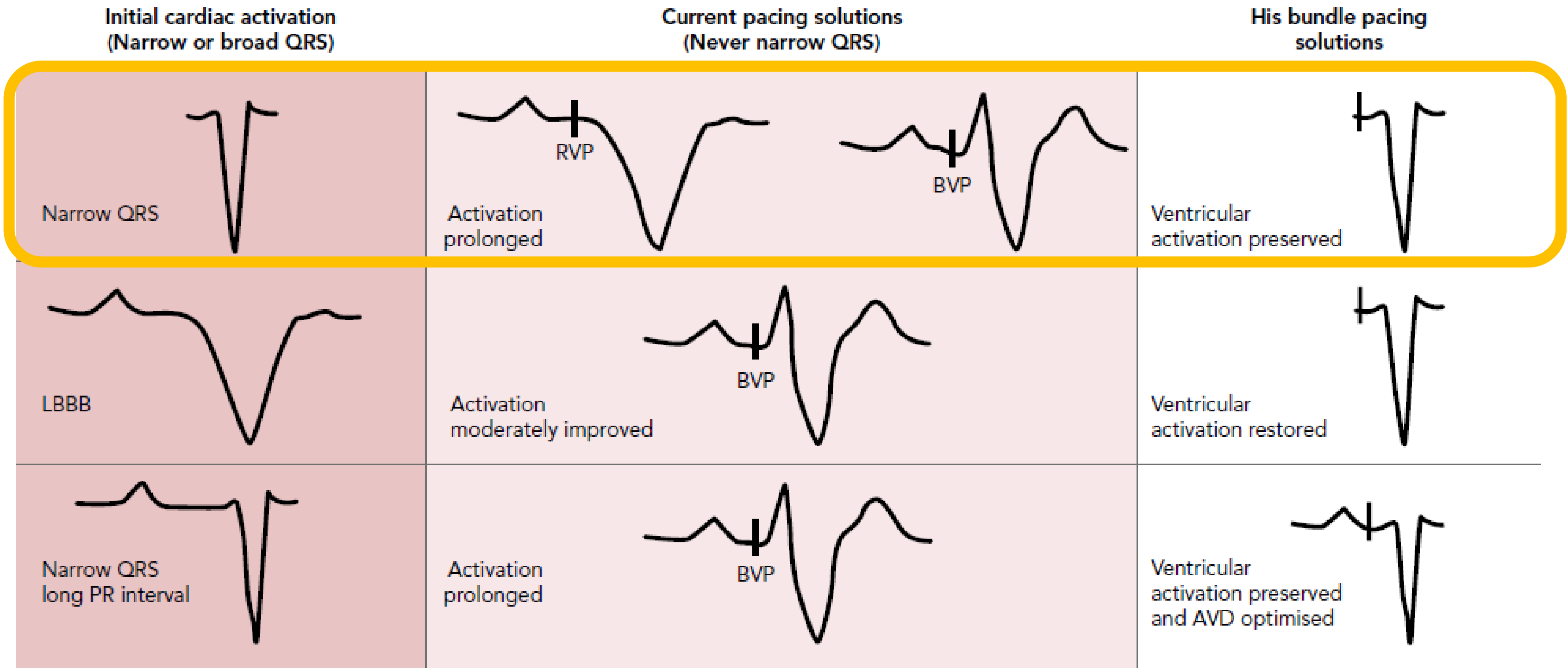
His Bundle Pacing – historical perspective

- First described in 1970 by Narula et al[1]
- 1977: HBP can eliminate LBBB[2]
- The first report of permanent His bundle pacing in humans in 2000[3]

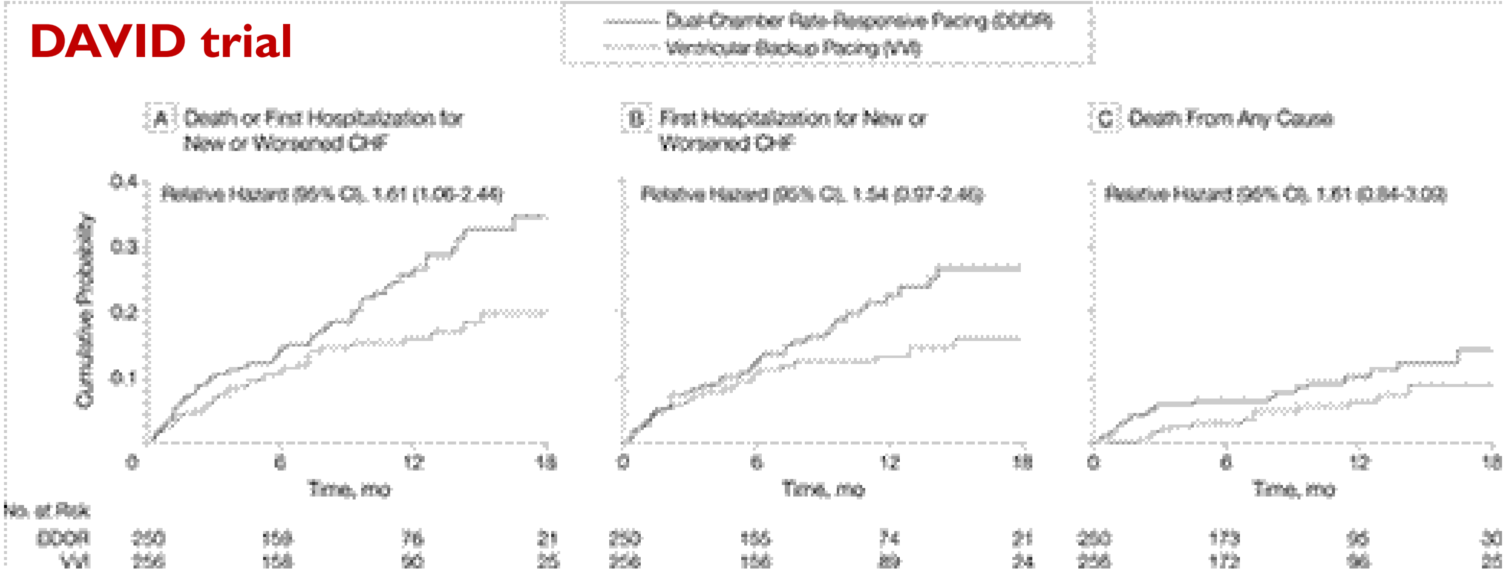
1. *Narula OS, et al. Circulation 1970;41:77–87*
2. *Narula OS, et al. Circulation 1977; 56(6):996-1006*
3. *Deshmukh P, et al. Circulation 2000;101:869–77*

Potential use of HBP



RV apical pacing

DAVID trial

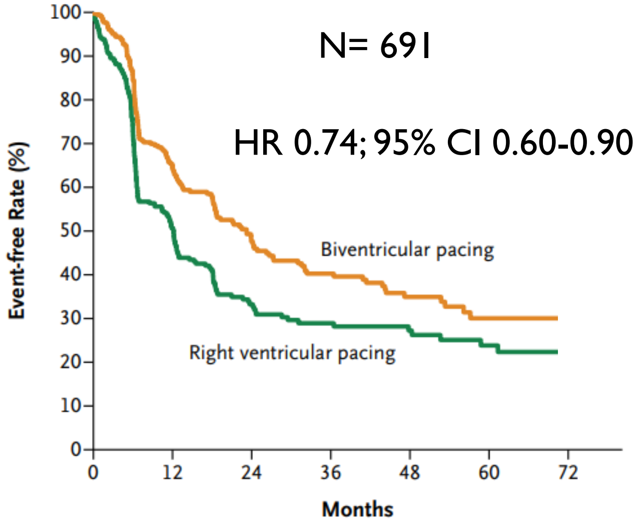


Sweeney MO, et al. Circulation 2003;107:2932–37

RVA vs. BiV

BLOCK-HF trial

Curtis AB, et al. N Engl J Med 2013;368:1585–93

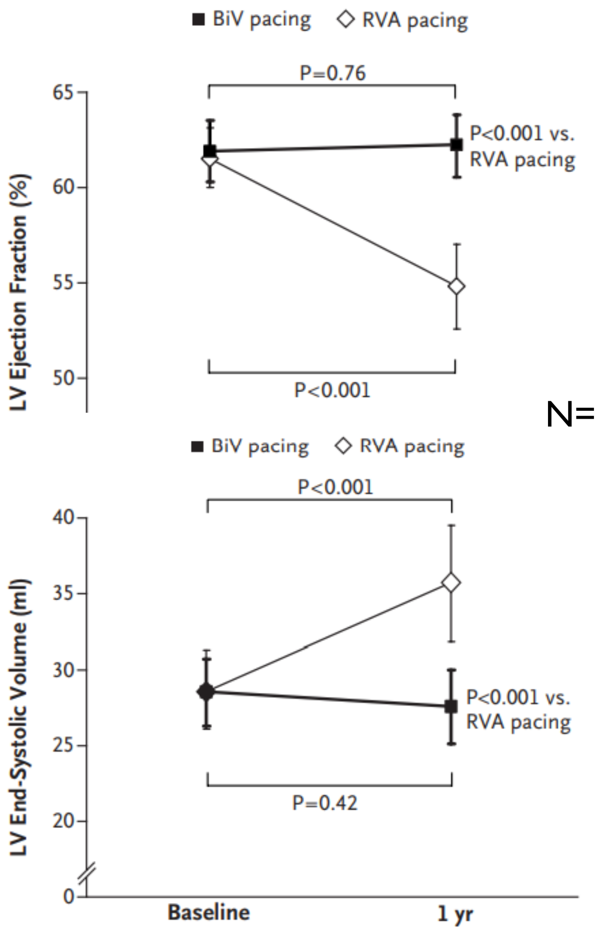


No. at Risk							
Biventricular pacing	349	161	87	62	38	17	3
Right ventricular pacing	342	126	59	39	28	18	10

Freedom from primary event = time to death from any cause, an urgent care visit for HF req. IV Thx or more increase in the LVESV index

BIOPACE trial

Yu CM, et al. N Engl J Med 2009;361:2123–34



N= 177

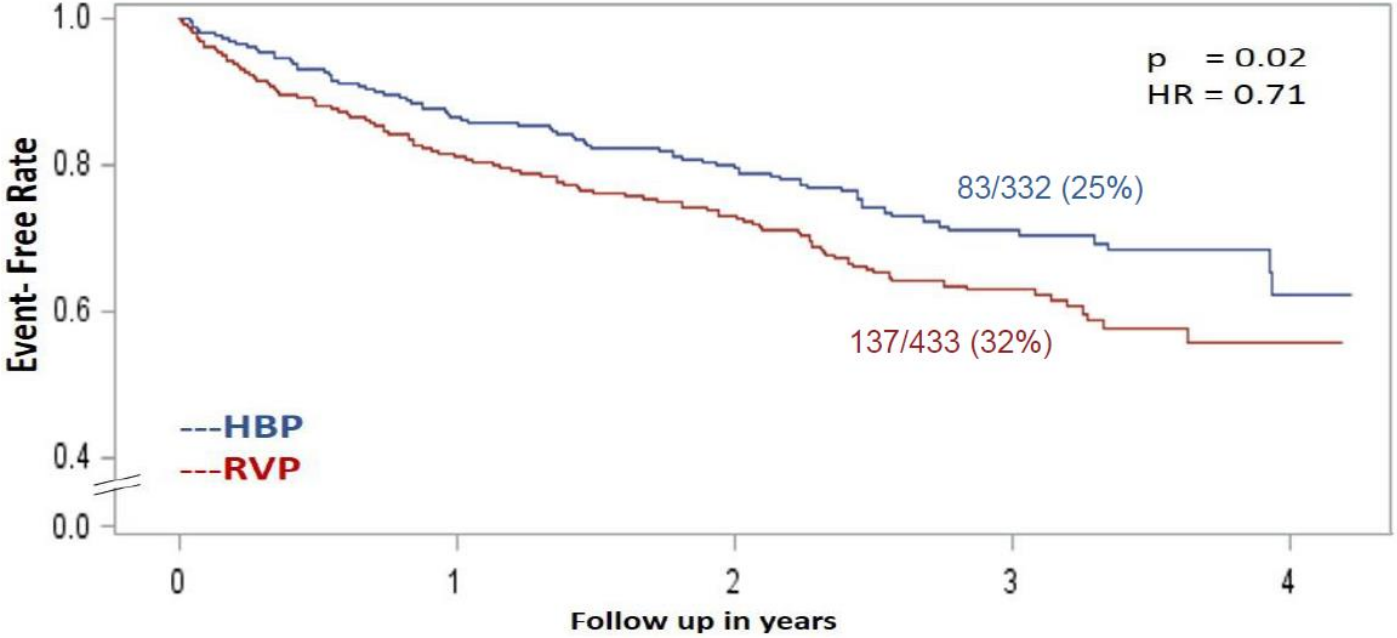
HBP vs. RVA pacing

Study	Total Patients and Inclusion Criteria	Study Design	His Pacing Success Rate	Outcomes	Summary
Bradycardia Pacing					
Zanon et al. 2008[22]	12	Non-randomised crossover study (3 months His pacing and 3 months RVP)	Only patients with confirmed His bundle pacing	Intra-patient myocardial perfusion (myocardial perfusion score) during His pacing compared to RVP	Myocardial perfusion score during His pacing was better than RVP
Catanzariti et al. 2013[18]	26	Non-randomised crossover study	Patients selected after successful His pacing established	Measurements of echocardiographic dyssynchrony parameters made during His pacing and RVP (intra-patient comparison)	Reduction of pacing-induced ventricular dyssynchrony with His pacing
Kronborg et al. 2014[20]	38 (12 months His pacing and 12 months RVP)	Randomised double-blind crossover study	84 % (32/38) Six patients had leads in high septal position and were still included in study	Left ventricular ejection fraction	Left ventricular ejection fraction was significantly higher during His pacing (55 % +/- 10 % versus 50 % +/- 11 %)
Vijayaraman et al. 2017[4]	192 (94 His and 98 RVP)	Case control study	80 % (75 from 94 attempted)	Death and heart failure hospitalisation	Death or heart failure was significantly lower in the His pacing group (32 % versus 53 %; HR 1.9)
Sharma et al. 2017[23]	30 (post-prosthetic valve surgery)	Prospective observational	93 % (28/30)	Feasibility of His pacing in this subgroup of patients	His bundle pacing was feasible and achieved pacing in 93 % of patients post-valve surgery
Shan et al. 2017[24]	18 (upgrade from RVP to His pacing in RVP patients)	Prospective observational	90 % (16/18)	Left ventricular ejection fraction, left ventricular end-diastolic dimensions, NYHA class and BNP	Reduced left ventricular end-diastolic dimensions and BNP. Improved ejection fraction and NYHA class
Abdelrahman et al. 2018[21]	756 (332 His and 433 RVP)	Case control study	92 % (302/332)	Death, heart failure hospitalisation and upgrade to BVP	Combined primary endpoint of death, heart failure hospitalisation and upgrade to BVP was significantly less in His pacing (HR 0.71)

Results From Geisinger HBP Registry

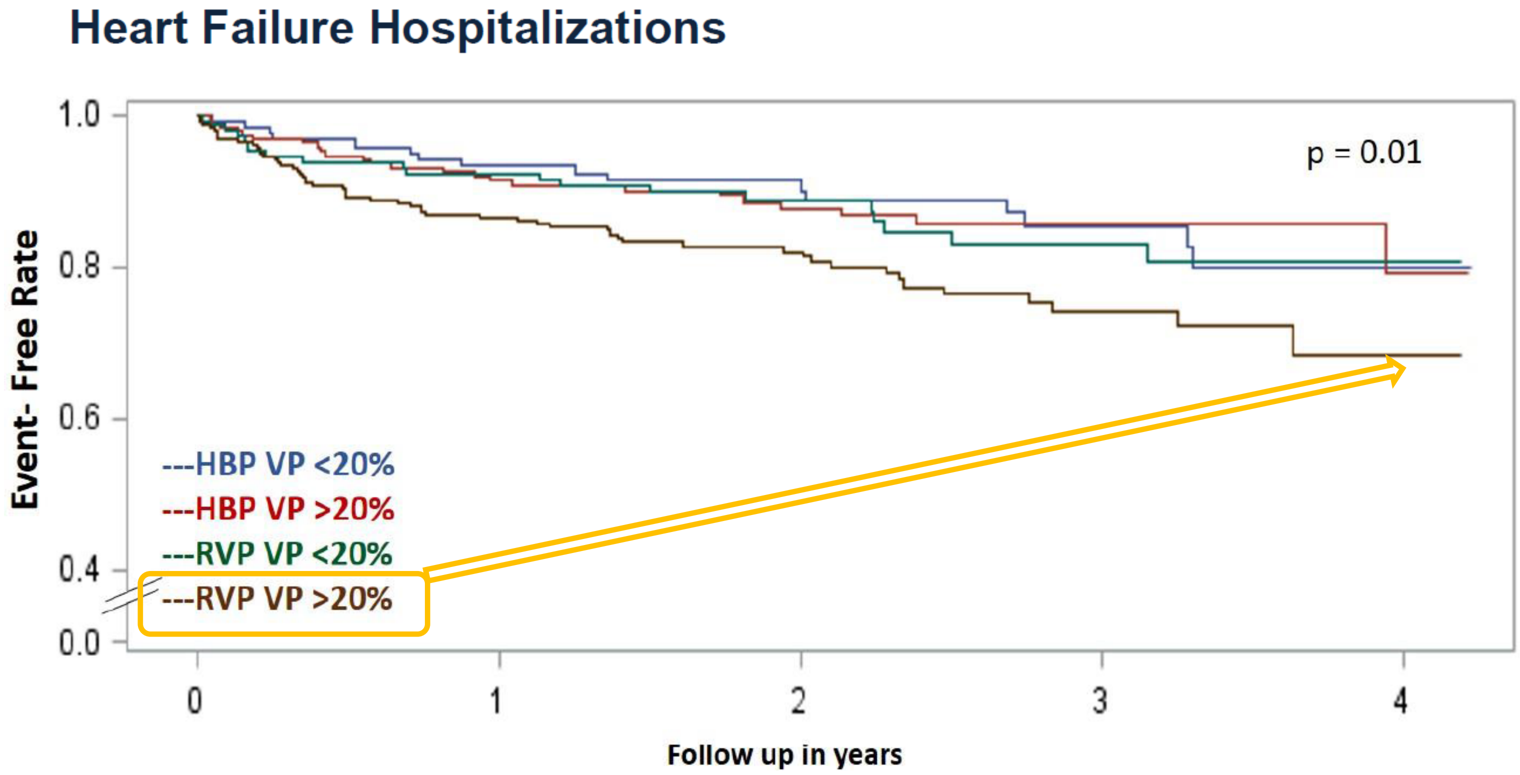
Primary Outcome (Death, HFH or upgrade to biventricular pacing) ***-All patients-***

Enrollment period: 10/2013-12/2016



Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330

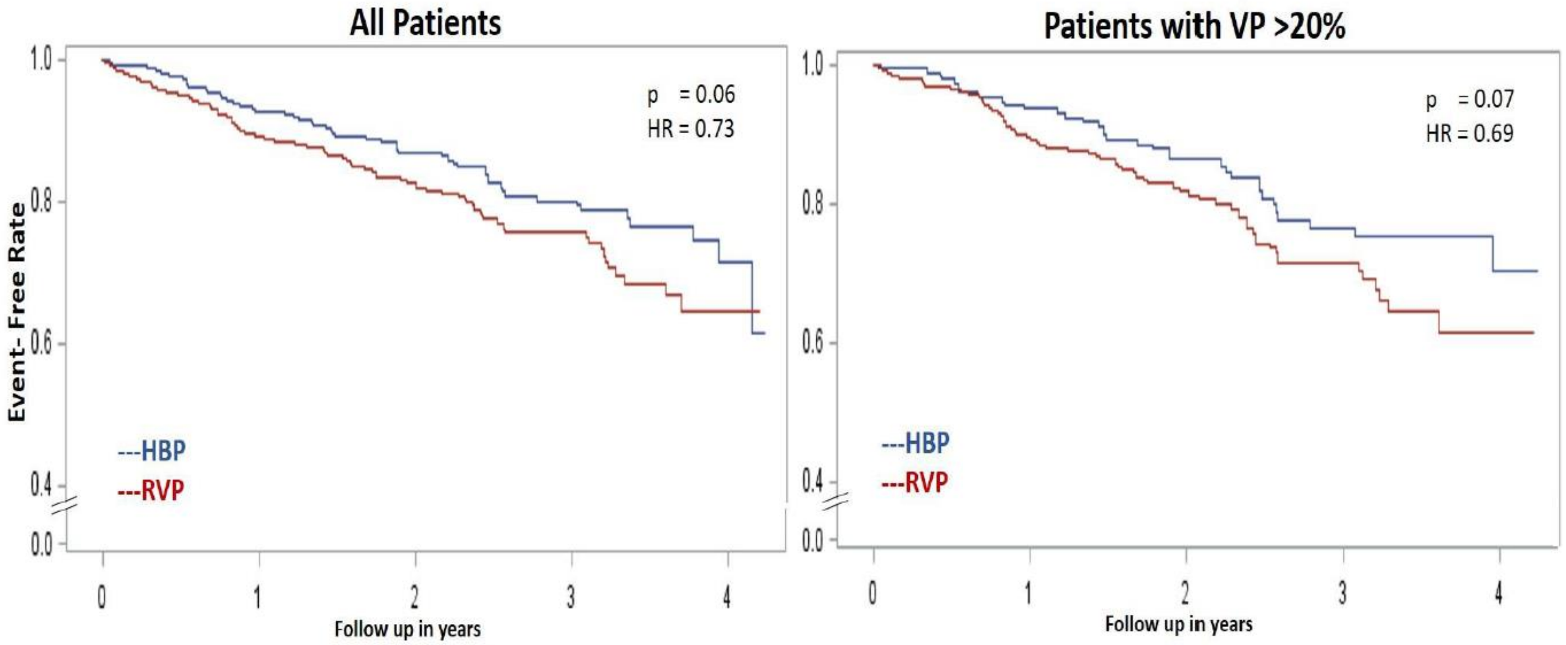
Results From Geisinger HBP Registry



Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330

Results From Geisinger HBP Registry

All- Cause Mortality



Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330

Suggested indications in AVB

- Pts with narrow QRS (especially when reduced LVEF)
- Pts with wide QRS – lower success
    - better NS-HBP in this group so as to have the safety of ventricular myocardial capture should conduction disease progress distally
- Pts with AAThx refractory SV arrhythmias amenable to AV node ablation and permanent pacing

HBP for cardiac resynchronization

- Kaufmann and Rothberger first proposed the idea of functional **longitudinal dissociation** of the HB in 1919

Is this concept true in majority of patients indicated to CRT?

Kaufmann R, Rothberger CJ. Zeitschrift für die Gesamte Experimentelle Medizin 1919;9:104–22

HBP for cardiac resynchronization

First Author (Ref. #)	Year	N	Indication	HBP Lead	Implant Success (%)	Major Findings
Barba-Pichardo et al. (46)	2013	16	CRT implant failure	Tendril 1488T, 1788TC, 1888TC	56	QRS narrowing achieved in 13 of 16 patients with HBP, of whom 9 underwent implant. During mean follow-up of 31.3 ± 21.5 months, NYHA functional class improved III→II and LVEF improved from 29%→36% (<0.05)
Lustgarten et al. (47)	2015	29	Crossover study of HBP and conventional CRT	Select-Secure 3830	59	QRS narrowing achieved in 21 of 29 patients with HBP, of whom 17 patients underwent implant and 12 completed follow-up. Both groups demonstrated significant improvement in NYHA functional class, 6-min walk, QOL, and LVEF compared with baseline.
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
Ajijola et al. (48)	2017	21	Primary HBP	Select-Secure 3830	76	QRS narrowing achieved in all 16 patients with implant success (180 ± 23 ms to 129 ± 13 ms; $p < 0.0001$). NYHA functional class III→II ($p < 0.001$), and LVEF improved from 27 ± 10% to 41 ± 13% ($p < 0.001$)
Sharma et al. (49)	2017	106	CRT implant failure (Group I) and primary HBP (Group II)	Select-Secure 3830	90	QRS narrowing achieved across all patients with implant success (157 ± 33 ms to 117 ± 18 ms; $p = 0.0001$). Underlying BBB was present in 48 patients and implant success was 92% in this group (33 of 36 LBBB and 11 of 12 non-LBBB). Among all patients NYHA functional class 2.8 ± 0.5→1.8 ± 0.6 ($p = 0.0001$) and LVEF improved from 30 ± 10% to 43 ± 13% ($p = 0.0001$).

BBB = bundle branch block; CRT = cardiac resynchronization therapy; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association; QOL = quality of life; RV = right ventricle.

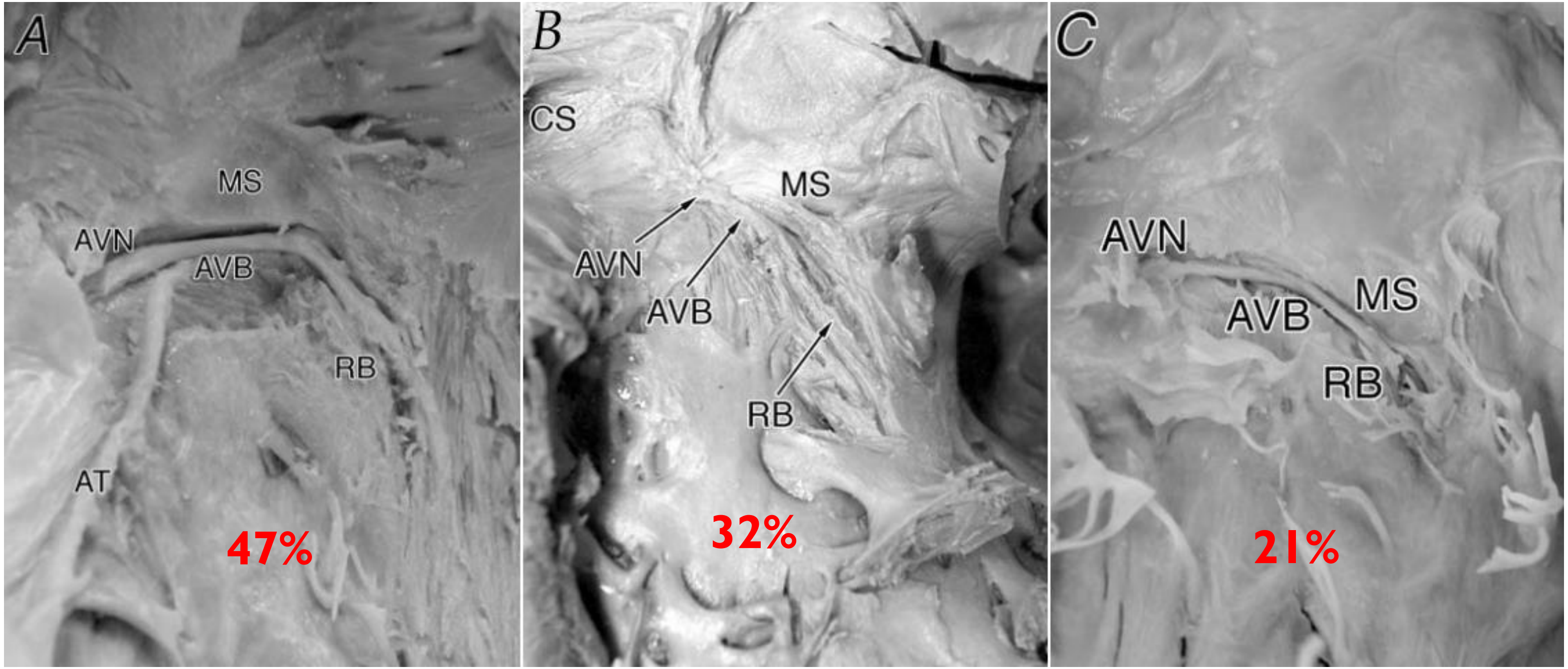
Suggested indications of HBP for CRT

- ???
- At present, HBP seems to be non-inferior when compared to CRT (?), but:
  - Procedural success lower
  - 10-30% of patients - LBBB uncorrectable
  - CRT-D!
- His-SYNC (HBP vs. CRT) – 6/2021
- HOPE-HF (HBP vs. VVI 30/min) – 10/2019

Limitations of HBP

- Variable anatomy of the bundle of His
- Technical challenges incl. requirement for EP skills = complex procedure ≈ to CRT
- Pacing thresholds
- Decreased stability
- Procedure/X-ray times
- Relatively low success rate
- For CRT indication, only proximal HB disease are amenable to correct by HBP

Limitations – variable anatomy



(A) Type I: The His bundle (AVB) runs under the membranous part of the interventricular septum (MS). (B) The type II His bundle runs within the muscular part of the interventricular muscle apart from the lower border of the membranous part of the interventricular septum. (C) The type III His bundle (arrow) is naked running beneath the endocardium with no surrounding myocardial fibers

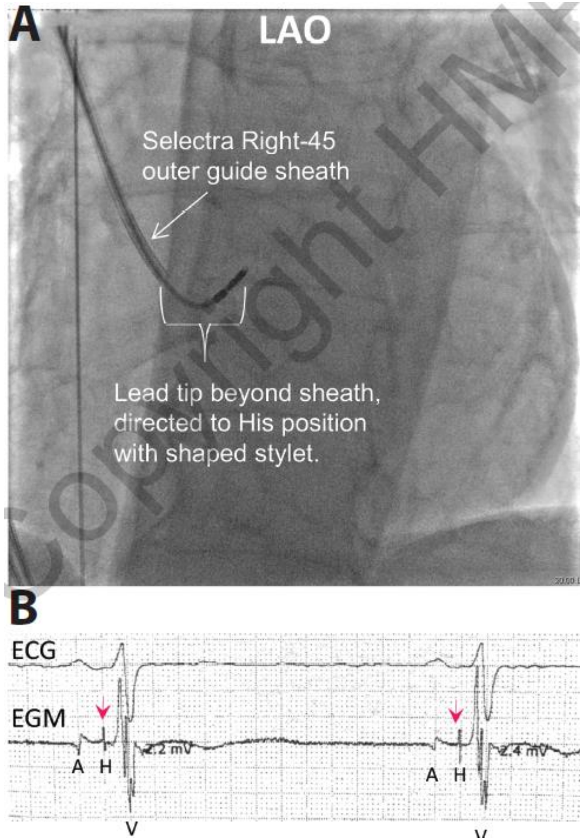
Kawashima T et al. Surgical and Radiologic Anatomy 2005; 27(3):206–213

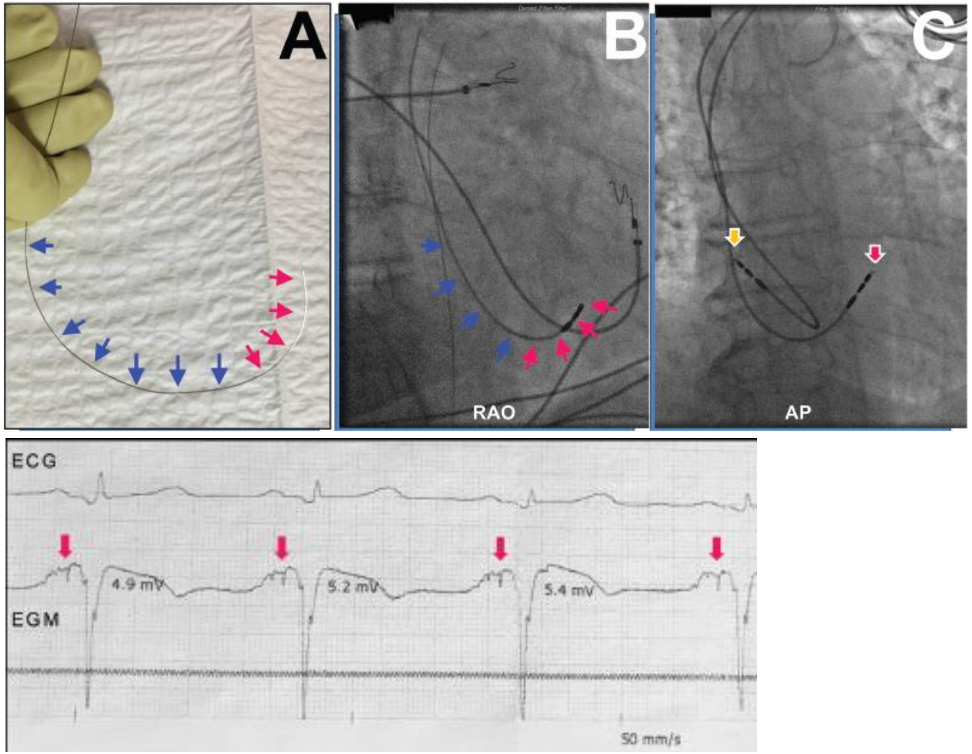
Limitations – implantation techniques

- SelectSecure 3830, C315His or C304 SelectSite (Medtronic)

Permanent HBP can be challenging due to the limited availability of delivery tools, particularly in patients with an enlarged right atrium and a displaced tricuspid annular region or right pectoral implants…

Emerging reports showing other techniques



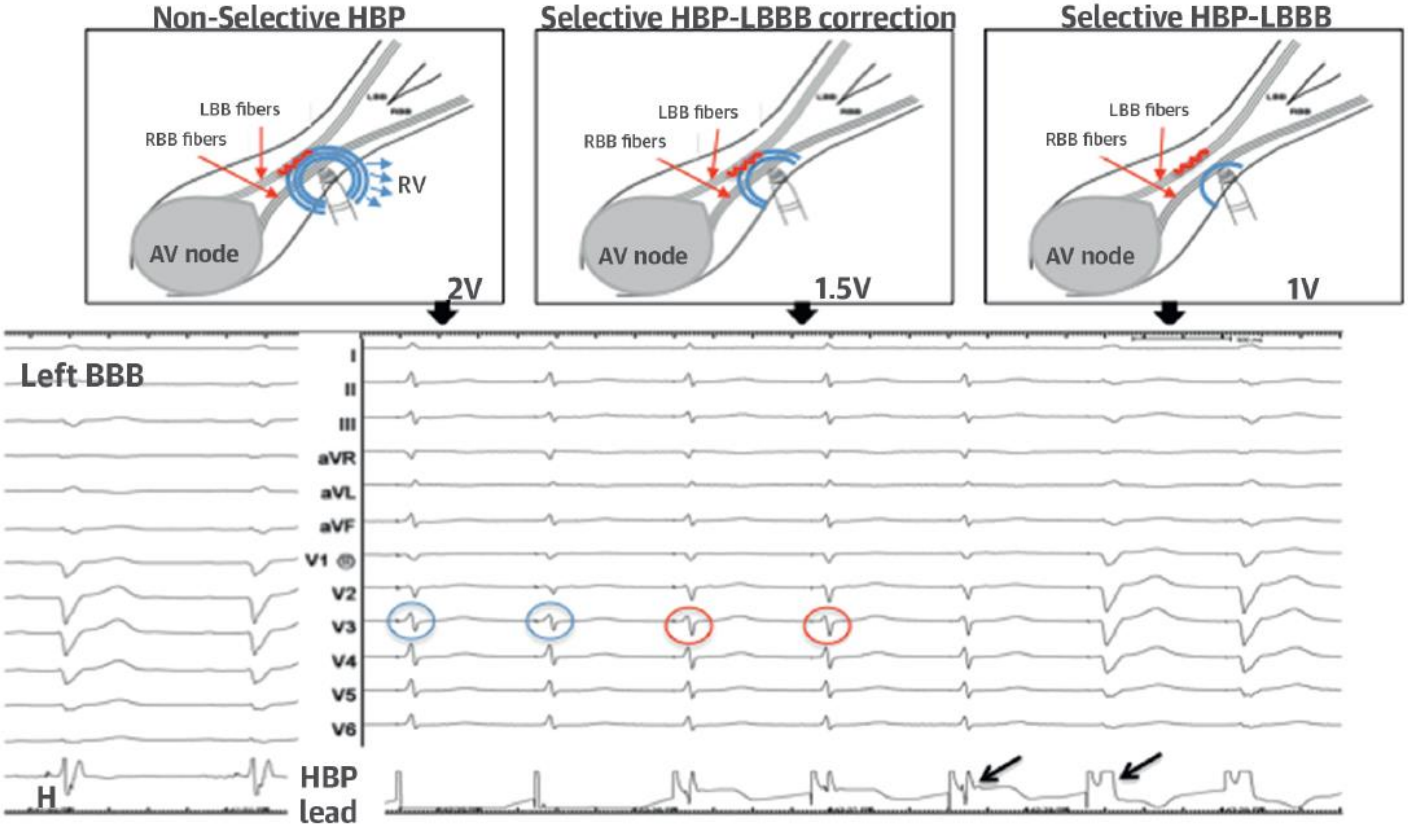


Kneller J. EP Lab Digest 2018; 18(8)
Kneller JR et al. Cardiology 2017; 137(Supl 1):168

Complexity!

- Not only delivery tools in variable anatomy, but…

Assessment: Selective and nonselective HBP



Sharma PS et al. Heart Rhythm 2018;15:413–20

Selective and Non-selective HBP

This holds true not only for the implanters,
But also for all personnel performing follow-ups!

On top of 3 S... ...arameters: PT,
impeda... ...sing!

Ba...		His-Purkinje Conducti...	
		With correction	...ection
Selective HBP	• ... lead ... • Paced QRS ... • Single capture thr...	• S-QRS ≤ H-QRS with isoelectric ... Discrete local ventricular ... ...S < n...	... with isoelectric ... ... ventricular electrogram ... ...d QRS = native QRS Single capture threshold (HBP with BBB)
Nonselective HBP	• S-QRS < H-QRS (S-QRS usually ... H-QRS$_{end}$) with or without isoelectric i... (Pseudodelta wave +/−) • Direct capture of local vent... gram in HBP lead by sti... myocardial captur... • Paced QRS ... precor... r... • ... ...ndle ca...	...end < ... interval ...ct capture ... ...th BBB correction, HB... correction, RV capture)	• S-QRS < H-QRS (S-QRS usually 0) with or without isoelectric interval (Pseudo-delta wave +/−) Direct capture of local ventricular ...trogram in HBP lead by stimulus ...ive QRS ...holds (HBP with

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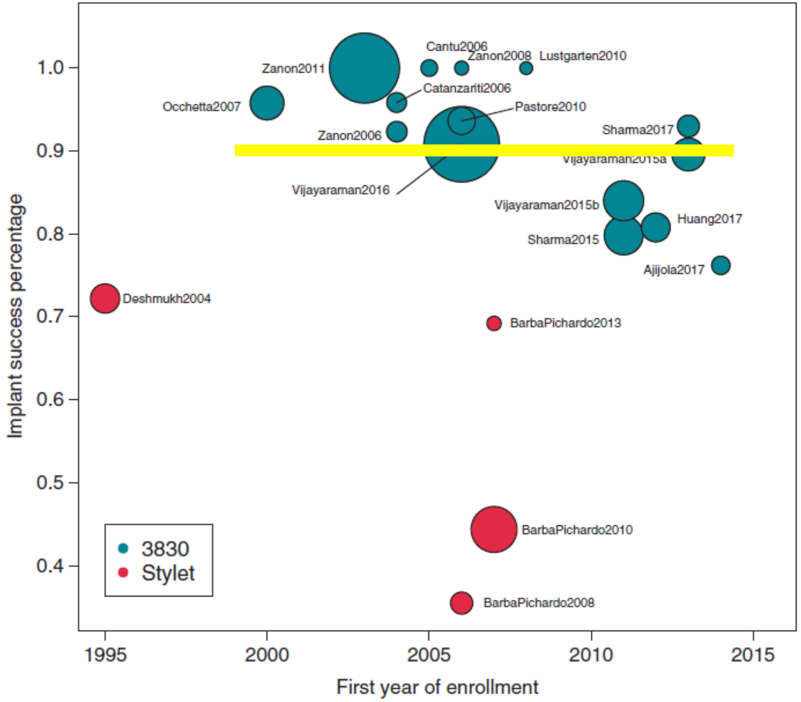
BBB = bundle branch block; dV/d... ...ange in voltage; H-QRS = His-QRS; H-V = His-ventricular; RV = right ventricle; S-QRS = stimulus-QRS; S-V = stimulus-v...

Limitations – success of the procedure

- In the original report by Deshmukh et al. , the success of permanent HBP in selected patients with cardiomyopathy undergoing AVN ablation was about 66% using traditional pacing leads
- Zanon et al. (26) reported an acute implant success rate of 92% in 26 patients without underlying HPCD while utilizing the 3830 pacing lead
- Sharma et al. reported the acute HBP implant success rate was 80% in a consecutive series of 94 unselected patients (including patients with HPCD) undergoing permanent pacemaker implantation
- Abdelrahman reported 92% in Geisinger HBP Registry in 332 attempts for HBP



Zanon F et al. J Europace 2018;20(11):1819-1826

Deshmukh P et al. Circulation 2000;101: 869–77
Zanon F et al. J Cardiovasc Electrophysiol 2006;17:29–33
Sharma PS et al. Heart rhythm 2015;12:305–12
Abdelrahman M et al. Geisinger HBP Registry

Limitations – Procedure duration and X-ray times

	His Bundle pacing (n=304)	RV pacing (n=433)	P-value
Procedure duration (min)	70.21±34	55.02±25	<0.01*
Fluoroscopy duration (min)	10.27±6.5	7.40±5.1	<0.01*
Implant Capture threshold (V @ ms)	1.30±0.85 @ 0.79±0.26	0.59±0.42 @ 0.5±0.03	<0.01*
Last follow up Capture threshold (V @ ms)	1.56±0.95 @ 0.78±0.30	0.76±0.29 @ 0.46±0.09	<0.01*
QRS duration (ms)	104.5±24.5	110.5±28.4	<0.01*
Paced QRS duration (ms)	128±27.7	166±21.8	<0.01*

Geisinger

JACC

Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330

Limitations – pacing thresholds

- In a study of 75 patients with successful permanent HBP, Vijayaraman et al. reported His capture thresholds of 1.35±0.5V at 0.5 ms at implant that remained stable during 5-year follow-up (1.62±1.0V at 0.5 ms)
- In another study of AV node ablation and HBP in 42 patients, His capture threshold at implant was 1.5±1.0V at 0.5 ms and remained unchanged during a median follow-up of 20 months
- In a study of 100 consecutive patients with advanced AV block, acute His capture threshold at implant was 1.3±0.9V at 0.5 ms and slightly increased to 1.7±1.0V at 0.5 ms during a mean follow-up of 19 months

Vijayaraman P et al. Heart Rhythm 2018;15:696–702
Huang W, et al. J Am Heart Assoc 2017 Apr 1;6:e005309
Vijayaraman P et al. J Am Coll Cardiol EP 2015;1:571–81

Limitations – lead revision rate

- Pts with AV block: 5%[1]
- Pts with CRT indication: 6.7%[2]

Table 1 Electrical parameters

	RVP				HBP			
Visit	n	Threshold (V)	R wave (mV)	Impedance (Ω)	n	Threshold (V)	R wave (mV)	Impedance (Ω)
Implant	98	0.62 ± 0.5	13.7 ± 5.7	754 ± 167	75	1.35 ± 0.9*	6.8 ± 5.3*	639 ± 159
1 year	88	0.80 ± 0.3	12.7 ± 5.6	585 ± 128†	66	1.60 ± 0.9*	6.7 ± 5.7*	476 ± 121†
2 years	77	0.80 ± 0.4	15.2 ± 6.6	515 ± 136	61	1.50 ± 0.8*	7.0 ± 6.0*	465 ± 75
5 years	58	0.84 ± 0.4†	13.3 ± 5.7	468 ± 117	51	1.62 ± 1.0*†	7.2 ± 5.2*	463 ± 78

Pacing threshold tested at 0.5-ms pulse duration.
HBP = His-bundle pacing; RVP = right ventricular pacing.
*$P < .01$ vs RVP.
†$P < .05$ vs implant.

1 Vijayaraman P et al. J Am Coll Cardiol EP 2015;1:571–81
2 Vijayaraman P et al. Heart Rhythm 2018;15:696–702

Many open questions…

- Specific situations in pts with infranodal, intra-Hisian AV block and BBB, where long-term safety of HBP has not been well studied:
  - In such patients, should a backup RV lead be placed with HBP?
  - What happens to the His bundle when it is traumatized by the screw on the tip of the lead in the long term?
- Can a second His Bundle pacing lead be placed successfully if the earlier lead fails in the long run?
- What are the implications of extracting a chronic HBP lead?
- Beyond pacing hemodynamics, what is the impact of HBP on arrhythmia?:
  - Does HBP reduce the risk of ventricular tachyarrhythmias in the presence of myocardial scar?
- Pts with need for CRT-D:
  - pacing/sensing/defibrillation

THANK YOU FOR YOUR ATTENTION

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