Conduction System Pacing

Principles, Advantages and Indications

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Declaration

- I have no disclosure.

Outline

- Principles of CSP
- Anatomy of CSP sites
- Indications
- Advantages

Principles of CSP

- Conduction system pacing (CSP) is a novel method of cardiac pacing that uses the heart's own conduction system to enable efficient, physiological ventricular activation

- CSP using His bundle pacing (HBP) or left bundle branch area pacing (LBBAP) has the potential to restore or preserve normal physiological activation

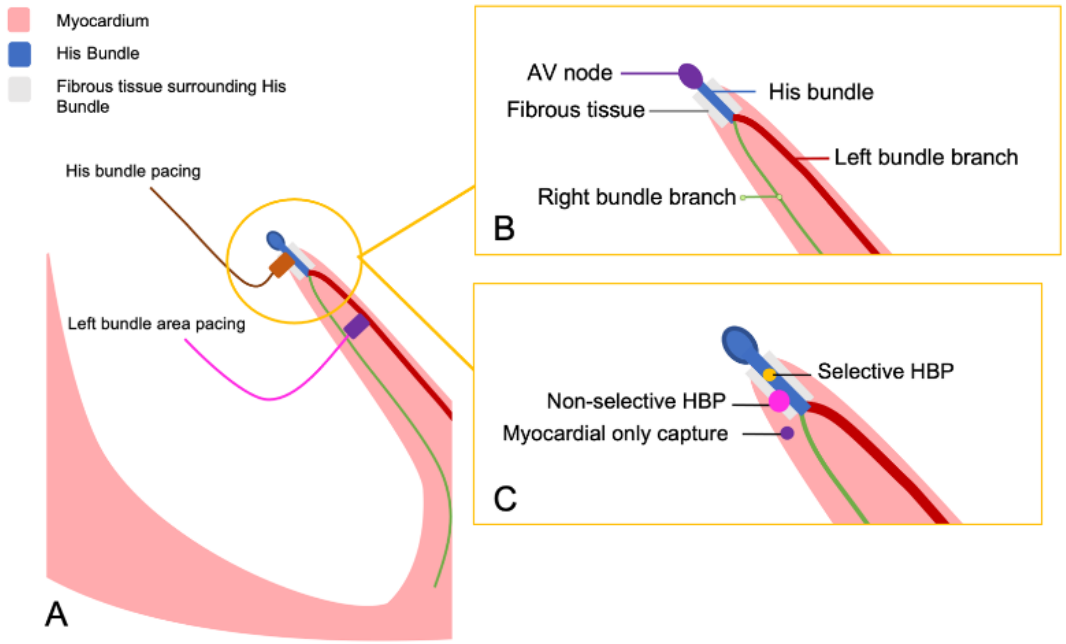
Principles of CSP

- LBBAP includes both LBBP with direct LBB capture and left ventricular septal pacing (LVSP) without direct capture of the LBB.

- LBBAP offers several potential technical advantages, compared to HBP including low and stable thresholds, the potential to treat more distal conduction system disease, and potentially a faster learning curve.

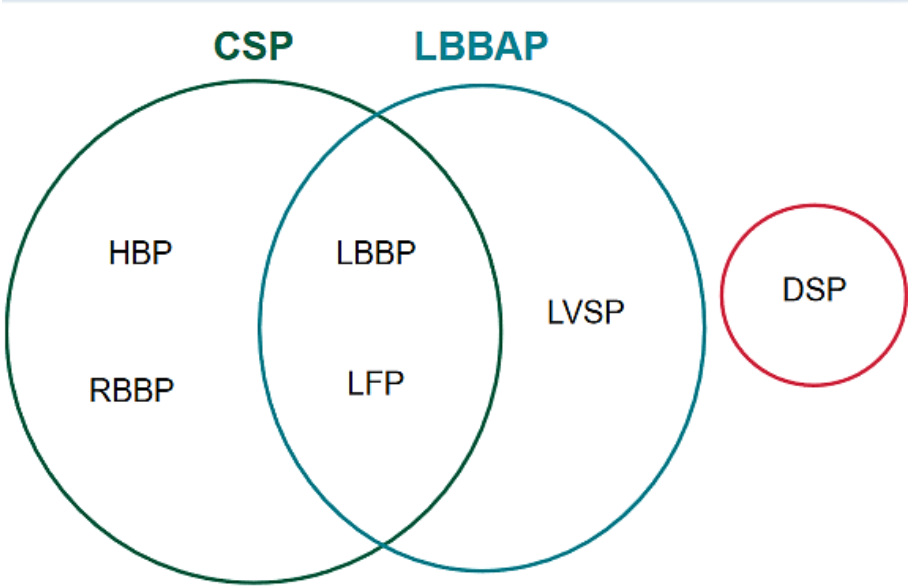
- Both LBBP and LVSP provide more physiological ventricular activation than right ventricular (RV) pacing despite delayed RV activation and a wider QRS interval, which in V1 has a pseudo-RBBB morphology.

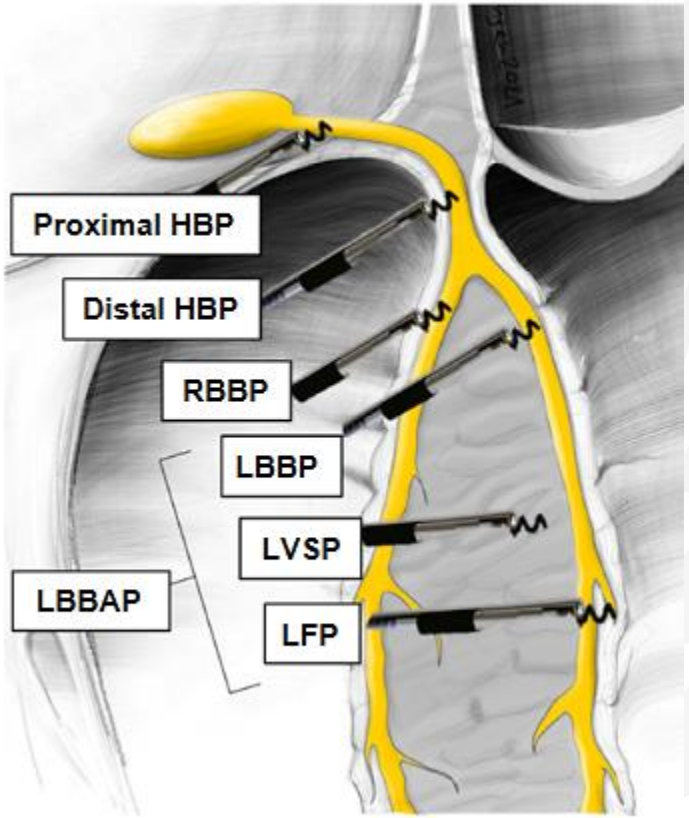
Anatomy of CSP sites



- A – Conduction system pacing sites
- B – Anatomy of conduction system
- C – Capture sites
  - Selective HBP captures the His-bundle alone.
  - Non-selective HBP captures the His-bundle and the myocardium.
  - Myocardium only capture, captures the myocardium alone

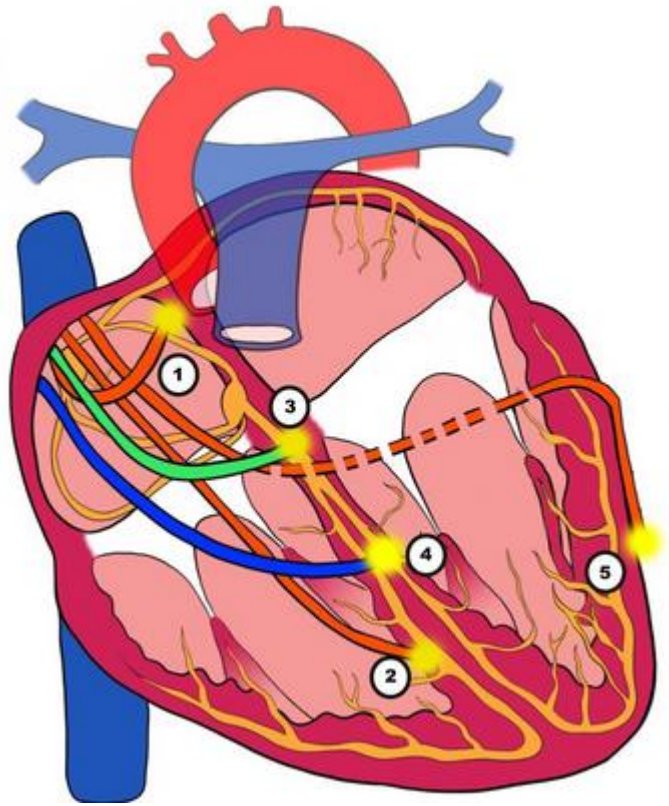
Synopsis of different entities of CSP and related forms of stimulation





CSP = conduction system pacing
DSP = deep septal pacing
HBP = His bundle pacing
LBBAP = left bundle branch area pacing
LBPP = left bundle branch pacing
LFP = left fascicular pacing
LVSP = left ventricular septal pacing
RBBP = right bundle branch pacing

Pacing techniques



- Illustration of pacing techniques
  - (1) Atrial pacing.
  - (2) Right ventricular (RV) pacing.
  - (3) His bundle pacing (HBP).
  - (4) Left bundle branch area pacing (LBBAP).
  - (5) Biventricular pacing (BVP) with an epimyocardial left ventricular lead via the coronary sinus (CS).

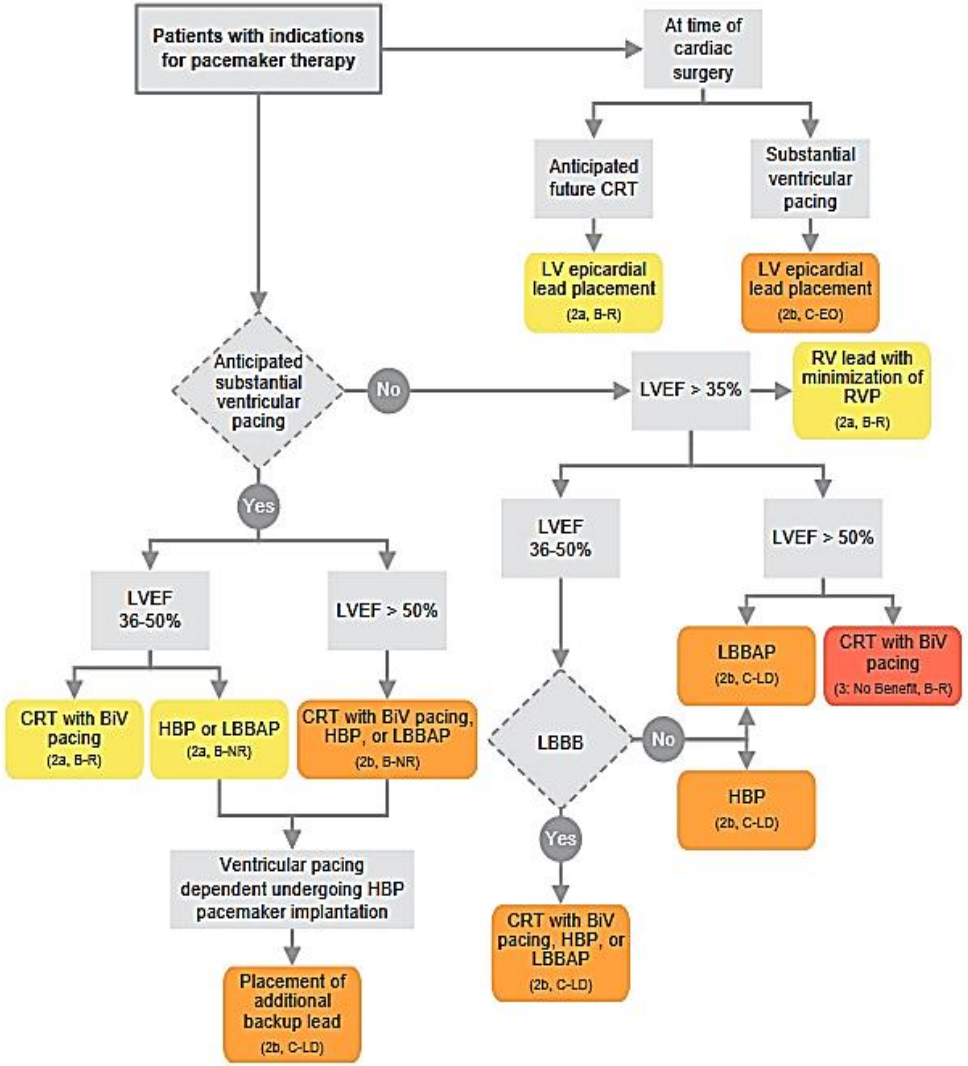
NEWS FROM THE HEART RHYTHM SOCIETY

2023 HRS/APHRS/LAHRS guideline on cardiac physiologic pacing for the avoidance and mitigation of heart failure

Term & Definition

Term	Definition
Left bundle branch block (LBBB)	For the purposes of this guideline, LBBB is defined by the 2009 AHA/ACCF/HRS Scientific Statement on recommendations for the standardization and interpretation of the electrocardiogram[11] as QRS duration $\geq$120 ms and a broad notched or slurred R-wave in leads I, aVL, V_5, and V_6.
Cardiac physiologic pacing (CPP)	CPP is defined as any form of cardiac pacing intended to restore or preserve ventricular synchrony. CPP can be achieved by engaging the intrinsic conduction system via CSP (eg, HBP or LBBAP) or CRT.
Conduction system pacing (CSP)	CSP involves recruitment of the intrinsic conduction system by either HBP or LBBAP.
His bundle pacing (HBP)	HBP involves the direct stimulation of the His bundle to engage the native conduction system. Based on location and pacing outputs, HBP may be selective (isolated recruitment of the His bundle) or nonselective (recruitment of both the local septal myocardium and the His bundle).[12]
Left bundle branch area pacing (LBBAP)	LBBAP is ventricular pacing that is intended to engage all or any part of the left bundle branch (LBB) fascicular system. Similar to HBP, various responses can be seen based on location and pacing outputs. These include selective LBBP (direct stimulation and isolated recruitment of the LBB fibers), nonselective LBBAP (direct stimulation and recruitment of both the local myocardium and the LBB fibers), or deep septal pacing (no direct recruitment of the LBB fibers).

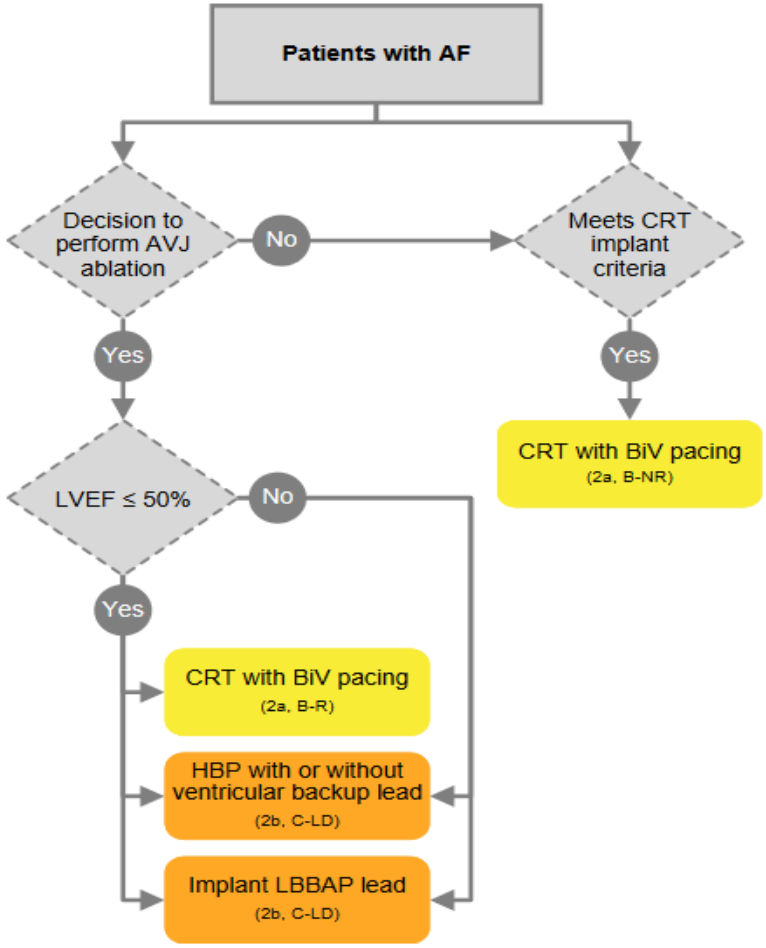
Algorithm for pacing strategies in patients undergoing pacemaker implantation for bradycardia indications



Recommendations for LBBB, sinus rhythm, QRS duration ≥ 150 ms, NYHA class I–IV symptoms		
COR	LOE	Recommendations
1	A	1. In patients with LVEF ≤ 35%, sinus rhythm, LBBB with QRS duration ≥ 150 ms, and NYHA class II–IV symptoms on GDMT, CRT with BiV pacing is indicated to improve symptoms and reduce morbidity and mortality.
2a	C-LD	2. In patients with LVEF ≤35%, sinus rhythm, LBBB with QRS duration ≥150 ms, and NYHA class II–IV symptoms on GDMT, CSP with HBP with LBBB correction or LBBAP is reasonable if effective CRT cannot be achieved with BiV pacing based on anatomical or functional criteria.

Recommendations for CPP in AF		
COR	LOE	Recommendations
2a	B-R	1. In patients with AF undergoing AVJ ablation with LVEF ≤50%, CRT with BiV pacing is reasonable to improve HFH, reverse structural remodeling, and improve quality of life, exercise capacity, LVEF, and potentially mortality.
2a	B-NR	2. In patients with AF who otherwise meet CRT implantation eligibility criteria, CRT with BiV pacing can be beneficial to improve quality of life, functional capacity, and LVEF.
2b	C-LD	3. In patients with AF undergoing AVJ ablation, HBP with or without a backup ventricular pacing lead may be reasonable to improve or preserve LVEF and improve functional class.
2b	C-LD	4. In patients undergoing AVJ ablation, it may be reasonable to implant an LBBAP lead.
2b	C-LD	5. In patients with a high burden of ventricular pacing, HBP or LBBAP may be reasonable to decrease the risk of AF.

Algorithm for cardiac physiologic pacing in patients with atrial fibrillation



Current recommendations for CSP (HBP or LBBAP) from the 2023 HRS/APHRS/LAHRS guidelines

- Patients with indications for pacemaker therapy with anticipated ventricular pacing ≥40% and an LVEF of 36%–50% (class IIa) or LVEF >50% (class IIb).

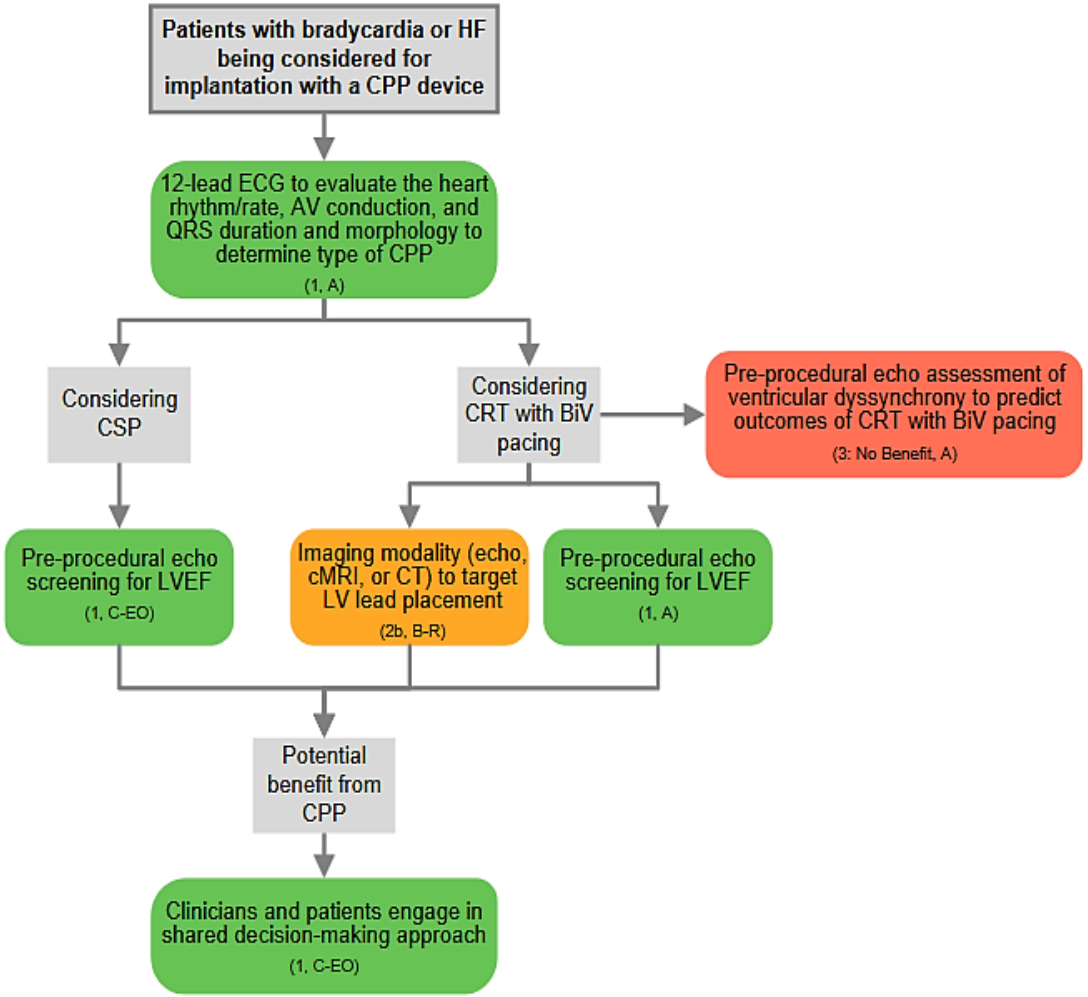
- CSP may be considered if less than 40% pacing is anticipated, with LVEF of 36%–50%, with or without a LBBB (class IIb), whereas only LBBAP may be considered if LVEF is >50% (class IIb).

Current recommendations for CSP (HBP or LBBAP) from the 2023 HRS/APHRS/LAHRS guidelines

- CSP may be also considered in HF patients with LBBB, LVEF 36%–50%, QRSd ≥150 ms and NYHA class II-IV (class IIb), or if effective CRT cannot be achieved with BiV pacing and LVEF ≤35% (class IIa).

- In patients with non-LBBB, LVEF ≤35%, QRSd 120–149 and NYHA class III–IV, CSP could be considered (class IIb)

Pre-procedure evaluation and preparation



Benefits and Challenges of Conduction System Pacing

Benefits of conduction system pacing	Challenges of conduction system pacing
• Synchronised ventricular contraction with intrinsic activation patterns to overcome dysynchrony of left bundle branch block • Improvement in ejection fraction when compared to conventional pacing • Reduces likelihood of right ventricular pacing induced cardiomyopathy when compared to biventricular pacing • Haemodynamic improvement in patients with heart failure seen by a rise in blood pressure when compared to biventricular pacing • Alternative implant site for failed left ventricular lead implantation • Contrast not required for implant	• An understanding of level of block is needed prior to implant to guide appropriate site selection, eg. Infranodal block would require pacing distal to the site of the block • Technically challenging with increased lead displacement and associated learning curve resulting in long procedure and fluoroscopy times. Often limited to specialist centres with specialised electrophysiology equipment and expert teams • Need for "back-up" RV pacing lead in high degree AV block and AV node ablation • Difficulty in identifying capture of the His-bundle and lack of defined capture characteristics of left bundle area pacing • High thresholds resulting in more readily depleted battery life, in turn requiring more frequent battery changes • Challenging and complex device programming, especially with the lack of dedicated conduction system algorithms for the devices

HBP vs LBBP

HBP

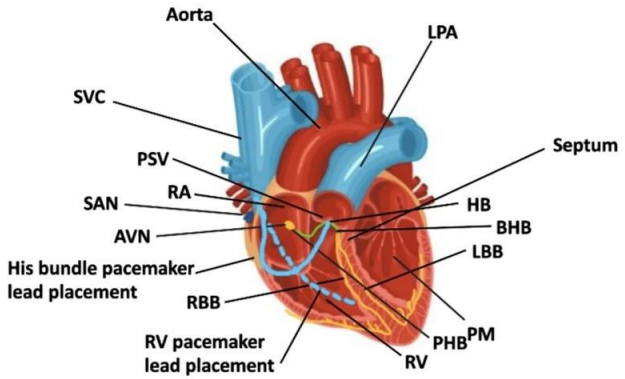
Strong point

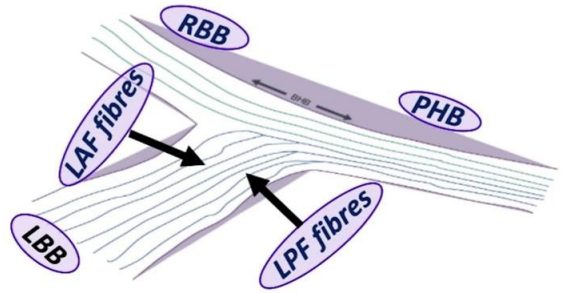
- ✓ Is considered to be the most physiological form - complete recruitment of conduction system

Drawbacks

- ▪ Narrow target zone resulting in a lengthy procedure and fluoroscopic times made HBP more anatomically difficult
- ▪ High capture thresholds at implantation and/or late follow-up can lead to premature battery depletion and replacement of generator
- ▪ Low sensed R wave amplitude may cause oversensing of atrial or His signals and undersensing of ventricular signals
- ▪ Has a limitation: in patients with infra-Hisian block and/or LBBP the success rate is lower

HBP versus LBBP





AVN = atrioventricular node; BHB = branching His bundle; HB = His bundle; LAF = left anterior fascicle; LBB = left bundle branch; LPA = left pulmonary artery; LPF = left posterior fascicle; LV = left ventricle; PHB = penetrating His bundle; PM = papillary muscles; PSV = pulmonary semilunar valve; RA = right atrium; RBB = right bundle branch; RV = right ventricle; SAN = sinoatrial node; SVC = superior vena cava

LBBP

Drawback

- ▪ There is a lack of evidence to define left conduction system (LCS) capture and left ventricular septal (LVS) capture

Strong points

- ✓ Wider target area of LBB fibres on the left sub-endocardium
- ✓ Low and stable threshold with no significant sensing issues
- ✓ High success rate in AV block due to the possibility of distal conduction system disease correction
- ✓ Provides lead stability away from AV node resulting in adequate safety margin for ablation in patients undergoing AV junction ablation

Advantages

HBP

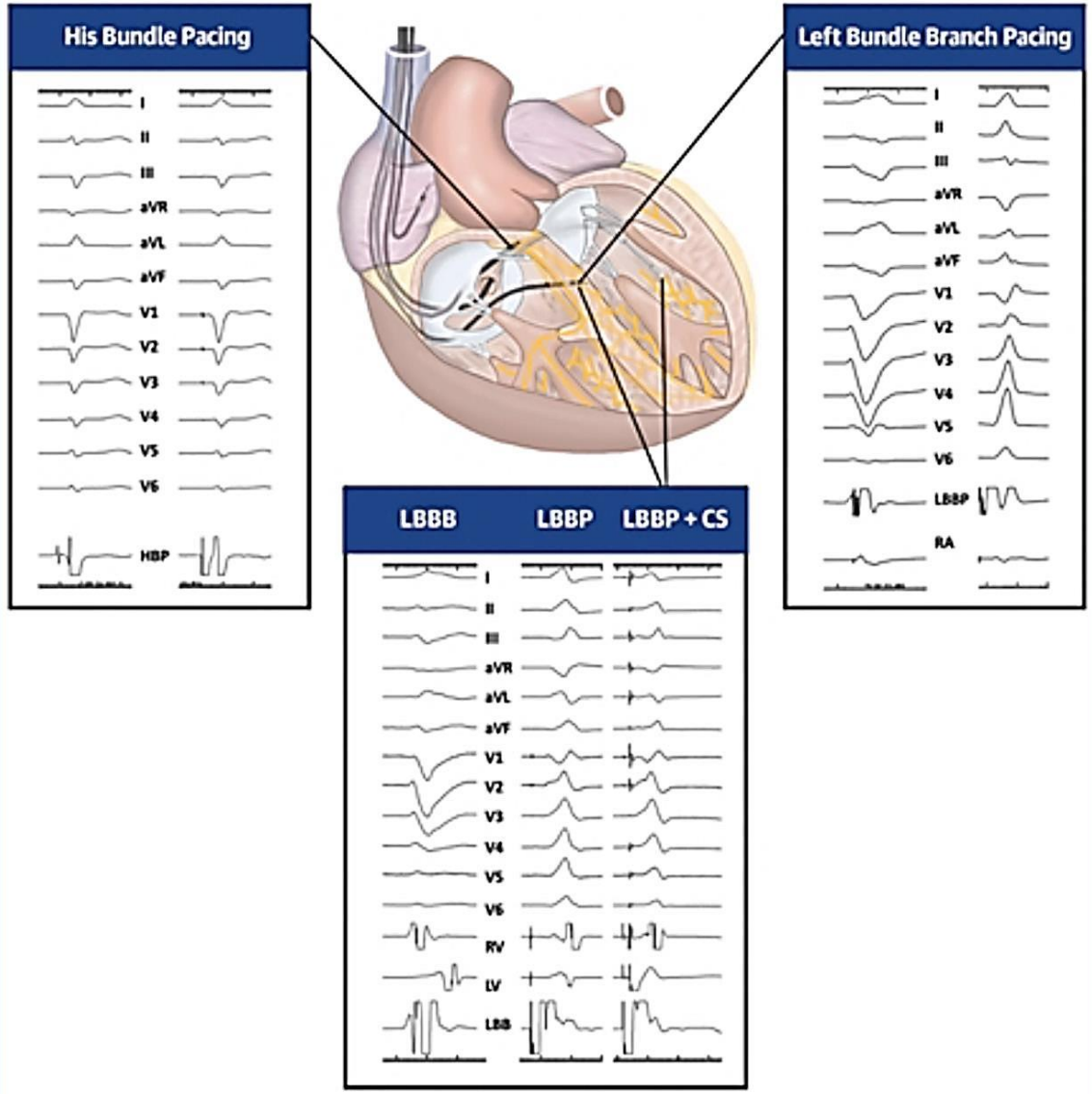
- Maximum electrical synchrony
- Endpoints well-defined for successful His capture
- Extractability has been demonstrated
- Relatively good mid-term evidence for safety and efficacy
- Avoids crossing the tricuspid valve when implanted on the atrial aspect of the annulus
- Some evidence of medium and long-term lead extraction

LBBAP

- Large target area
- Correction of more distal conduction disease
- Low capture thresholds
- Good sensing parameters
- Consistent back-up myocardial capture (in addition by anodal capture by the ring electrode)
- No requirement for back-up pacing leads
- AV nodal ablation without risk of compromising lead function

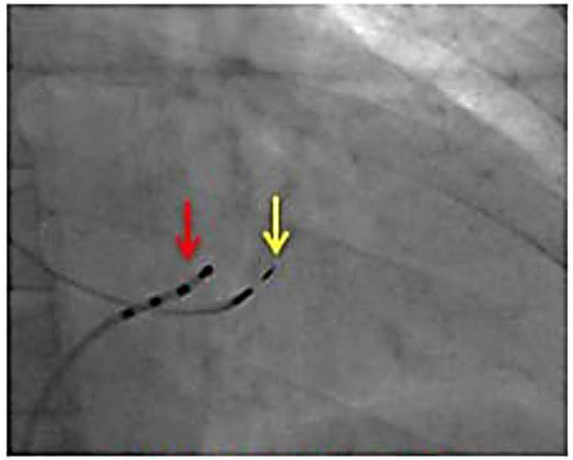
Ref :EHRA clinical consensus statement on conduction system pacing implantation: endorsed by the Asia Pacific Heart Rhythm Society (APHRS), Canadian Heart Rhythm Society (CHRS), and Latin American HeartRhythm Society (LAHRS)

CENTRAL ILLUSTRATION: Conduction System Pacing: Anatomic Location and ECG Responses of Conduction System Pacing Are Shown

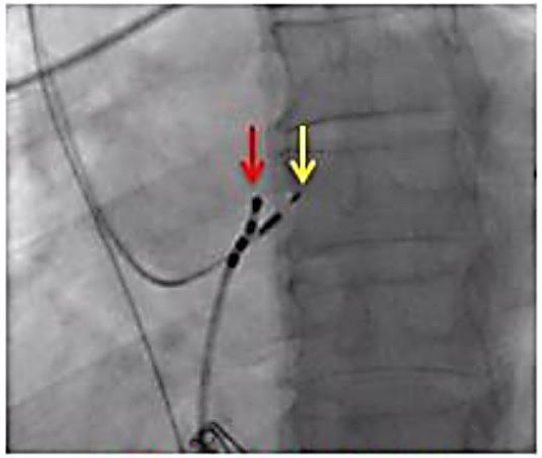


Vijayaraman P, et al. J Am Coll Cardiol EP. 2023;■(■):e013134.

Fluoroscopic view & Electrocardiographic features of LBBAP

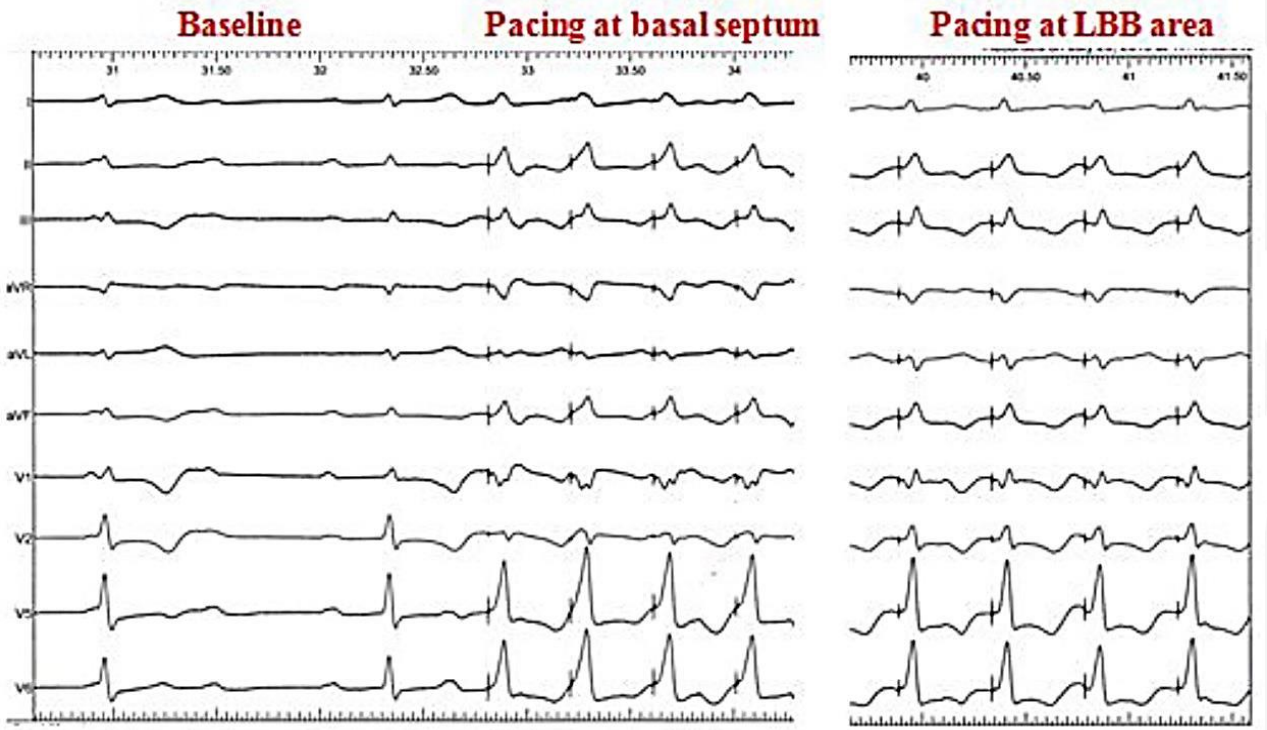


RAO 30 Degree view



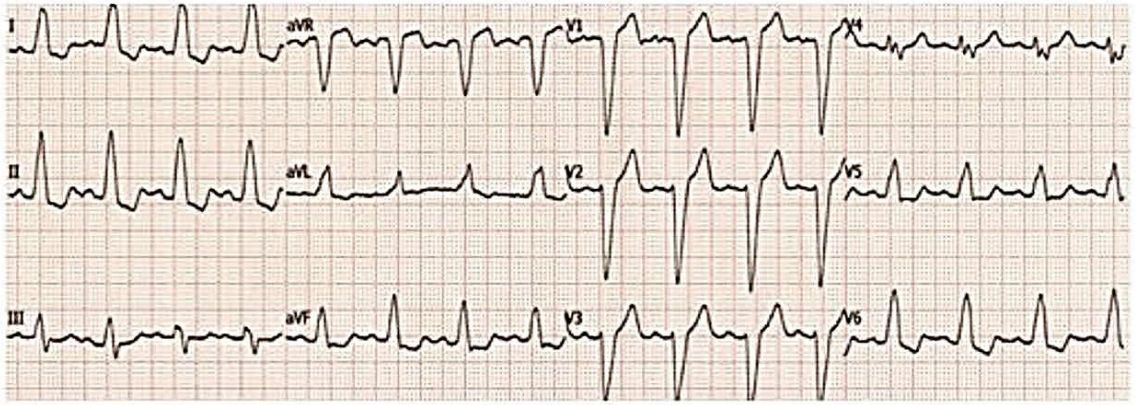
LAO 40 Degree view

(A)



(B)

LBBAP Electrocardiographic features



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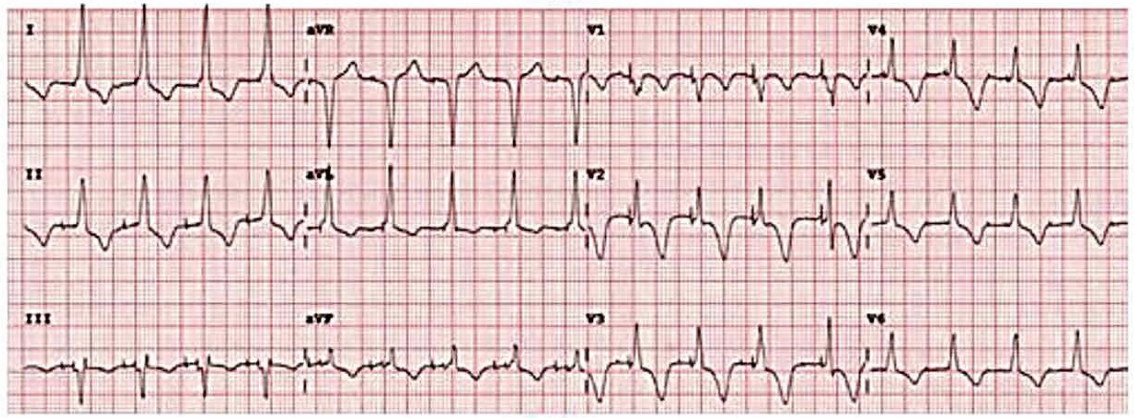

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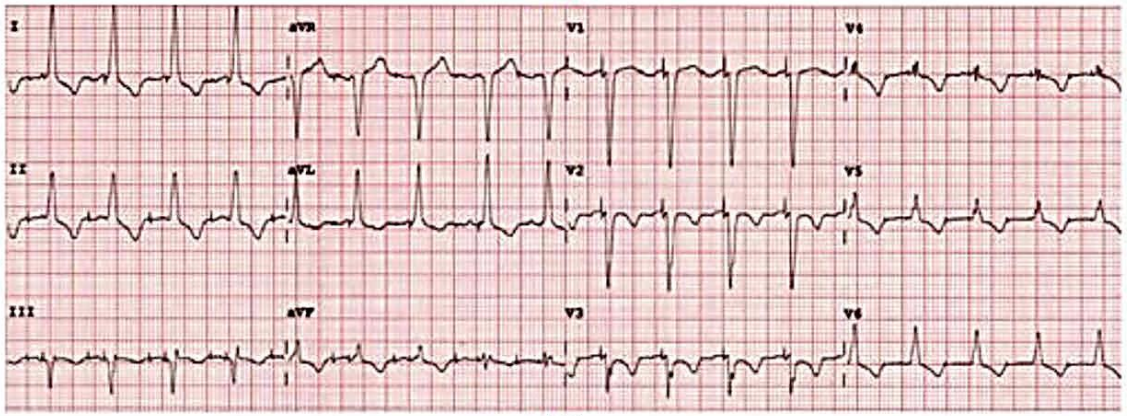

(C)

Conclusion

- CSP is a physiology-based approach, but adoption is limited by implantation challenges.
- Imaging, mapping, & electrogram recording techniques facilitate implantation along the conduction system
- Improvement of implantation tools & adoption of implantation techniques should reduce complication and increase utilization.

THANK YOU