Editorial

Conduction system pacing: What is new in 2025 Clinical Consensus Statement

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Abstract

Conduction system pacing (CSP), which includes His bundle pacing (HBP) and left bundle branch area pacing (LBBAP), is increasingly recognized as a physiological and clinically effective alternative to conventional right ventricular pacing (RVP) and biventricular pacing (BiVP). The 2023 EHRA consensus provided a detailed overview of implantation techniques and procedural endpoints, while the 2025 EHRA/ESC clinical consensus expands the discussion to clinical decision-making and patient selection across various scenarios.

This review highlights the evolving role of CSP specifically in the context of bradycardia management and cardiac resynchronization therapy (CRT). We focus on how recent recommendations guide the choice of pacing strategy or resynchronization modality depending on individual clinical scenarios.

Key words: Conduction system pacing, His bundle pacing, left bundle branch area pacing, cardiac resynchronization therapy, HOT-CRT, LOT-CRT

(Heart Vessels Transplant 2025; 9: doi: 10.24969/hvt.2025.588)

Introduction

Conventional right ventricular pacing (RVP) is associated with non-physiological activation of the ventricles, resulting in asynchronous contraction of the left ventricle (LV). This, in turn, may lead to structural remodeling, decline in left ventricular ejection fraction (LVEF), functional mitral regurgitation, increased risk of atrial fibrillation, and progression of heart failure. These changes contribute to the development of pacing-induced cardiomyopathy, observed in approximately 15–20% of chronically paced patients.

To overcome these limitations, conduction system pacing (CSP) has emerged as a physiological alternative. By directly engaging the His-Purkinje system, CSP aims to restore near-native ventricular activation. The two primary modalities – His bundle pacing (HBP) and left bundle branch area pacing (LBBAP) – have rapidly gained widespread clinical interest.

This review addresses the rapidly growing interest of both clinicians and researchers in CSP as a technique already implemented in routine practice and likely to expand its evidence base in the near future. The results of the randomized comparative trials discussed below support increasing adoption of CSP.

Consensus on CSP: Focus shift

The previous expert consensus on CSP published by EHRA in 2023 defined the procedural criteria for CSP. For HBP, selective and non-selective capture were defined based on different criteria such as stimulus-QRS latency and output-dependent transitions in QRS morphology (1). For LBBAP, during lead implantation it is important to rely on anatomical landmarks in multiple projections, to assess lead advancement during screwing, and to follow the detailed criteria for confirming conduction system capture. The most appropriate criteria are short stimulus-to-peak LV activation time, terminal r-wave in lead V1 and the presence of left bundle branch potential.

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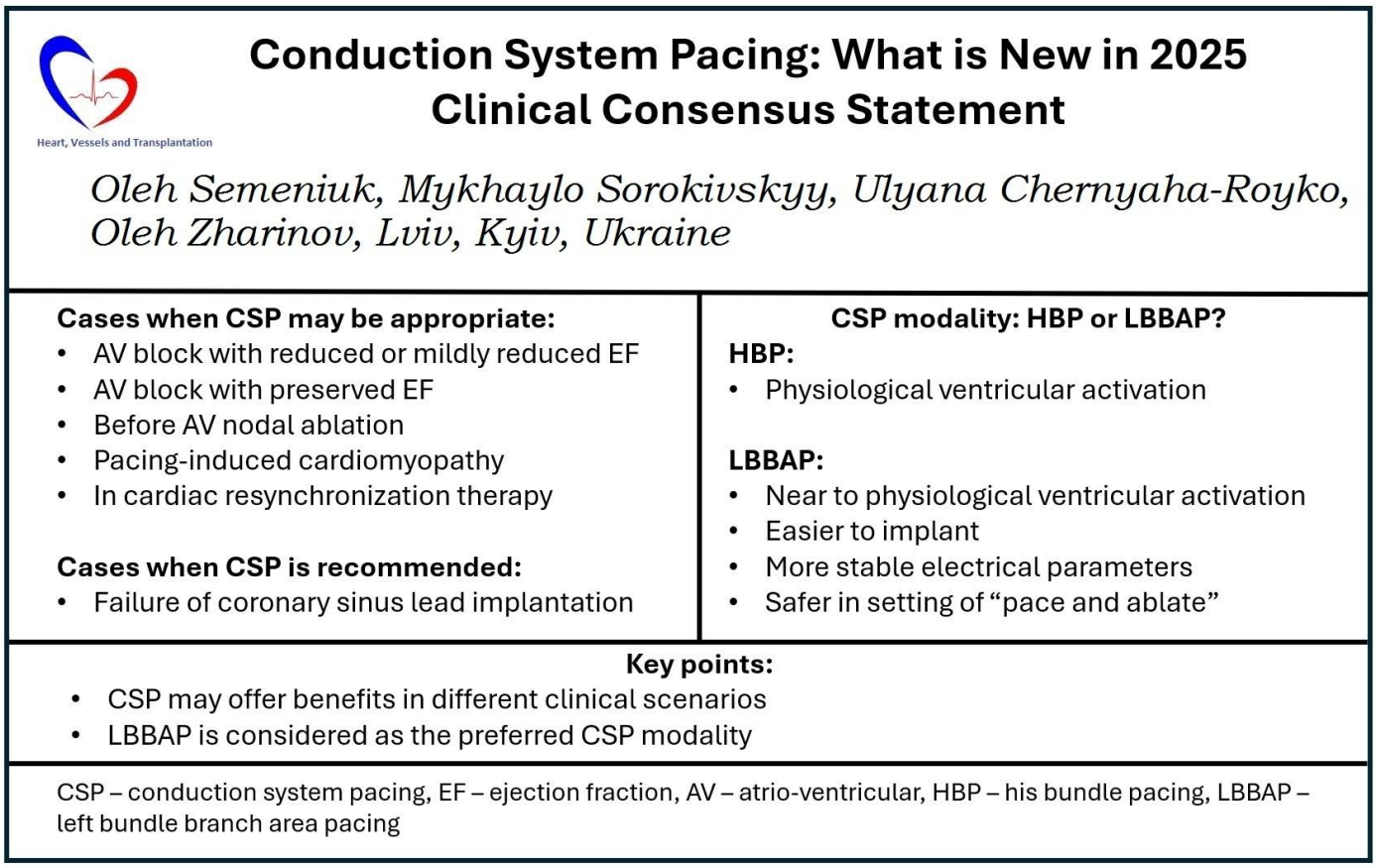
Citation: Semeniuk O, Sorokivskyy M, Chernyaha-Royko U, Zharinov O. Conduction system pacing: What is new in 2025 Clinical Consensus Statement. Heart Vessels Transplant 2025; 9: doi: 10.24969/hvt.2025.588

Received: 14.08.2025 **Accepted:** 15.08.2025

Graphical abstract



http://hvt-journal.com/articles/art588 doi: 10.24969/hvt.2025.588

The consensus also emphasized the importance of learning curves, sheaths and tools, complications, and lead management. While HBP often requires higher pacing output and is sensitive to atrial oversensing, LBBAP emerged as a more technically reproducible and stable technique (2).

In contrast, the 2025 EHRA/ESC clinical consensus redirected focus from technical aspects towards patient-centered indications and clinical decision-making (3). This document not only compares procedural outcomes across CSP modalities but also provides guidance on selecting appropriate pacing or resynchronization strategies depending on specific clinical scenarios.

Comparison of CSP strategies

In 2025 Consensus, HBP is compared with LBBAP. HBP provides a physiological ventricular activation but is often limited by high pacing thresholds, greater risk of lead dislodgement and lead instability (4). LBBAP, in contrast, offers better procedural parameters, including lower pacing thresholds, improved lead stability, and higher implantation success rates demonstrated in a major meta-analysis (5).

While LBBAP stimulates the conduction system at a slightly more distal level, it also ensures early and synchronized activation of the left ventricle. This closely mimics physiological conduction and has demonstrated excellent clinical outcomes in both bradycardia and cardiac resynchronization therapy (CRT) indications (6). In patients with proximal conduction disease, such as atrioventricular (AV) nodal or intra-Hisian block, HBP remains a preferred option. However, for the majority of cases – particularly those involving distal conduction delay or an indication for cardiac resynchronization – LBBAP is now considered as a primary CSP strategy. Thus, the 2025 Consensus positions LBBAP as a preferred modality in routine clinical practice, while reserving HBP for selected patient populations with specific anatomical or electrical considerations.

Conduction system pacing for AV block with LVEF >40%

In patients with AV block and preserved or mildly reduced LVEF (>40%), the 2025 EHRA/ESC consensus recommends considering CSP as an alternative to traditional RVP. While RVP remains a feasible approach, chronic pacing from the right ventricular apex or interventricular septum has been associated with a risk of pacing-induced cardiomyopathy due to asynchronous ventricular activation (7). CSP, through either HBP or LBBAP, offers a physiological pattern of ventricular depolarization, potentially preserving LV function and reducing adverse remodeling. For patients expected to have a high burden of ventricular pacing – at least more than 20% – CSP may provide clinical benefit by reducing the risk of heart failure progression and improving outcomes (8). On the other side, RVP is associated with higher success rate and fewer complications.

As a result, CSP (particularly LBBAP) is advised in patients with AV block and LVEF >50%, either as a preferred or appropriate strategy alongside RVP. In patients with LVEF of 41–50% and anticipated ventricular pacing burden ≥20%, CSP and biventricular pacing (BiVP) are both considered as appropriate options.

Conduction system pacing for AV block with LVEF ≤40%

In patients with AV block and reduced LVEF (≤ 40%), the 2025 EHRA/ESC consensus supports the use of CSP, particularly LBBAP, as an effective alternative to traditional BiVP. While BiVP remains the standard for CRT, LBBAP offers comparable improvements in ventricular synchrony and function, while also providing practical advantages, such as a smaller device size and fewer leads required for implantation. These features may translate into a lower risk of procedural and long-term complications. In patients who are not suitable for BiVP, for example, due to venous anatomy constraints or failed coronary sinus lead placement, CSP is proposed as a compelling alternative. CSP may also serve as a first-line strategy in selected cases.

Conduction system pacing in AV node ablation

In patients undergoing AV node ablation, CSP can maintain or improve ventricular synchrony and function compared to RVP, while regarding efficacy is comparable with BiVP.

For patients with preserved LVEF (>50%), RVP remains a reasonable option. However, CSP may provide additional benefits and is now considered appropriate in selected cases, whereas BiVP is not regarded as a method of choice in this setting. In those with mildly reduced LVEF (41–50%), both BiVP and CSP are considered to be appropriate pacing strategies. In patients with significantly reduced LVEF (≤40%), CSP may be used as an alternative when BiVP is not feasible or fails to provide sufficient benefit.

When selecting a CSP modality for AV node ablation, it should be noted that with HBP, an increase in pacing thresholds may occur post-ablation due to close anatomical proximity — particularly when the distance between the lead tip and the ablation site is less than 6 mm. This may be avoided by using AV node cryoablation; however, the latter is associated with higher rate of repeat interventions due to recovery of AV conduction (9). For these reasons, LBBAP is generally preferred, and when HBP is used, it should be combined with a backup ventricular lead to ensure safety and reliability.

CSP for resynchronization therapy

In patients who have heart failure with reduced ejection fraction and indications for resynchronization such as left bundle branch block (LBBB), CSP is being explored as an alternative to conventional BiVP. LBBB often causes delayed and uncoordinated ventricular activation, worsening systolic function in those with reduced ejection fraction. While BiVP remains a standard therapy in these cases, providing clear benefits in symptom relief and reverse remodeling, it also has limitations mentioned above. A significant proportion of patients do not respond to BiVP, and technical difficulties – such as unsuccessful coronary sinus lead placement due to the absence or small diameter of a target lateral cardiac vein, or the inability to achieve LV pacing because of phrenic nerve stimulation – can further limit its effectiveness (10). CSP, particularly through LBBAP, offers a more physiological way to restore ventricular synchrony by directly engaging the conduction system. This approach has been used both as a first-line resynchronization strategy and as a backup when BiVP is not an option. Early studies and registry data suggest that CSP may match or even outperform BiVP in some patients, especially when it comes to electrical synchrony and pacing efficiency (11). Among CSP techniques, LBBAP is generally favored over HBP due to easier implantation and better pacing stability. Still, the consensus notes that larger randomized trials are needed before CSP can fully replace BiVP in this group of patients.

HOT-CRT and LOT-CRT

His-optimized CRT (HOT-CRT) and left bundle branch pacing-optimized CRT (LOT-CRT) are advanced CSP strategies designed for patients who need cardiac resynchronization but cannot achieve optimal results with conventional BiVP. These approaches combine direct conduction system capture – via HBP or LBBAP – with additional left ventricular lead stimulation to maximize electrical and mechanical synchrony.

According to the summarized recommendations, HOT-CRT and LOT-CRT are considered particularly useful in patients with:

- Suboptimal QRS narrowing or mechanical response after BiVP,
- Failed or non-feasible coronary sinus LV lead implantation,
- Complex conduction disease with only partial correction from CSP alone.

LBBAP-based LOT-CRT is associated with higher implantation success rates and more stable pacing thresholds compared to HOT-CRT, though HOT-CRT can deliver the most physiological activation when technically successful. These hybrid approaches are increasingly regarded as useful, both as an initial CRT strategy in selected patients and as a backup option when conventional BiVP does not provide sufficient benefit.

Conclusion

The 2025 EHRA/ESC consensus marks a clear evolution in CSP from a technically feasible innovation to a mainstream pacing and resynchronization strategy. LBBAP has emerged as the preferred modality in the majority of clinical contexts due to its procedural advantages and reliable long-term performance, though HBP remains important in specific cases.

CSP offers physiological activation that may prevent pacing-induced dysfunction and improve outcomes in AV block, AV node ablation, and selected CRT scenarios. The optimization strategies such as HOT-CRT and LOT-CRT broaden the therapeutic potential of CSP. Ongoing and future research, particularly large randomized trials may not only strengthen the evidence base but also expand the range of clinical settings in which CSP is routinely applied, potentially making it a first-line pacing option in an even broader spectrum of patients.

Peer-review: Internal
Conflict-of-interest: None to declare
Authorship: O.S., M.S., U.C-R., and O.Zh. equally contributed to the study and fulfilled authorship criteria
Acknowledgement and Funding: None to declare
Statement on A.I.-assisted technologies use: AI-assisted technology (Chat GPT) was used solely for language editing and rephrasing in the preparation of this manuscript. The scientific content was developed entirely by the authors.
Availability of data and materials: Not applicable

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