His Bundle Pacing
Benefits and Limitations

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His Bundle Pacing – historical perspective

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

## Potential use of HBP

<table>
<thead>
<tr>
<th>Initial cardiac activation (Narrow or broad QRS)</th>
<th>Current pacing solutions (Never narrow QRS)</th>
<th>His bundle pacing solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow QRS</td>
<td>Activation prolonged</td>
<td>Ventricular activation preserved</td>
</tr>
<tr>
<td>LBBB</td>
<td>Activation moderately improved</td>
<td>Ventricular activation restored</td>
</tr>
<tr>
<td>Narrow QRS long PR interval</td>
<td>Activation prolonged</td>
<td>Ventricular activation preserved and AVD optimised</td>
</tr>
</tbody>
</table>
RV apical pacing

DAVID trial

**RVA vs. BiV**

**BLOCK-HF trial**


N= 691

HR 0.74; 95% CI 0.60-0.90

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**


N= 177

BiV pacing vs. RVA pacing

LV Ejection Fraction (%)

LV End-Systolic Volume (ml)
# HBP vs. RVA pacing

<table>
<thead>
<tr>
<th>Study</th>
<th>Total Patients and Inclusion Criteria</th>
<th>Study Design</th>
<th>His Pacing Success Rate</th>
<th>Outcomes</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zanon et al. 2008[^2]</td>
<td>12</td>
<td>Non-randomised crossover study</td>
<td>Only patients with confirmed His bundle pacing</td>
<td>Intra-patient myocardial perfusion (myocardial perfusion score) during His pacing compared to RVA</td>
<td>Myocardial perfusion score during His pacing was better than RVA</td>
</tr>
<tr>
<td>Catanzariti et al. 2013[^6]</td>
<td>26</td>
<td>Non-randomised crossover study</td>
<td>Patients selected after successful His pacing established</td>
<td>Measurements of echocardiographic dyssynchrony parameters made during His pacing and RVA (intra-patient comparison)</td>
<td>Reduction of pacing-induced ventricular dyssynchrony with His pacing</td>
</tr>
<tr>
<td>Kronborg et al. 2014[^5]</td>
<td>38 (12 months His pacing and 12 months RVA)</td>
<td>Randomised double-blind crossover study</td>
<td>84 % (32/38) Six patients had leads in high septal position and were still included in study</td>
<td>Left ventricular ejection fraction</td>
<td>Left ventricular ejection fraction was significantly higher during His pacing (55 % +/- 10 % versus 50 % +/- 11 %)</td>
</tr>
<tr>
<td>Vijayaraman et al. 2017[^4]</td>
<td>192 (94 His and 98 RVA)</td>
<td>Case control study</td>
<td>80 % (75 from 94 attempted)</td>
<td>Death and heart failure hospitalisation</td>
<td>Death or heart failure was significantly lower in the His pacing group (32 % versus 53 %; HR 1.9)</td>
</tr>
<tr>
<td>Sharma et al. 2017[^9]</td>
<td>30 (post-prosthetic valve surgery)</td>
<td>Prospective observational</td>
<td>93 % (28/30)</td>
<td>Feasibility of His pacing in this subgroup of patients</td>
<td>His bundle pacing was feasible and achieved pacing in 93 % of patients post-valve surgery</td>
</tr>
<tr>
<td>Shan et al. 2017[^4]</td>
<td>18 (upgrade from RVA to His pacing in RVA patients)</td>
<td>Prospective observational</td>
<td>90 % (16/18)</td>
<td>Left ventricular ejection fraction, left ventricular end-diastolic dimensions, NYHA class and BNP</td>
<td>Reduced left ventricular end-diastolic dimensions and BNP. Improved ejection fraction and NYHA class</td>
</tr>
<tr>
<td>Abdelrahman et al. 2018[^9]</td>
<td>756 (332 His and 433 RVA)</td>
<td>Case control study</td>
<td>92 % (302/332)</td>
<td>Death, heart failure hospitalisation and upgrade to BVP</td>
<td>Combined primary endpoint of death, heart failure hospitalization and upgrade to BVP was significantly less in His pacing (HR 0.71)</td>
</tr>
</tbody>
</table>
Results From Geisinger HBP Registry

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

Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330
Results From Geisinger HBP Registry

Primary Outcome (Death, HFH or upgrade to biventricular pacing) - Patients with VP >20% -

Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330
Results From Geisinger HBP Registry

Heart Failure Hospitalizations

Follow up in years

---HBP VP <20%
---HBP VP >20%
---RVP VP <20%
---RVP VP >20%

Event-Free Rate

p = 0.01

Abdelrahman M et al. J Am Coll Cardiol 2018;71(20):2319-2330
Results From Geisinger HBP Registry

All-Cause Mortality

All Patients

Patients with VP >20%

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 (Class IIa, LoE: B)
# HBP for CRT indication

<table>
<thead>
<tr>
<th>First Author (Ref. #)</th>
<th>Year</th>
<th>N</th>
<th>Indication</th>
<th>HBP Lead</th>
<th>Implant Success (%)</th>
<th>Major Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barba-Pichardo et al. (46)</td>
<td>2013</td>
<td>16</td>
<td>CRT implant failure</td>
<td>Tendril 1488T, 1788TC, 1888TC</td>
<td>56</td>
<td>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% (&lt;0.05)</td>
</tr>
<tr>
<td>Lustgarten et al. (47)</td>
<td>2015</td>
<td>29</td>
<td>Crossover study of HBP and conventional CRT</td>
<td>Select-Secure 3830</td>
<td>59</td>
<td>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.</td>
</tr>
<tr>
<td>Su et al. (50)</td>
<td>2015</td>
<td>16</td>
<td>CRT implant failure</td>
<td>Select-Secure 3830</td>
<td>100</td>
<td>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.</td>
</tr>
<tr>
<td>Ajjola et al. (48)</td>
<td>2017</td>
<td>21</td>
<td>Primary HBP</td>
<td>Select-Secure 3830</td>
<td>76</td>
<td>QRS narrowing achieved in all 16 patients with implant success (180 ± 23 ms to 129 ± 13 ms; p &lt; 0.0001). NYHA functional class III → II (p &lt; 0.001), and LVEF improved from 27 ± 10% to 41 ± 13% (p &lt; 0.001)</td>
</tr>
<tr>
<td>Sharma et al. (49)</td>
<td>2017</td>
<td>106</td>
<td>CRT implant failure (Group I) and primary HBP (Group II)</td>
<td>Select-Secure 3830</td>
<td>90</td>
<td>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).</td>
</tr>
</tbody>
</table>

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 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, HOPE-HF
- OPTIMIST VIEW: There may come a time when a conventional CS or epicardial LV lead is a bail out for HBP in the appropriately selected patients
  - …but we are still far far away
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
(A) Type 1: 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.
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

Complexity and profound EP knowledge

- The presence of a His bundle injury current has been shown to predict excellent acute and long-term capture thresholds.

You need to set high pass filters down to 0.5 Hz to see!
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.

*Sharma PS et al. Heart rhythm 2015;12:305–12*
*Zanon F et al. J Cardiovasc Electrophysiol 2006;17:29–33*
*Abdelrahman M et al. Geisinger His Bundle Pacing Registry*
Selective and Non-selective HBP

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

On top of 3 key parameters: PT, impedance, performing follow-ups!

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## Limitations – Procedure duration and X-ray times

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

- In a study of 75 patients with successful permanent HBP, Vijayaraman et al. reported His capture thresholds of $1.35 \pm 0.5 \text{V}$ at 0.5 ms at implant that remained stable during 5-year follow-up ($1.62 \pm 1.0 \text{V}$ at 0.5 ms)
- In another study of AV node ablation and HBP in 42 patients, His capture threshold at implant was $1.5 \pm 1.0 \text{V}$ 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 $1.3 \pm 0.9 \text{V}$ at 0.5 ms and slightly increased to $1.7 \pm 1.0 \text{V}$ at 0.5 ms during a mean follow-up of 19 months

Huang W, et al. J Am Heart Assoc 2017 Apr 1;6:e005309
Limitations – lead revision rate

- Pts with AV block: 5%\(^1\)
- Pts with CRT indication: 6.7%\(^2\)

Table 1: Electrical parameters

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

Pacing threshold tested at 0.5-ms pulse duration.
HBP = His-bundle pacing; RVP = right ventricular pacing.

\(^*\)P < .01 vs RVP.
\(^\dagger\)P < .05 vs implant.

CRT indication – proximal disease

- 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?

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:
  - 1, 2 or even 3 electrodes? – pacing/sensing/defibrillation
THANK YOU FOR YOUR ATTENTION

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