His Bundle Pacing in the Era of Left Bundle Branch Pacing

Marek Jastrzębski [1], Weijian Huang [2], Pablo Moriña Vazquez [3] and Pugazhendhi Vijayaraman [4]

1. First Department of Cardiology, Interventional Electrocardiology and Hypertension, Jagiellonian University Medical College, Kraków, Poland; 2. The First Affiliated Hospital of Wenzhou Medical University, Nanbaixiang, Wenzhou, China; 3. Hospital General Juan Ramón Jiménez, Huelva, Spain; 4. Geisinger Heart Institute, Wilkes Barre, PA, US

Abstract

Soon after the rapid growth of the popularity of His bundle pacing (HBP), the use of this conduction system pacing modality was overshadowed by left bundle branch area pacing (LBBAP). This focused review on HBP addresses whether there are any advantages of HBP over LBBAP and what the current uses of HBP may be. We conclude that HBP must be considered as an alternative physiological pacing method with several potential applications, undoubtedly at least as a rescue option for failed CRT/LBBAP. For wider application of HBP, prospective studies are needed to document a reduction in the incidence of late threshold rise with modern implantation techniques. Nevertheless, HBP should be available in every modern pacing laboratory. This requires an active HBP program to maintain and develop the ability of operators to deliver HBP when it is most needed.

Keywords

His bundle pacing, left bundle branch pacing, conduction system pacing, physiological pacing

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Correspondence: Marek Jastrzębski, First Department of Cardiology, Interventional Electrocardiology and Hypertension, Jagiellonian University, ul. Jakubowskiego 2, 30-688 Kraków, Poland. E: mcjastrz@cyf-kr.edu.pl

Soon after the rapid growth in popularity of His bundle pacing (HBP) over the period 2016–20, this conduction system pacing (CSP) modality was overshadowed by left bundle branch area pacing (LBBAP). The LBBAP technique was widely adopted by clinicians due to better pacing parameters, higher efficacy in patients with distal conduction system abnormalities, a broader pacing target and more lenient success criteria, resulting in an apparently faster learning curve. Given this situation, there are several relevant questions regarding HBP:

- Are there any advantages of HBP over LBBAP?
- What could the current uses of HBP be?
- Where are we today regarding the development of the HBP technique?
- Can we overcome the known limitations of HBP with better tools, improved implantation techniques and/or patient selection?

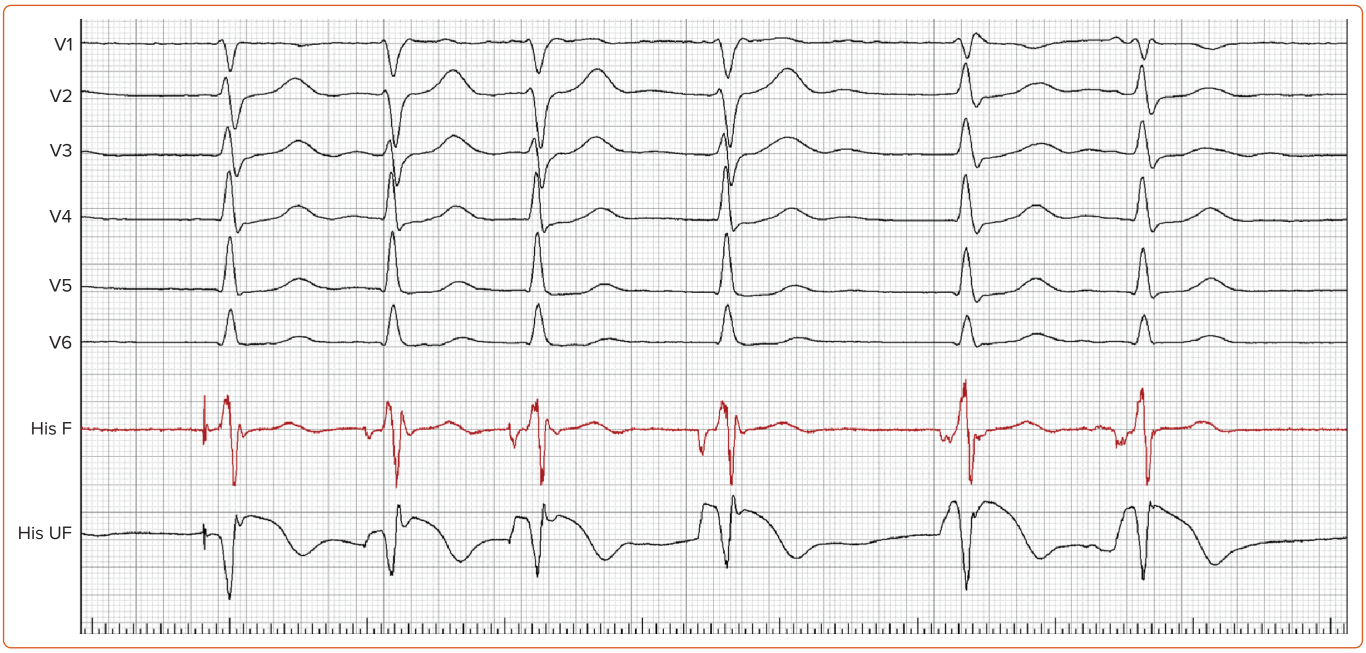
This focused review addresses these questions.

Milestones in His Bundle Pacing

The feasibility of temporary pacing of the His bundle (HB) in humans was first demonstrated by Narula et al. in 1970.[1] It took three decades before these observations led to clinical implementation: Deshumukh et al. reported the outcomes of permanent HBP in a series of 12 patients with narrow QRS in 2000, and a similar study was published by Moriña Vázquez et al. in 2001.[2,3] These very first reports of HBP pacemaker implantation addressed the potentially most important clinical indication for HBP, namely heart failure with permanent AF and the need for regular and synchronous activation of the left ventricle (LV). These reports were followed by studies from pioneering centres in Europe.[4–10] The feasibility of HBP in routine clinical practice was first reported by Sharma et al., and Keene et al. published the first large multicentre study on learning curves and mid-term outcomes.[11,12]

The feasibility of HBP-CRT in patients with left bundle branch block (LBBB) is based on the concept introduced by James and Sherf of the longitudinal separation (by collagen and sparse transverse junctions) of Purkinje fibres within the HB, making them predestined for the left bundle branch (LBB) or right bundle branch.[13,14] This concept was validated by Narula in 1977, who demonstrated that LBBB may be due to a focal lesion in the HB, a lesion that causes block or block-equivalent delay in LBB-predestined fibres.[15] Narula showed that pacing the HB proximal to the lesion reproduces the LBBB QRS morphology, whereas pacing the HB distal to the lesion restores a narrow, fully physiological QRS.[15] Recently, this concept was further substantiated by Upadhyay et al., who demonstrated the absence of pre-QRS conduction system potentials in the septal portion of the LBB, which could be restored by pacing the HB distal to the lesion in LBB-predestined fibres (if QRS normalisation was achieved).[16] The clinical use of HBP in patients with LBBB and CRT indications dates back to the first case report by Moriña-Vázquez et al. in 2005, followed by another study by the same group.[17,18] The practical use of HBP to correct

Figure 1: Continuous Recording From the His Bundle Lead During the Initial Phase of Lead Deployment



In His F, the progressive development of negative His bundle potential can be appreciated. In His UF, the progressive development of His bundle current of injury can be seen. Both of these are excellent markers of lead stability, direct contact with the His bundle and low long-term capture threshold. His F = filtered signal; His UF = unfiltered signal.

LBBB dyssynchrony was further expanded by Vijayaraman et al. by combining HBP with coronary venous pacing, resulting in a hybrid pacing approach labelled His-OpTimised (HOT)-CRT.[19] This pacing modality can be used when HBP results in only partial correction of LBBB. Recently, the first multicentre observational studies and randomised trials evaluating HBP-CRT and HOT-CRT were published, with favourable results.[20–22]

Development and Limitations of the His Bundle Pacing Technique

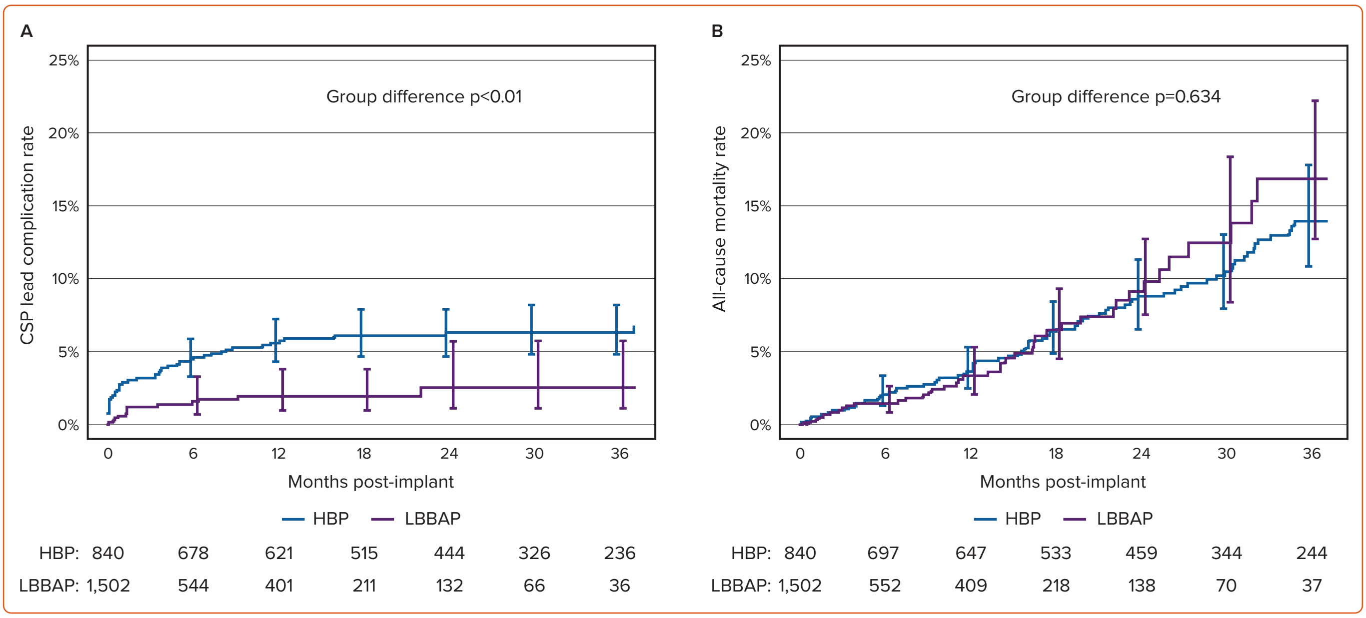
Initially, the lack of dedicated equipment for HBP necessitated manual reshaping of the lead stylet to reach the HB area; often the HB region was delineated with a diagnostic catheter introduced via femoral access, adding to the complexity of the procedure. The first reports of HBP used this method, coupled with the use of an active helix lead. Relatively low success rates, high capture thresholds, long procedure/fluoroscopy times and sensing issues limited the use of permanent HBP to a few pioneering centres.[2] At that time, the reported HB capture thresholds ranged from values of 1.5–3.2 V in narrow QRS to 3.7 V in LBBB patients.[2,4–6,9,10,18] The success rate at that time is difficult to assess reliably because of the known under-reporting of failures in observational studies, the high likelihood of the preselection of patients, the lack of established criteria to confirm HB capture during presumed non-selective pacing (common use of the term 'para-Hisian pacing') and the acceptance of excessively high (by current standards) acute capture thresholds. Nevertheless, the success rate appears to be less than 70% and 30% in patients with narrow QRS and LBBB, respectively.[2,4–6,9,10,18]

An evident increase in the success rate and an improvement in pacing parameters were observed with the use of the SelectSecure 3830 fixed-helix, lumenless, thin (4.1 Fr) lead, together with the dedicated C315HIS delivery catheter with a preformed septal curve (Medtronic).[10] It was widely accepted that a delivery catheter offered more support during lead fixation and facilitated localisation of the HB region compared with the manually shaped stylet-based lead delivery technique. Using a delivery catheter soon became the dominant approach for HBP worldwide, resulting in an improvement in acute and chronic HB capture thresholds to approximately 1.6–1.8 V (already in the early experience phase) and a success rate of approximately 80–90%.[23–26] Another step forward was the use of an electrophysiological system for HBP; this approach facilitated confirmation of HB capture, visualisation of HB potential during mapping and visualisation of HB current of injury (COI) with appropriate filter settings (0.1–250 Hz).[27]

Further research to improve the HBP technique focused on achieving a lower acute capture threshold and higher success rates. This included the introduction of the dual-lead technique, reports on the importance of the HB COI and the development of the negative HB potential as an intraprocedural marker of the optimal HB pacing site and good lead contact, and the use of contrast to delineate the summit of the tricuspid annulus and distal HBP region.[27–32] However, the extent to which these seminal observations and recommendations have changed real-world clinical practice is not known. Of note are advances in the delineation of HB physiology, including the development of several HB capture criteria beyond the simple threshold test and the determination of HB chronaxie and strength–duration curves to optimise battery longevity and facilitate selective or non-selective HB capture.[33–36]

Important clues for the future use of HBP (for patient selection and improvement of implantation tools) came from studies that delineated the limitations of HBP, namely a relatively low success rate in LBBB as well as in distal atrioventricular block.[16,37–39] Since then, the only progress in the HBP implantation technique was the introduction of the steerable 3D catheter, which provides better reach to superior sites and facilitates localisation of the HB region, especially for beginners. The use of steerable catheters probably results in a higher success rate and a steeper learning curve, but this has never been formally investigated because research interests have already shifted to LBBAP. One of the authors (MJ) believes that the use of a continuous pacing and recording technique for HBP is also a valuable step forward (*Figure 1*). This technique places more emphasis on constant monitoring of HB signals and pace

Figure 2: Kaplan–Meier Survival Curves of Conduction System Pacing Safety With a Catheter-guided Lead



A: Cumulative probability of CSP lead-related complications. B: Cumulative probability of all-cause mortality. CSP = conduction system pacing; HBP = His bundle pacing; LBBAP = left bundle branch area pacing; Source: Vijayaraman et al. 2024.[43] Reproduced from Heart Rhythm Society under a CC BY 4.0 License.

mapping rather than activation mapping, potentially facilitating the localisation of low-threshold areas and helping with lead fixation, because loss of HB capture during lead rotation due to unfavourable lead trajectory is then immediately apparent.

Programming HB devices is still more challenging than programming LBBAP or non-CSP devices. A long stimulus-to-ventricular potential interval results in the absence of an evoked potential immediately after the pacing stimulus, meaning that autocapture algorithms are unable to detect ventricular depolarisation. This can be offset by careful adjustment of pacing output during follow-up visits to ensure battery longevity. In addition, programming of the atrioventricular interval must take into account the latency interval, because the programmable atrioventricular delay is now the atrio-His delay. The position of the HB lead on the atrial side of the tricuspid annulus invariably results in a small-amplitude ventricular signal and a tendency for undersensing ventricular signals and oversensing of the atrial and HB signals. In most cases this can be prevented by following the implantation rules described below, but these issues also require more attention during follow-up.

Recent His Bundle Pacing Studies

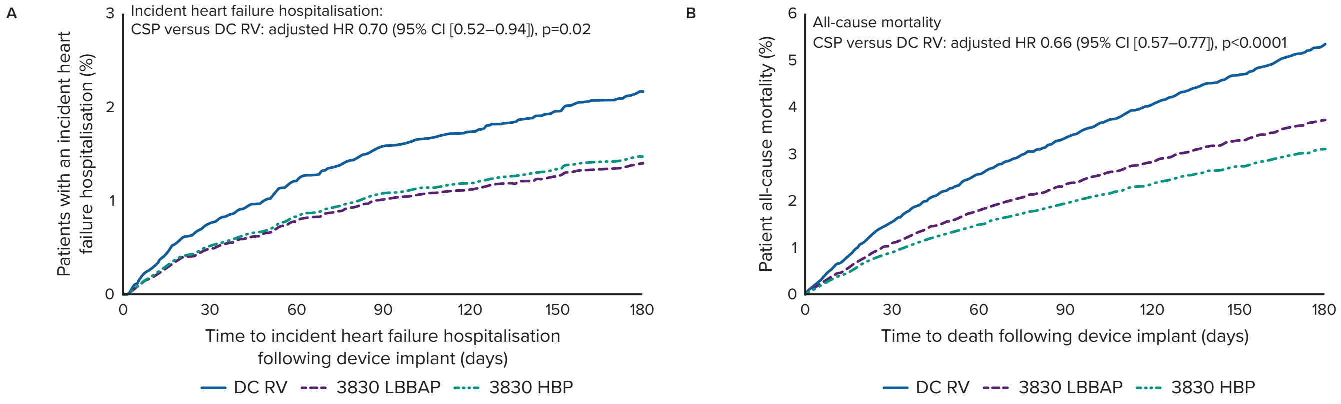
In the recent prospective observational international Physiological Pacing Registry of 849 patients implanted at 44 centres, the success rate for HBP was 88.5% (529/598 patients).[40] In that study, the mean (± SD) HB capture thresholds were reported to be 1.44 ± 1.0 V at the time of implantation, and they remained stable at the 6-month follow-up (1.59 ± 0.97 V). The success rates for HBP implanters with experience in >10 cases were 90%, compared with 78% for those with minimal experience. No differences in success rates were observed in patients undergoing LBBAP.[40] The feasibility of performing atrioventricular node ablation from axillary vein access at the same time as HBP and LBBAP has been described, with high success rates and shorter procedure times, as well as early ambulation and discharge compared with traditional femoral access for ablation.[41] In another series of 70 patients undergoing atrioventricular node ablation and strict threshold criteria of <1.5 V, HBP was successful in 56 (80%) patients in whom LBBAP was used as a back-up.[42] Over a mean (± SD) follow-up period of 13 ± 5 months, only one patient experienced an increase in the HBP threshold of >1 V.[42] In a prospective Medtronic product surveillance registry of SelectSecure 3830 pacing leads, 1,502 patients with LBBAP were compared with 840 patients with HBP.[43] In that study, the incidence of lead complications 36 months after implantation was 2.5% in the LBBAP group and 6.3% in the HBP group (*Figure 2*).[43] Moreover, there was no significant difference in the rate of all-cause mortality between the two groups.[43] A recent comparison analysis of CSP (HBP, n=1,459 patients; LBBAP, n=4,738 patients) to dual-chamber right ventricular (RV) pacing (n=16,989) in a large, population-based cohort using data from the Micra Coverage with Evidence Development study revealed that CSP (LBBAP and HBP) patients with a SelectSecure 3830 catheter-delivered lead experienced significantly lower rates of incident heart failure hospitalisation (HR 0.70, p=0.02) and all-cause mortality (HR 0.66, p<0.0001) at 6 months compared with RV pacing patients.[44] In that study, there was a significant difference at 70 days in the incidence of heart failure hospitalisation (HR 0.70, p=0.02) and all-cause mortality (HR 0.66, p<0.0001) between the CSP and RV pacing groups (*Figure 3*).[44]

Unmet Needs in His Bundle Pacing

Unfortunately, there has been little progress in the most crucial areas, namely how to prevent HB lead revision due to late threshold rise or undersensing issues, and how to simplify and standardise the implantation technique. Late threshold increase/loss of HBP have been observed in 1.5–40% of patients during follow-up.[12,26,38,39,42,45,46] This wide range probably reflects differences in implantation technique between reporting centres. No clear predictors of late threshold rise have been identified, other than a lack of septal perpendicularity of the lead course.[45] Hypothetically, deterioration of the HB capture threshold must be related to one of the following:

- microdislocation of the lead tip;
- progressive/continuing local inflammation;
- damage to the HB induced by the pacing lead; or
- progression of conduction system disease slightly distal to the pacing site.

Figure 3: Kaplan–Meier Survival Curves of Conduction System Pacing (His Bundle Pacing or Left Bundle Branch Area Pacing) Compared With Dual-chamber Right Ventricular Pacing



A – N at risk

3830 LBBAP	3,086	3,041	2,798	2,587	3,294	2,207	2,031
3830 HBP	1,026	1,012	1,005	990	976	960	951
DC RV	11,837	11,586	11,153	10,758	10,329	9,845	9,404

B – N at risk

3830 LBBAP	4,738	4,680	4,312	3,965	3,661	3,390	3,119
3830 HBP	1,459	1,433	1,417	1,400	1,380	1,359	1,346
DC RV	16,989	16,691	16,083	15,487	14,852	14,141	13,492

A: Incident heart failure hospitalisation. B: Time to death following device implant. 3830 = SelectSecure 3830 catheter-delivered lead; CSP = conduction system pacing; DC RV = dual-chamber right ventricular pacing; HBP = His bundle pacing; LBBAP = left bundle branch area pacing; Source: Vijayaraman et al. 2024.[44] Reproduced with permission from Heart Rhythm Society.

Microdislocation due to poor initial lead fixation, inadequate lead orientation with respect to the HB, inappropriate slack and/or excessive lead tip movement is the most likely suspect. It appears that the initial acute capture threshold, lead revision rate and late threshold elevation are strongly related to operator experience and implantation technique.[26,39] Therefore, modern HBP implantation techniques should empirically address these likely causes of late threshold elevation. To this end, all markers of optimal HB lead position should be rigorously followed, suboptimal sites/parameters should never be accepted and the implantation technique should be highly standardised (see 'Proposed Use of His Bundle Pacing in the Modern Pacing Laboratory' below).

There are several simple technical solutions that could improve the HBP technique that have not been explored, including:

- pacemakers with larger-capacity batteries to mitigate the impact of a late threshold rise;
- leads with a longer active screw to facilitate distal HBP;
- larger steroid deposits at the lead tip;
- dedicated pacemaker software, especially autocapture algorithms; and
- steerable sheaths with a greater reach (larger proximal curve).

Advantages of His Bundle Pacing over Left Bundle Branch Area Pacing

His Bundle Pacing is less invasive

The LBBAP technique inherently requires blind deep septal penetration with the pacing lead. This leads to an unavoidable risk of damage to the septal vessels, septal myocardium and perforation into the LV cavity. The resulting complications include MI, septal hematoma (sometimes life-threatening), arteriovenous fistula, ventricular arrhythmias and stroke. All these complications of LBBAP have been reported and, although they are rare, they seem serious enough to favour a less invasive physiological pacing method.[47–49] Moreover, the long-term sequelae of myocardial damage from indwelling deep septal leads and damage/fibrosis (microscar formation) associated with repeated lead repositioning during initial implantation are unknown; however, proarrhythmic effects, especially in heart failure, must be considered. Similarly, LBBAP lead extraction after many years of pacing may not be possible without serious septal damage, potentially even formation of a ventricular septal defect or abandonment of the intraseptal lead tip. All these considerations regarding the acute and long-term risks, which seem to be higher with LBBAP than HBP, are especially valid for patients with a low expected need for ventricular pacing (patients with sick sinus syndrome), in whom a less invasive physiological pacing method seems preferable, even if the pacing parameters are inferior.

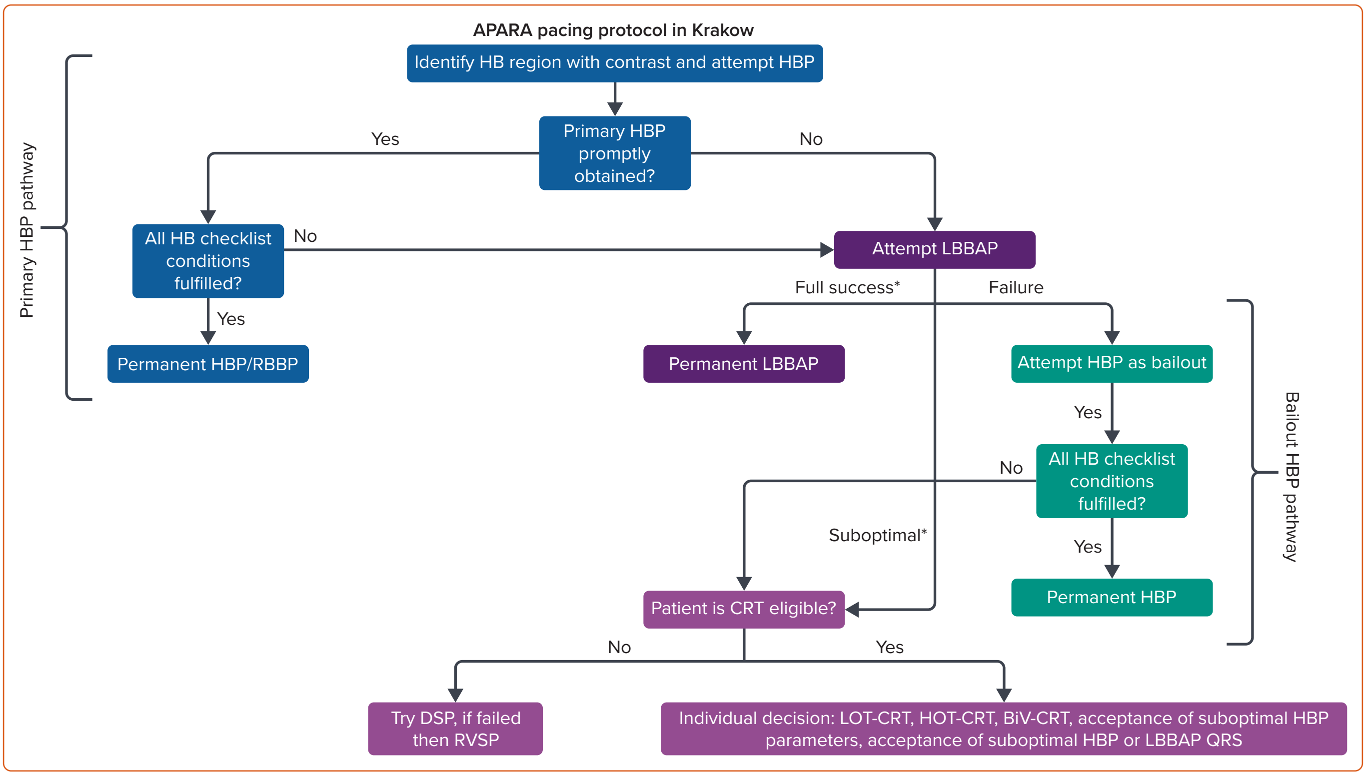
His Bundle Pacing is More Physiological

Selective activation of the HB is undoubtedly the 'gold standard' for physiological ventricular pacing, providing identical ventricular activation as during native conduction. With non-selective HBP, the deviation from physiology is, in most cases, minor and is unlikely to affect LV activation. In addition, inadvertent lack or loss of HB capture is immediately apparent due to the significant differences between the HBP QRS and the RV-paced QRS from the basal septum. This leads to easy confirmation of capture during the procedure and easy detection of loss of HBP during follow-up, leaving no 'grey zone' in HBP and thus further limiting the impact of the non-physiological component with the HBP strategy.

In contrast, LBBAP clearly deviates from physiology by inducing some RV delay in almost all cases, as reflected by the presence of a terminal r/R wave in V1. Moreover, confirmation of LBB capture is often challenging, and the lack of direct LBB capture affects a significant percentage of LBBAP patients. In MELOS, lack of LBB capture (i.e. obtaining only LV septal pacing [LVSP]), was noted in 20% of patients.[47] In laboratories with a lower threshold for accepting LVSP and/or less strict criteria for LBB capture, this percentage may be higher.

Furthermore, loss of LBB capture during follow-up due to microdislodgement, which sometimes occurs immediately after slitting the delivery catheter, is probably an underestimated phenomenon. There is a paucity of data regarding the maintenance of LBB capture during long-term follow-up. In one series, loss of LBB capture was noted in 4.6% of 323 patients with successful LBBAP with SelectSecure 3830 lumenless leads, compared with 12% in a smaller series of 22 patients with stylet-driven leads.[50,51] In our experience (MJ, unpubl. data), loss of LBB capture

Figure 4: The 'As Physiological As Reasonably Achievable' Pacing Protocol Followed at the University Hospital in Krakow



**Full success is defined as a QRS with a V6 R wave peak time in the physiological range (i.e. <90 ms), whereas suboptimal success is defined as a broad QRS with a long V6 R wave peak time and/or other features that indicate a lack of synchronous activation of the left ventricle. APARA = as physiological as reasonably achievable; BiV = biventricular pacing; CRT = cardiac resynchronisation therapy; DSP = deep septal pacing; HB = His bundle; HBP = His bundle pacing; HOT-CRT = His-optimised CRT; LBBAP = left bundle branch area pacing; LOT-CRT = LBBAP-optimised CRT; RBBP = right bundle branch pacing; RVSP = right ventricular septal pacing.*

occurs in approximately 12% of patients; this percentage may be higher when stylet-driven leads are used. In the study of Cano et al., the combined acute and late LBBAP lead microdislodgement rates were 5.5% and 16.8%, respectively.[52] Consequently, when the primary LVSP rate is added to the secondary loss of LBBAP, it is possible that LVSP may be present in >30% of LBBAP patients in a real-world scenario.

The physiological benefits of following the HBP strategy also include diagnostic insights: with HBP it is possible to categorise the level of atrioventricular block (with His-ventricle [HV] interval assessment and response to HBP) as nodal, intra-Hisian or sub-Hisian; similarly, the level of LBBB can be determined (QRS normalisation with HBP at low/medium output indicates intra-Hisian LBBB). In addition, LBBB QRS normalisation with HBP provides an individualised reference value for the V_6 R wave peak time to diagnose LBB capture should LBBAP be attempted.[53]

His Bundle Pacing May Be Simpler Than Left Bundle Branch Area Pacing or the Only Conduction System Pacing Option

The success rate of LBBAP is approximately 92%, and is much lower in heart failure patients (80%), the pacing candidates who probably need it most.[47] A recent prospective multicentre study reported a success rate of 55% for LBBAP in heart failure patients with advanced conduction system disease.[54] Although the real-world success rate of LBBAP in specific patient subpopulations remains to be determined, it is clear that LBBAP is not an option for many patients with septal fibrosis and/or heart failure or with an artificial tricuspid valve. In addition, septal fibrosis is often associated with a severely diseased left septal conduction system and, in such cases, even when the left side of the septum is reached, recruitment of the left conduction system is absent or inadequate. In such cases, access to the HB may be relatively easy, resulting in activation of the entire preserved left conduction system.

Proposed Use of His Bundle Pacing in the Modern Pacing Laboratory

There are currently two distinct uses of HBP: one as part of a routine CSP implantation strategy and the other as a bailout technique for failed or suboptimal LBBAP and biventricular CRT.[55,56] Although the first use requires a fast and reliable technique with a low lead revision rate that can compete with LBBAP, the second is more focused on providing synchronous activation of the LV when it is most needed and longer procedure times and suboptimal pacing parameters may be acceptable. However, to be able to use HBP as a bailout, the operator must be proficient in this technique, and this is difficult without an active HBP program for routine bradycardia cases. With this in mind, and in the belief that HBP is faster, easier, less invasive, more physiological and offers comparable pacing parameters to LBBAP in selected patients, one author's (MJ) centre currently follows checklist-based HB implantation within the 'as physiological as reasonably achievable' (APARA) pacing concept (*Figure 4*). This approach is broken down as follows:

1. If the HB is quickly identified with contrast and activation mapping or pace mapping, and lead fixation at the HB site is not a problem, attempt HBP. If not, the pacing strategy is immediately changed to the next step in the physiological pacing ladder (i.e. LBBAP). If LBBAP fails, then the HBP option is revisited as a bailout option with more effort.

2. If HBP is obtained, the operator must ensure that all the points on the checklist (see below) are marked off before accepting HBP as a permanent pacing option. This is considered pivotal for preventing a late threshold rise and undersensing, and for good long-term performance of HBP in routine clinical use. If the checklist conditions are not met, LBBAP is attempted.
3. If both HBP and LBBAP fail, deep septal pacing or RV septal pacing is used in patients without CRT indications, whereas HOT-CRT, LBBAP-optimised CRT or biventricular CRT is used in CRT candidates.

The checklist for the proposed HBP implantation method focusing on limiting the need for lead revision is as follows:

1. For primary HBP, patients with a narrow QRS or isolated right branch bundle block are most suitable.
2. Follow a standardised lead implantation/fixation technique.
   a. Contrast: Use of contrast routinely as a first step in determining the HB area (tricuspid valve summit), giving preference to the distal HB (i.e. HB on the ventricular side).
   b. Strong lead rotation: Rotation of the lead must always result in a noticeable build-up of torque, which is maintained for a moment until the lead is released, resulting in a vigorous counterclockwise rotation of the lead to release the excess torque.
   c. Mandatory bonus lead rotations: After assessing the pacing parameters in a slack position, push the guiding catheter back to the septum and always perform vigorous bonus lead rotations, ending like the initial rotations with a build-up of torque and again with an evident counterclockwise rebound of the lead. Using the push/pull technique, regain the slack and reassess the pacing and electrophysiological parameters (COI, sensitivity).
   d. Stability check: Before slitting the guiding catheter, check that several push/pull manoeuvres with increasing/decreasing lead slack do not affect the endocardial signal (COI, HB potential amplitude) and pacing parameters.
   e. Optimised slack: Ensure the presence of 'J'- rather than 'L'-type lead slack during deep inspiration and the lack of forceful lead rocking with heartbeats.

3. Absolutely do not accept suboptimal/borderline HB pacing sites/ acute outcomes.
   a. The acute/subacute (end of procedure) pacing threshold must be ≤1.5 V at 0.4 ms. With a large COI and a progressive threshold decrease every 5–10 minutes, a slightly higher subacute threshold may be acceptable.
   b. Sensing in bipolar mode must be >2 mV unless sensing is provided by a separate RV lead (CRT device with indications for RV defibrillation lead implantation or with an old, abandoned RV lead).
   c. Persistent (i.e. >5 minutes) HB COI, or the development of a negative HB potential, after lead deployment is mandatory, unless the acute pacing threshold is very low (<1.0 V).
   d. The HV interval during sensing or pacing at the working output (<3 V) must be <55 ms.
   e. The paced V6 R wave peak time must be <110 ms.
   f. Fast incremental pacing at the working output to a cycle length of ≤300 ms must document 1:1 conduction via the HB without evident prolongation of either the HV interval or QRS not related to right bundle branch block aberration or loss of septal myocardial capture.

With this approach, HBP is implemented in patients in whom it can be done quickly (usually faster than LBBAP in the same patients) and safely, as well as in patients who need it most (CRT candidates). Since implementing the above checklist-based approach for HB implantation approximately 2 years ago, there has not been a single significant threshold rise or other HB lead-related problem requiring reintervention at the author's (MJ) institute. Points 2b and 3a above are probably the most important. It is likely that the main cause of a late threshold rise is lead instability, resulting in microdislodgement. Surprisingly, after initial lead deployment, even with counterclockwise rebound and HB COI, leads can be unstable and benefit from bonus rotations. Bonus lead rotations can increase lead stability and cause augmentation or development of HB COI, resulting in a stable long-term threshold. However, if the COI or pacing threshold deteriorates after the bonus rotations (or stability check), this is also good because it indicates that the lead was in a fragile position prone to microdislodgement anyway and that it is better to have threshold deterioration at implantation (when it can be corrected) than at follow-up (when it cannot be helped). Lead instability can potentially be increased by small lead slack and vigorous tip movement, so these should be avoided.

The second major reason for lead revision is probably the acceptance of a borderline/high threshold and suboptimal sensing at implantation. Suboptimal pacing parameters may themselves be markers of a poor HBP candidate/suboptimal lead position (i.e. too proximal to the site of block or a too-diseased HB). Moreover, in a patient with a threshold of 0.8 V, a late threshold increase of 1 V is not a major problem, whereas the same degree of threshold increase in a patient who initially had a threshold of 2.5 V at 0.4 ms (or even more so with a threshold of 2.5 V at 1 ms, as originally recommended for HBP[57]) will result in very rapid battery depletion because the programmed output will have to be very high.

Conclusion

At this stage, HBP must be considered as an alternative physiological pacing method with several potential applications, undoubtedly at least as a rescue option for failed CRT/LBBAP. The search for optimal candidates for HBP and for optimal HBP techniques and devices is ongoing. For a wider application of HBP, a prospective study is needed to document reductions in the incidence of late threshold rise with modern implantation techniques. Nevertheless, HBP should be available in every modern pacing laboratory. This requires an active HBP program to maintain and develop the ability of operators to deliver HBP when it is most needed. ❑

Clinical Perspective

- HBP provides more physiological ventricular depolarisation and is less invasive than LBBAP, and may be considered as a primary pacing strategy in some cases.
- In patients with heart failure who have failed LBBAP and/or biventricular pacing, HBP offers an excellent bailout pacing option.
- Future development of HBP must focus on addressing the incidence of late threshold rises and appropriate patient selection.
- Integration of HBP into the workflow and implantation strategy of the modern pacing laboratory is necessary; the 'as physiological as reasonably achievable' (APARA) approach is proposed in this review.

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