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Hong Kong College of Cardiology
28th Annual Scientific Congress
Best Challenging / Interesting Cardiac Intervention Cases Presentation

Left Bundle Branch Pacing as a Physiological Pacing Alternative to Cardiac Resynchronization Therapy in Patients with Heart Failure and Left Bundle Branch Block

5th July 2020

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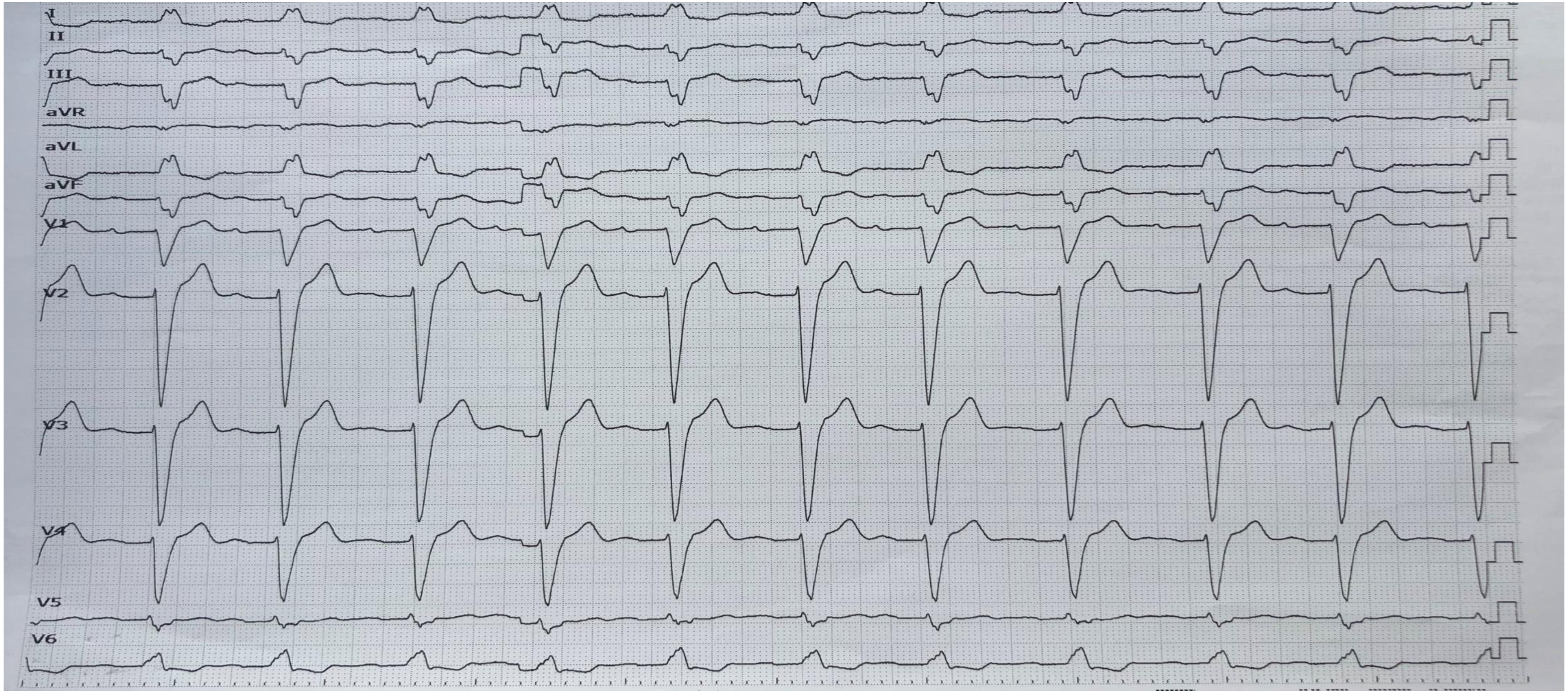
Specialist in Cardiology
Pro-Care Heart Clinic

Case Summary

- M/70. Non-smoker. Non-drinker.
- PMH: Hypertension. Mild CAD.
- c/o: SOB for 2 years, with exacerbation for 1 week
- P/E: BP /P stable. JVP elevated. CVS: HS dual, PSM apex/LLSB. Chest: bi-basal crepitation. Bilateral ankle edema.
- CXR: Cardiomegaly. Pulmonary congestion.
- Blood tests: NTproBNP 8884pg/ml. TnT 0.066ng/ml. TFT & other blood tests unremarkable.

Baseline ECG: Normal sinus rhythm.
First degree AVB. Complete LBBB. QRS 150ms



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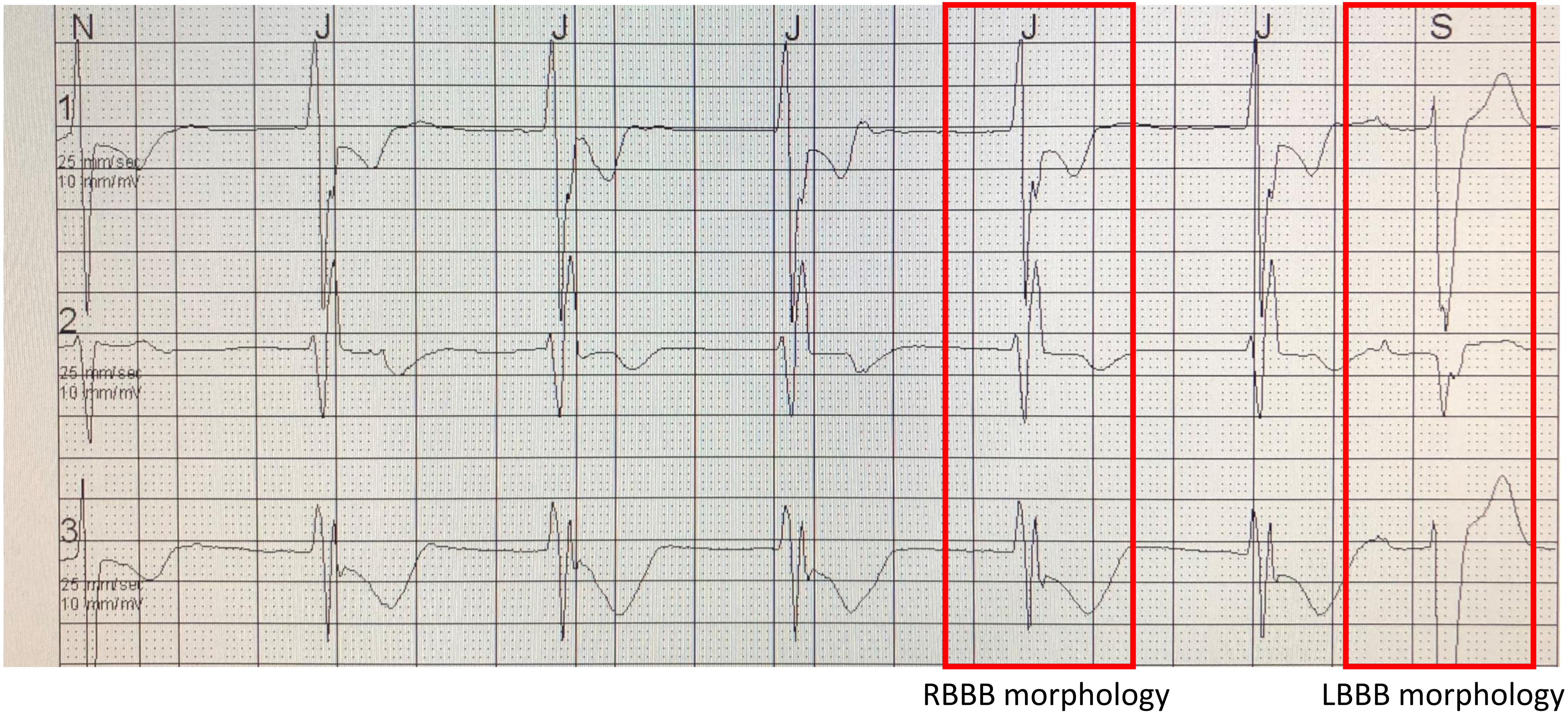
Holter: Sinus arrest. Junctional bradycardia. Complete LBBB. Alternating RBBB. Maximum RR 1.76s.



Baseline Echo

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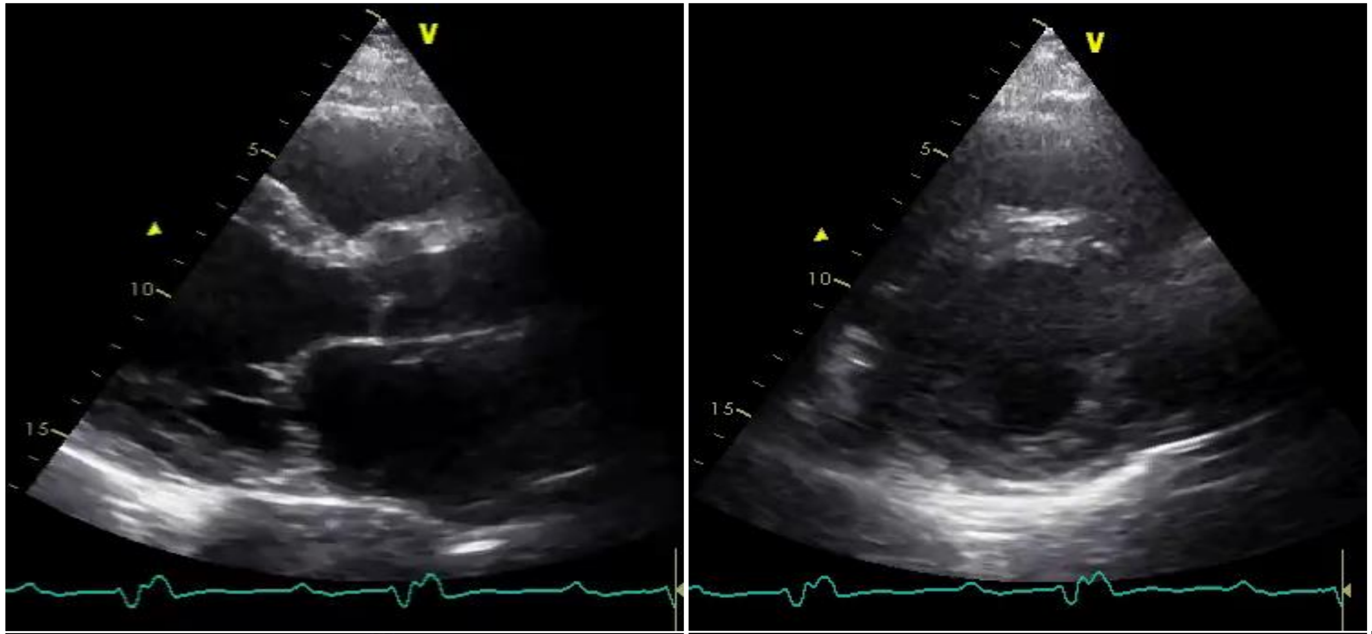
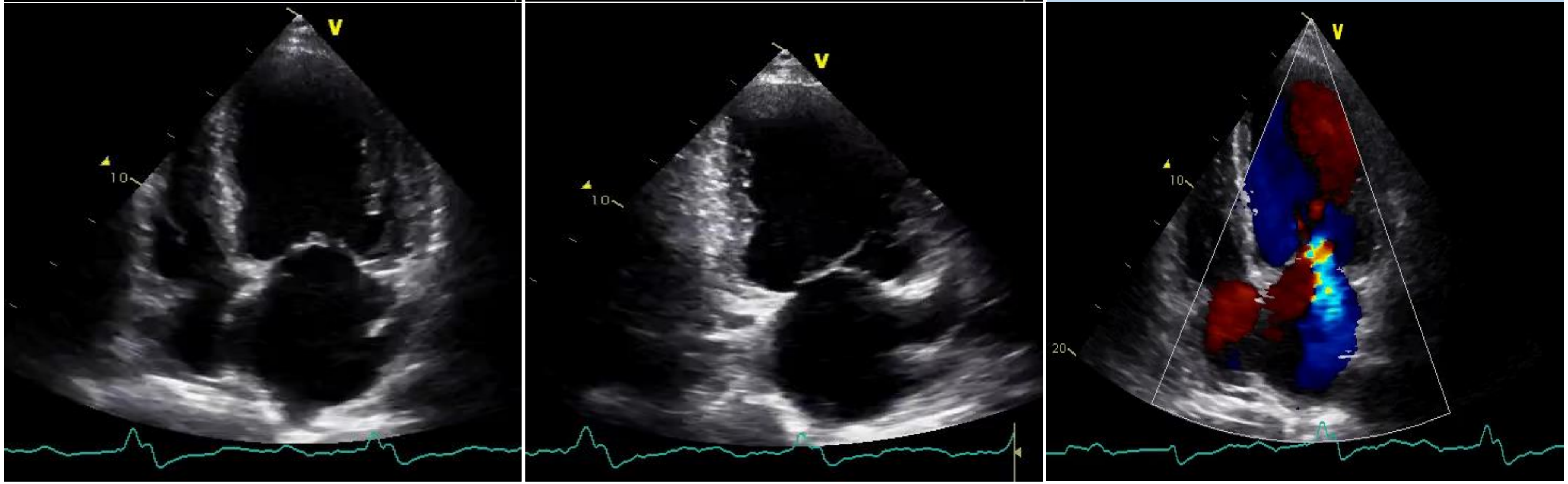


- Dilated LA: 5.5cm
- Dilated LV: LVEDD 63mm
- Global hypokinesia
- LVEF 24% by Bi-plane Modified Simpson’s
- Severe MR
- Moderate TR.
- RVSP 36mmHg



Management

- Coronary angiogram : Mild CAD. No critical coronary artery stenosis.
- Medical treatment: Entresto 100mg bd. Aldactone 20mg daily. Cardiprin 100mg daily. Frusemide.
- Could not tolerate betablocker due to underlying SND, junctional bradycardia and alternating LBBB/ RBBB (inherent risk of CHB).

Management

- Symptomatic SND with junctional bradycardia. Alternating LBBB/RBBB.
  - Pacing Indication (Risk of RV pacing induced cardiomyopathy)

- Non-ischemic cardiomyopathy. LVEF 24%. NYHA III-IV. LBBB. QRS 150ms.
  - CRT-D Indication (Patient could not afford)

- What would you do next ?

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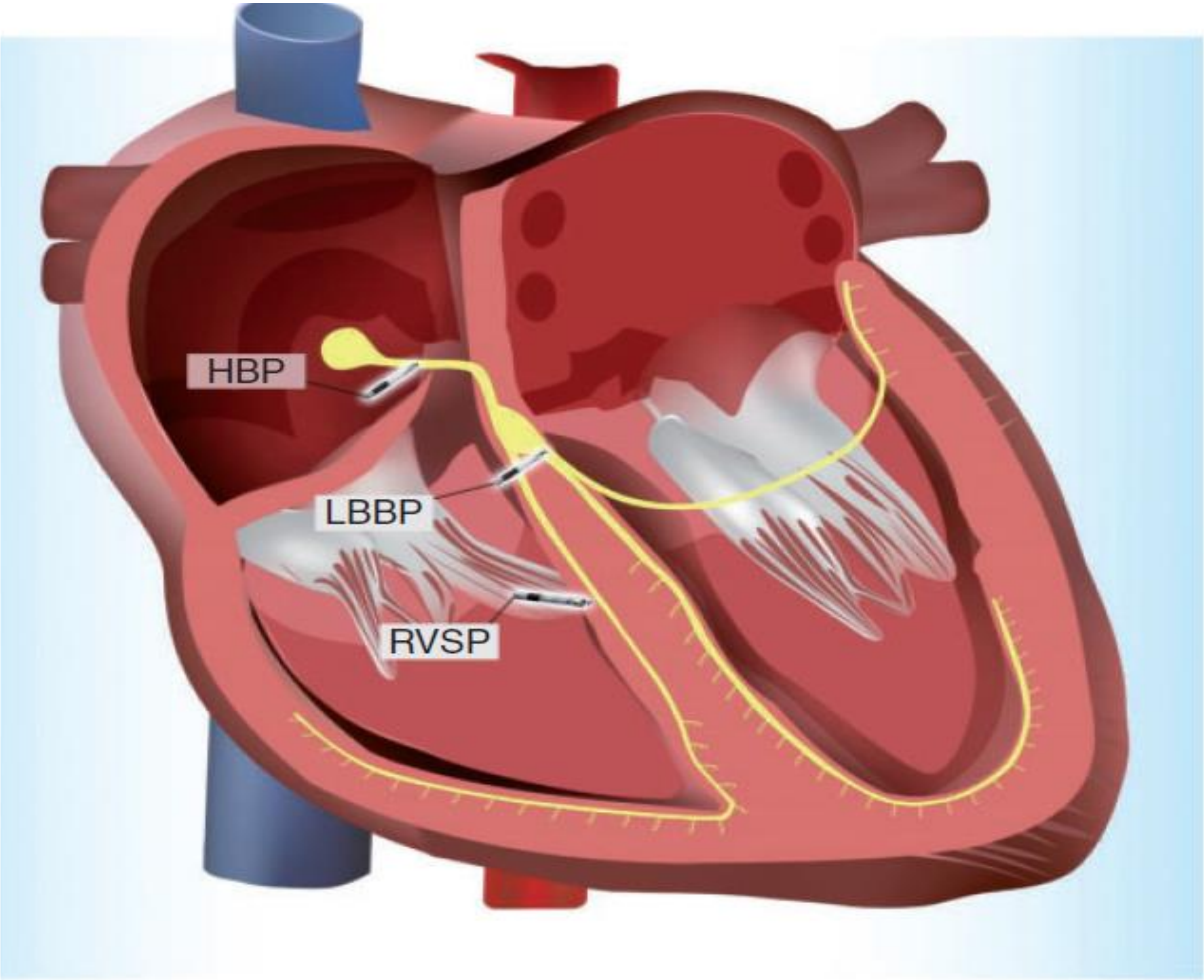
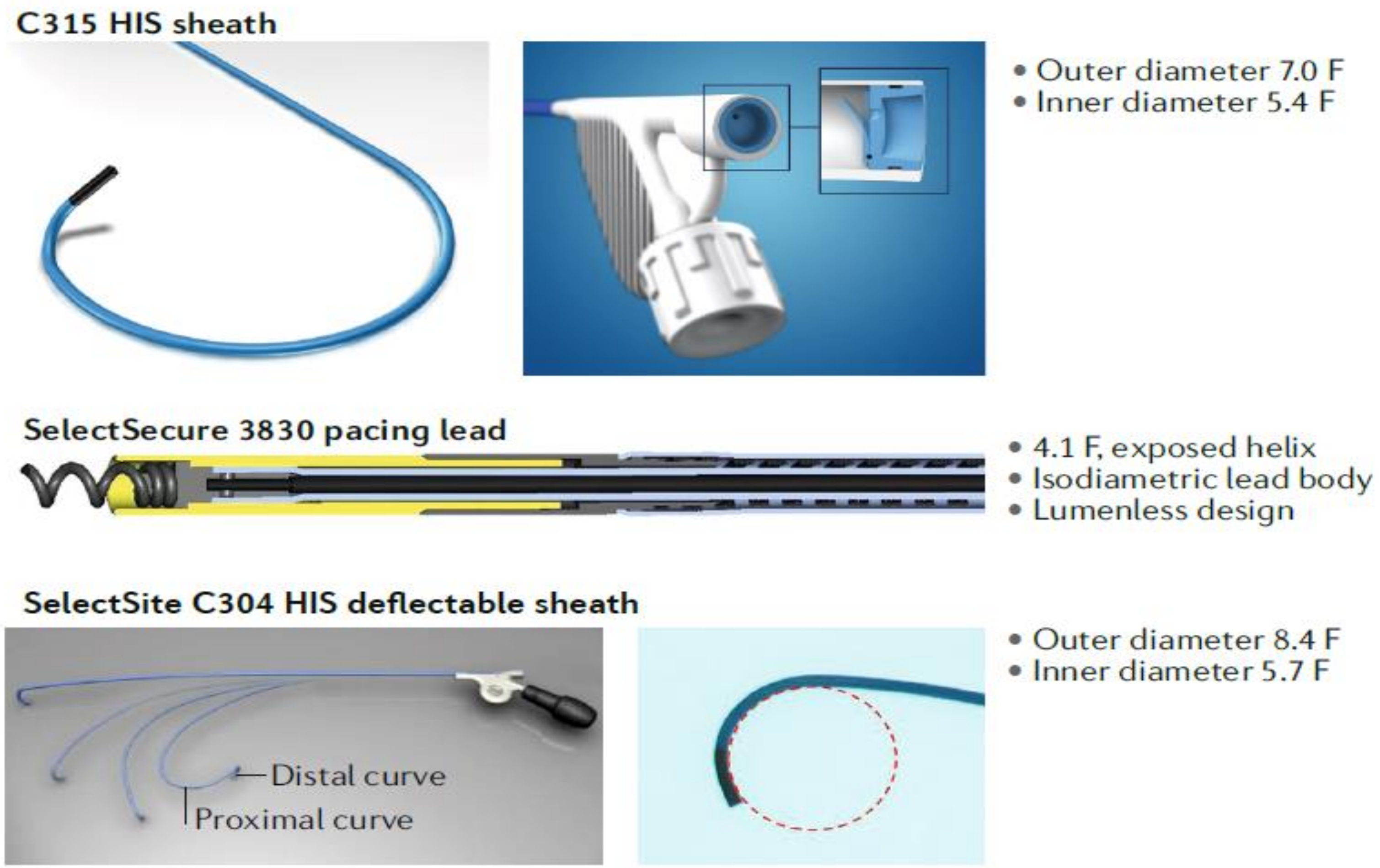
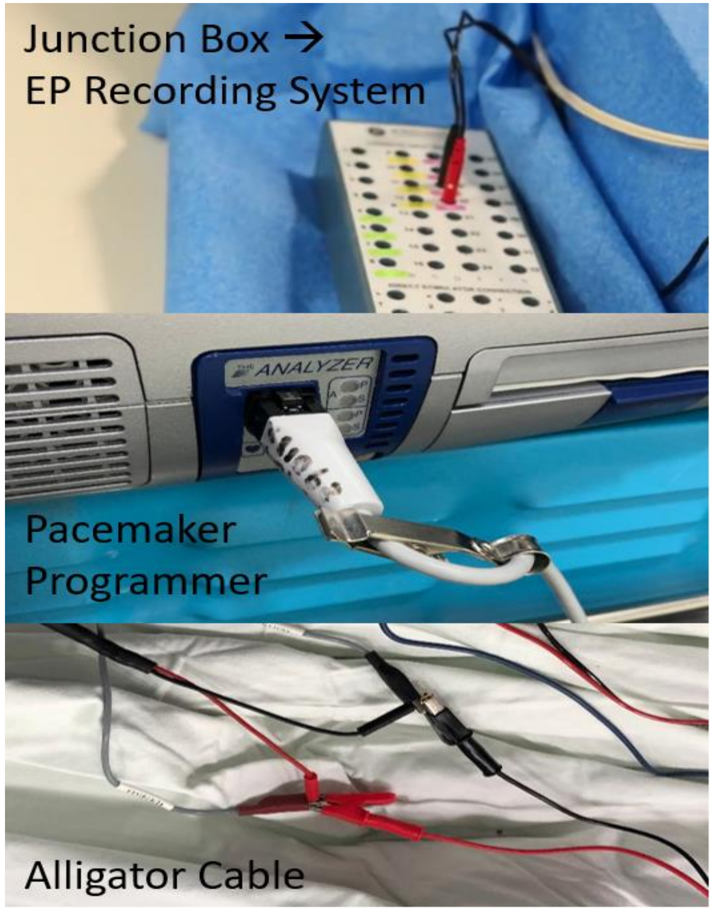
His Bundle Pacing (HBP) / Left Bundle Branch Pacing (LBBP)



Europace (2019) 00, 1–9 doi:10.1093/europace/euz188

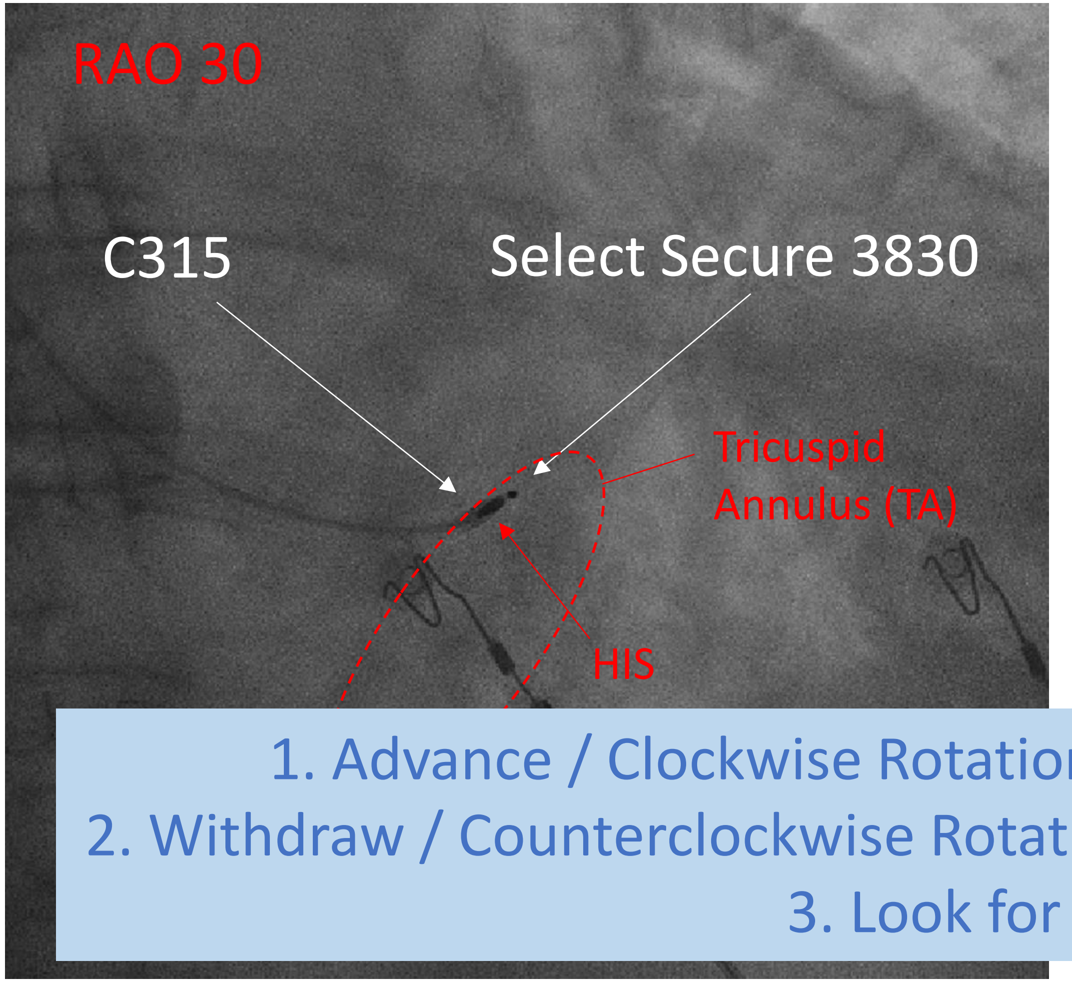
LBB Pacing – Hardware Requirement
Select Secure 3830 & C315 His Catheter

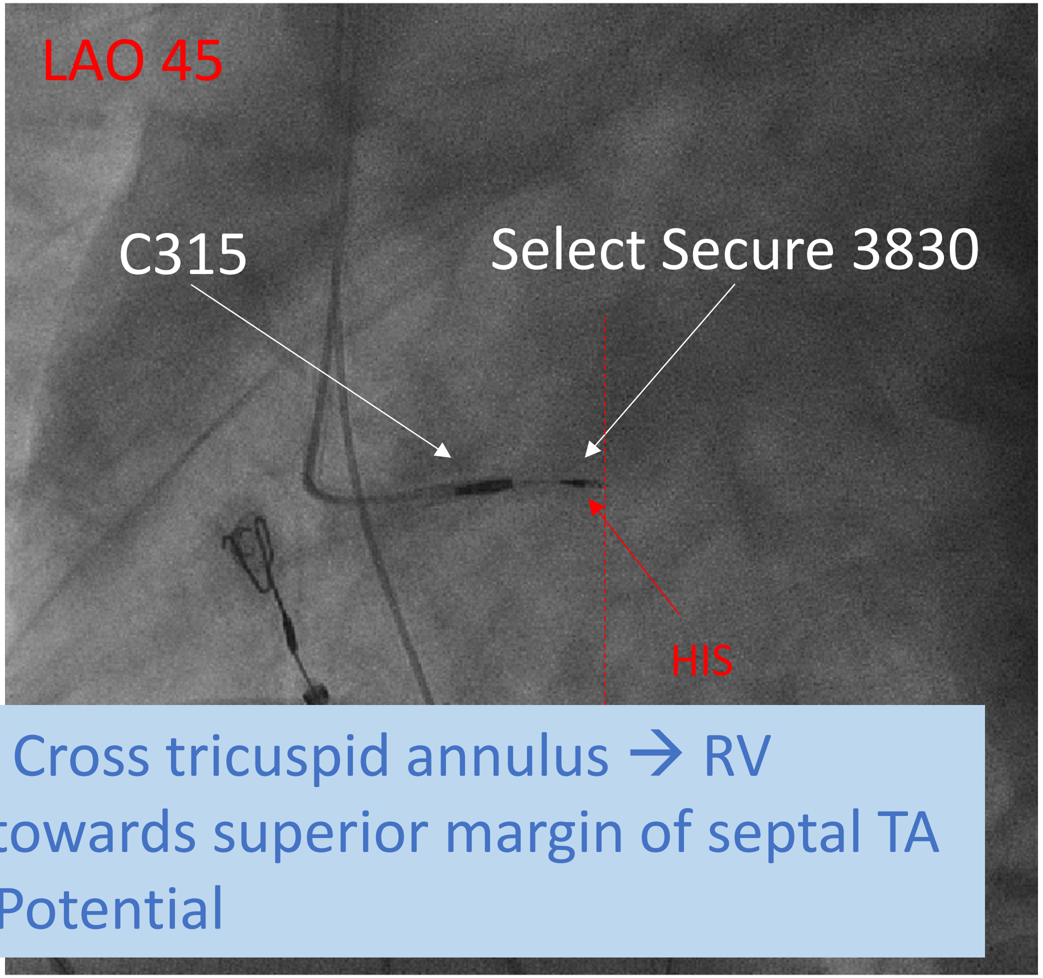




Nat Rev Cardiol. 2020 Jan;17(1):22-36. doi: 10.1038/s41569-019-0224-z.

Step 1: Locating His Bundle Fluoroscopic Confirmation





1. Advance / Clockwise Rotation → Cross tricuspid annulus → RV
2. Withdraw / Counterclockwise Rotation towards superior margin of septal TA
3. Look for His Potential

Step 2: Locating His Bundle Electrical Confirmation – Identify His Signal & Perform His Pacing in Unipolar Mode

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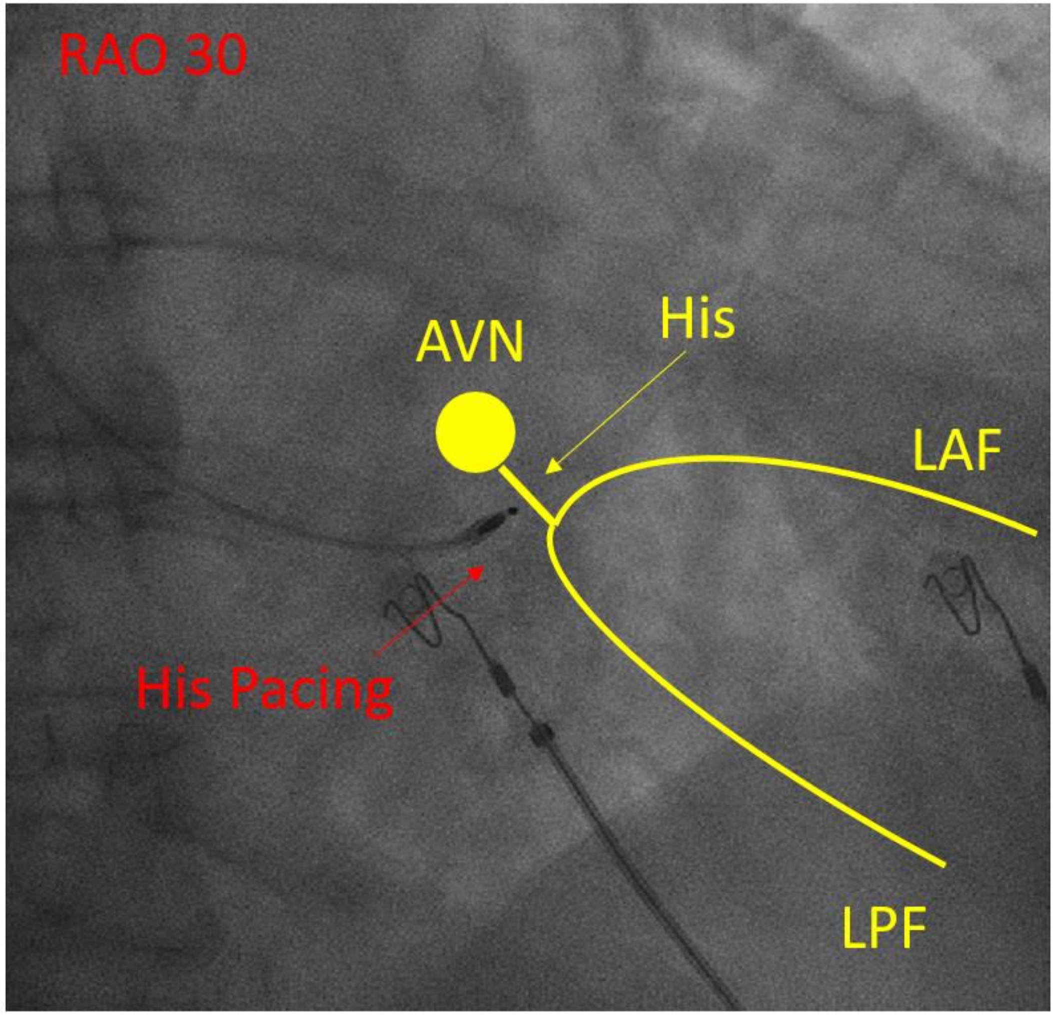
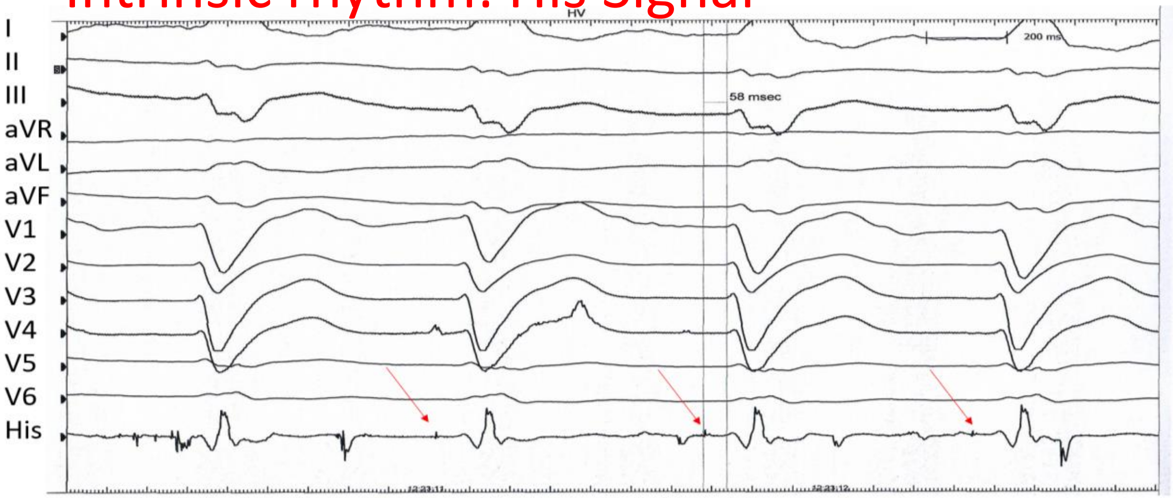


Intrinsic rhythm: His Signal



His Bundle Pacing

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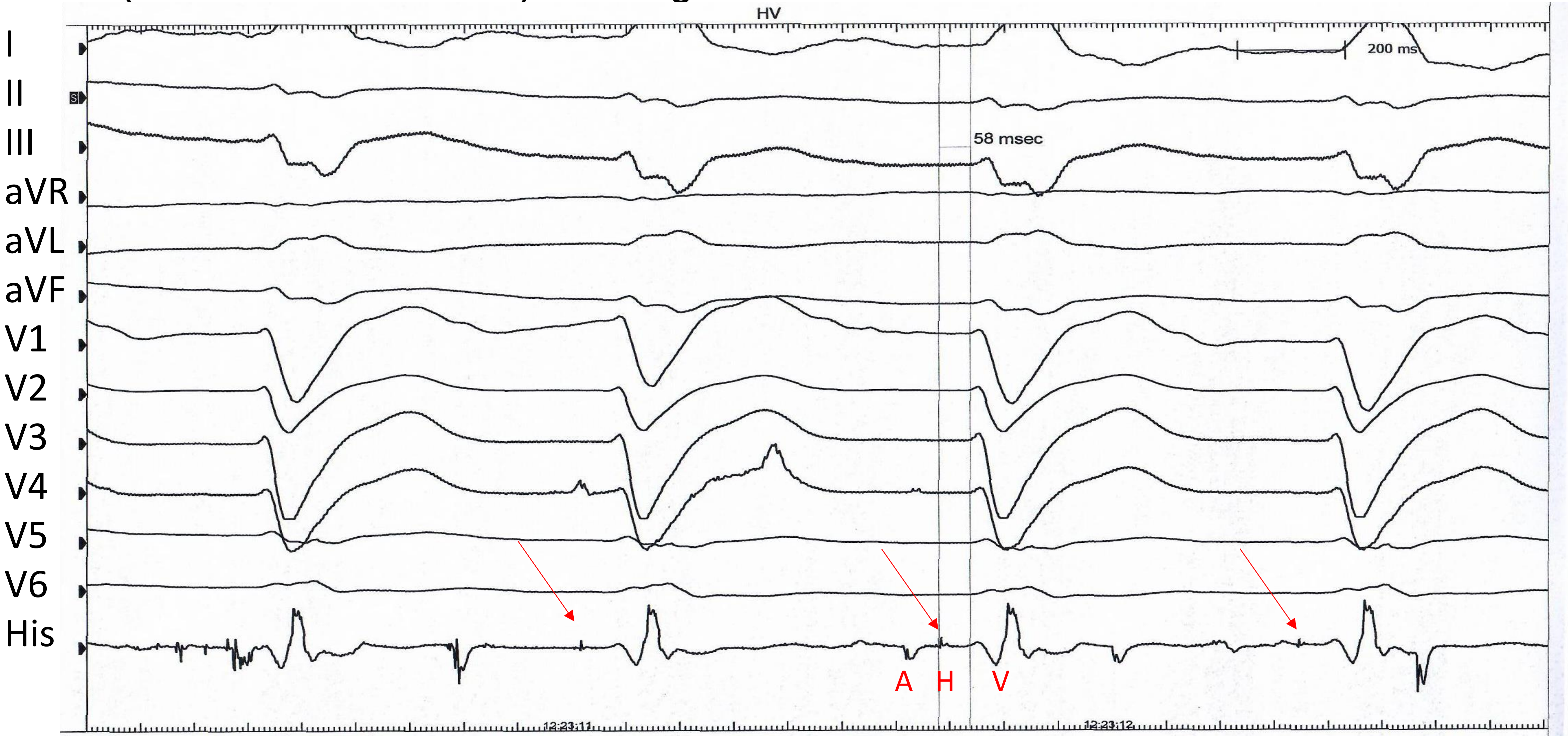
His Signal – Baseline HV Interval 58ms (Normal HV 35-55ms) Prolonged HV → Infra-hisian Conduction Disease



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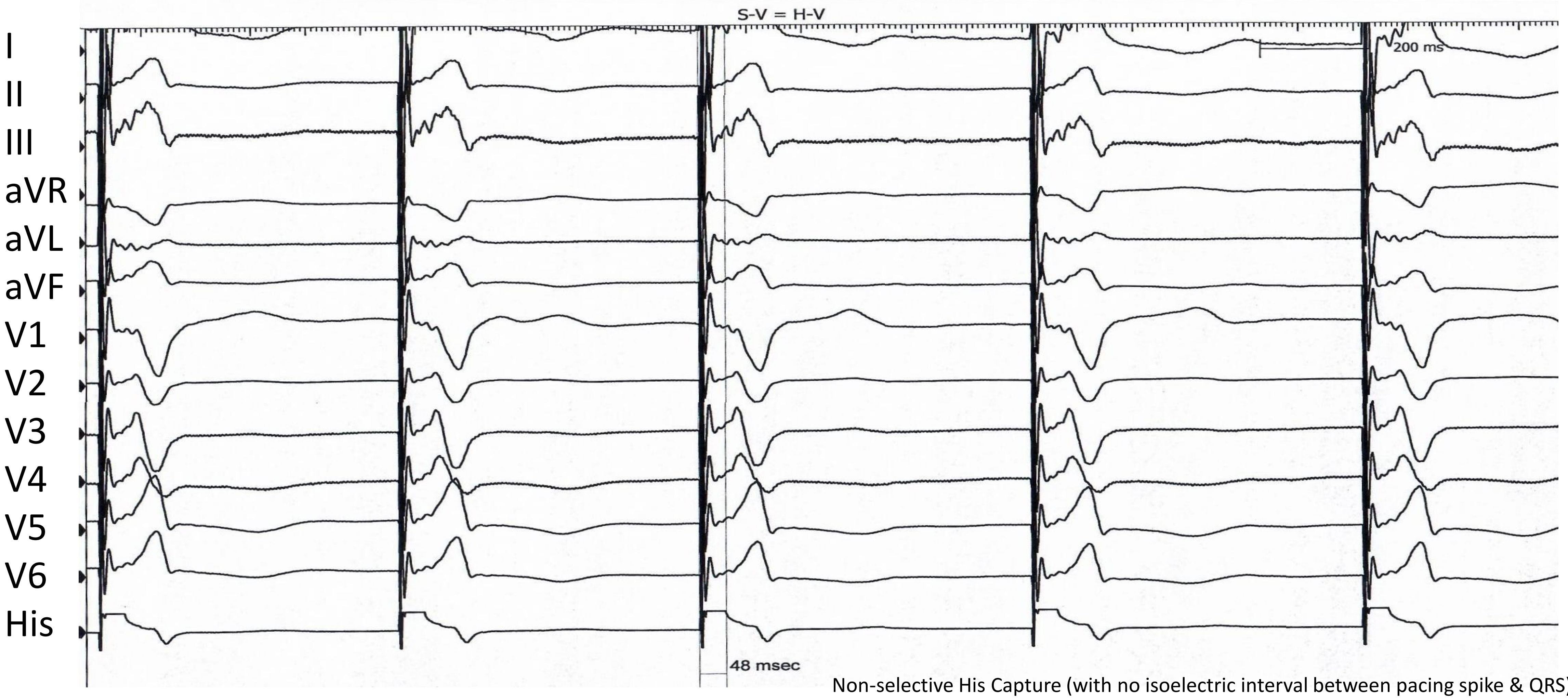
His Bundle Capture :

1. Narrow QRS (91ms) morphology & normal axis (+/- identical to intrinsic rhythm QRS)
2. Stim to V interval (SV) Interval during His Bundle Pacing (48ms)
→ Similar to HV Interval in intrinsic rhythm (58ms)



Non-selective His Capture (with no isoelectric interval between pacing spike & QRS)

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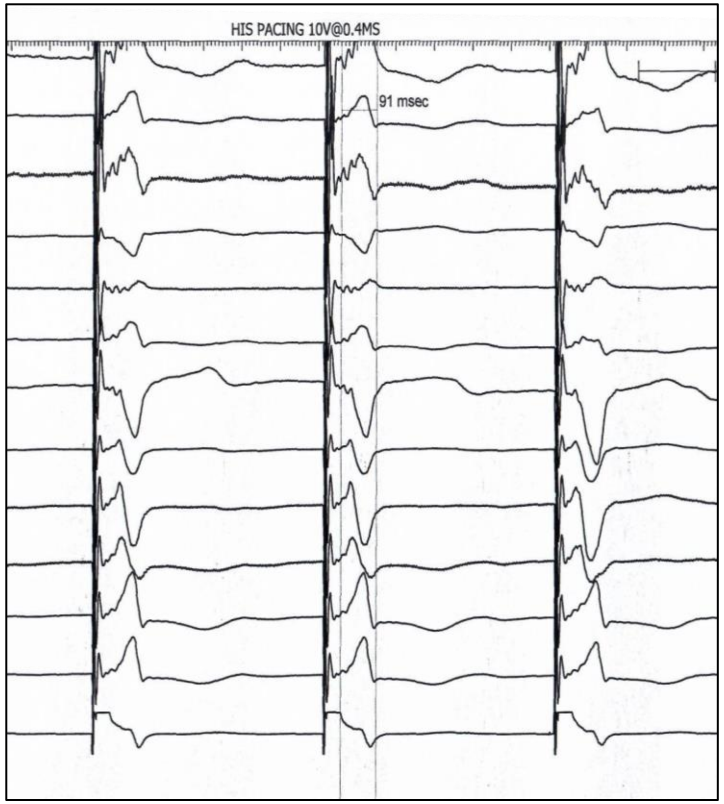
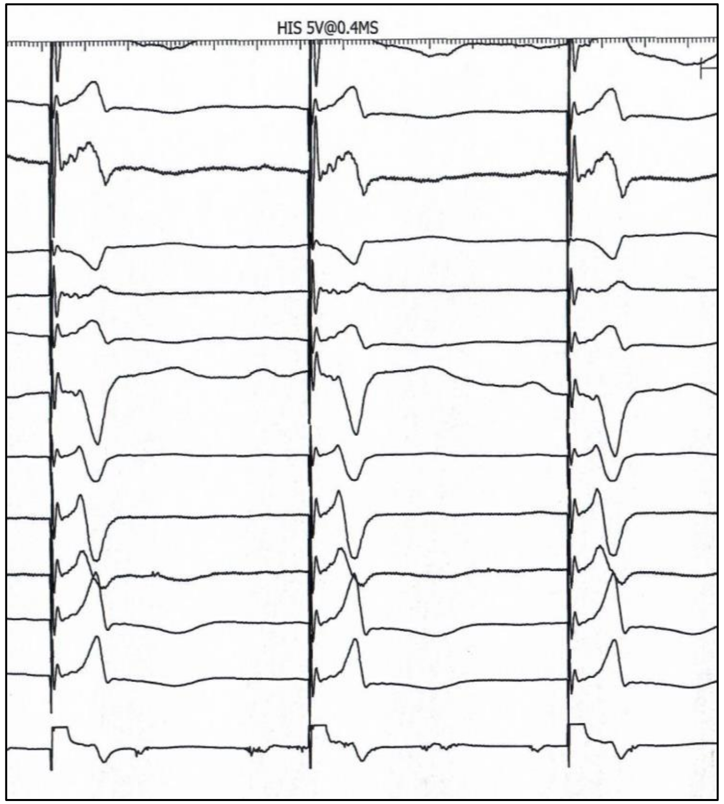
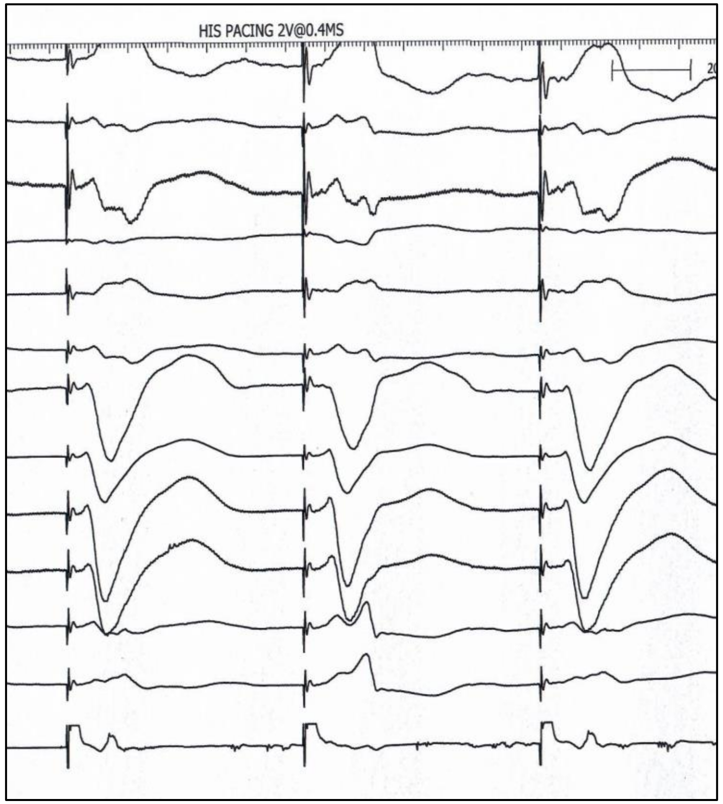
Confirm His Bundle Pacing Capture Threshold
High Pacing Threshold

10V@0.4ms	5V@0.4ms	2V@0.4ms
QRS 91ms	QRS 91ms	QRS 136ms

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
His







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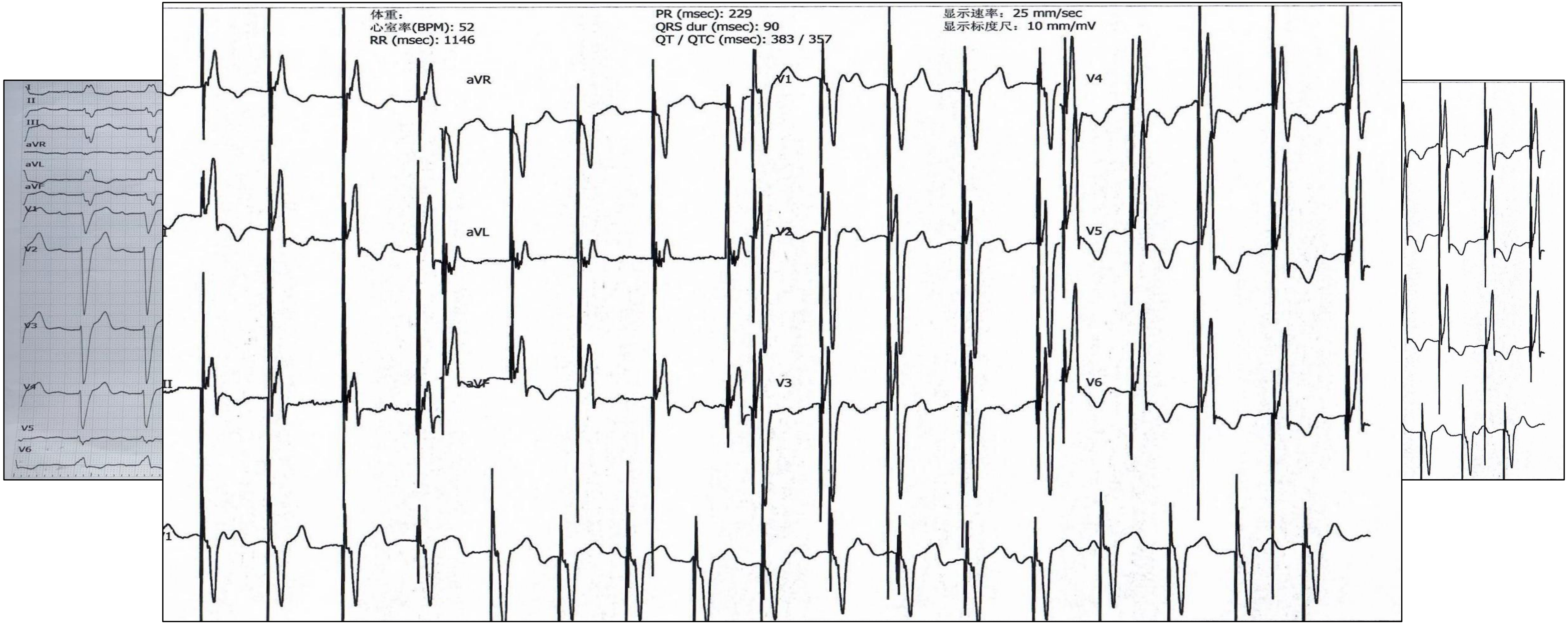
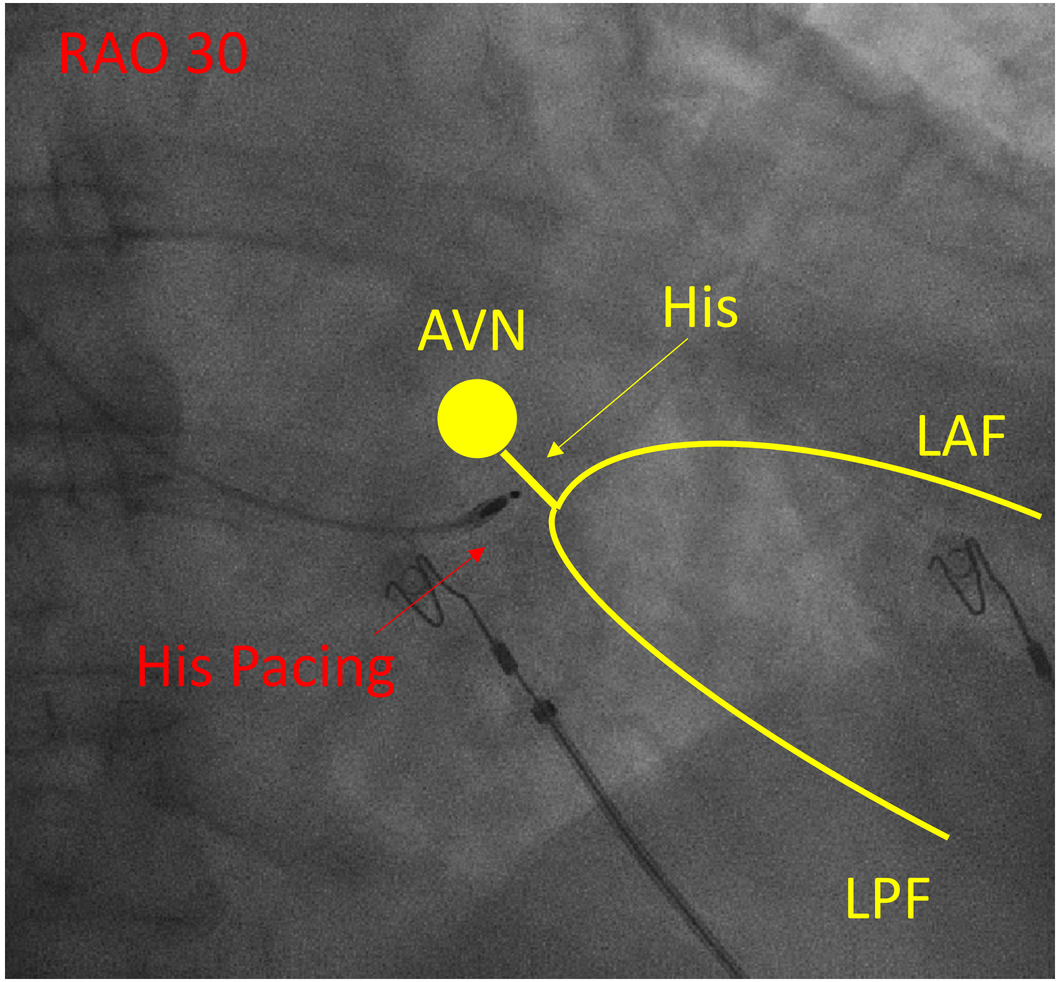
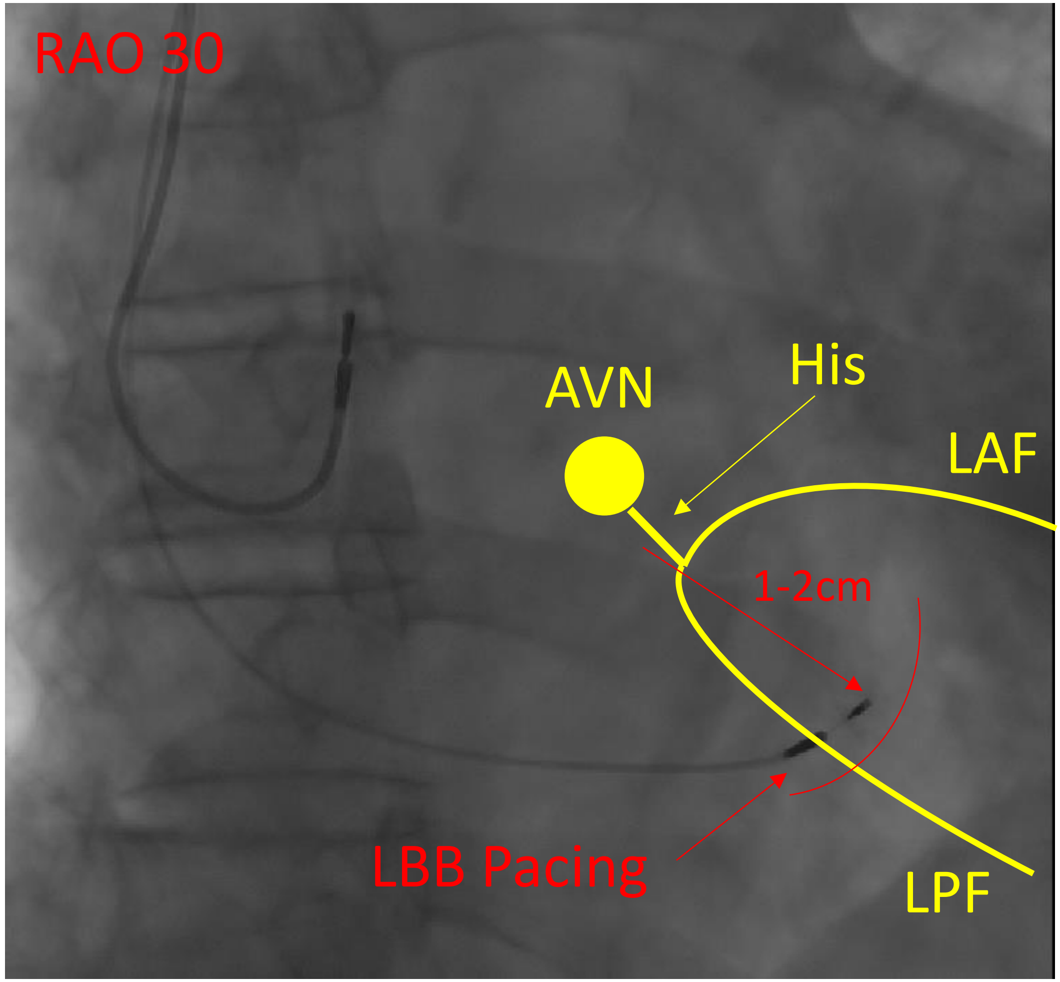
His Bundle Pacing
Corrects the LBBB and ↓ QRS 150ms → 90ms



Step 3: Locating Left Bundle Branch
Advance Pacing Lead from His Position Towards RV Apex for 1-2cm
Fluoroscopic Confirmation





Step 4: LBB Pacing
Electrical Confirmation –
Identify the “W” Potential in V1 & Perform LBB Pacing in Unipolar Mode

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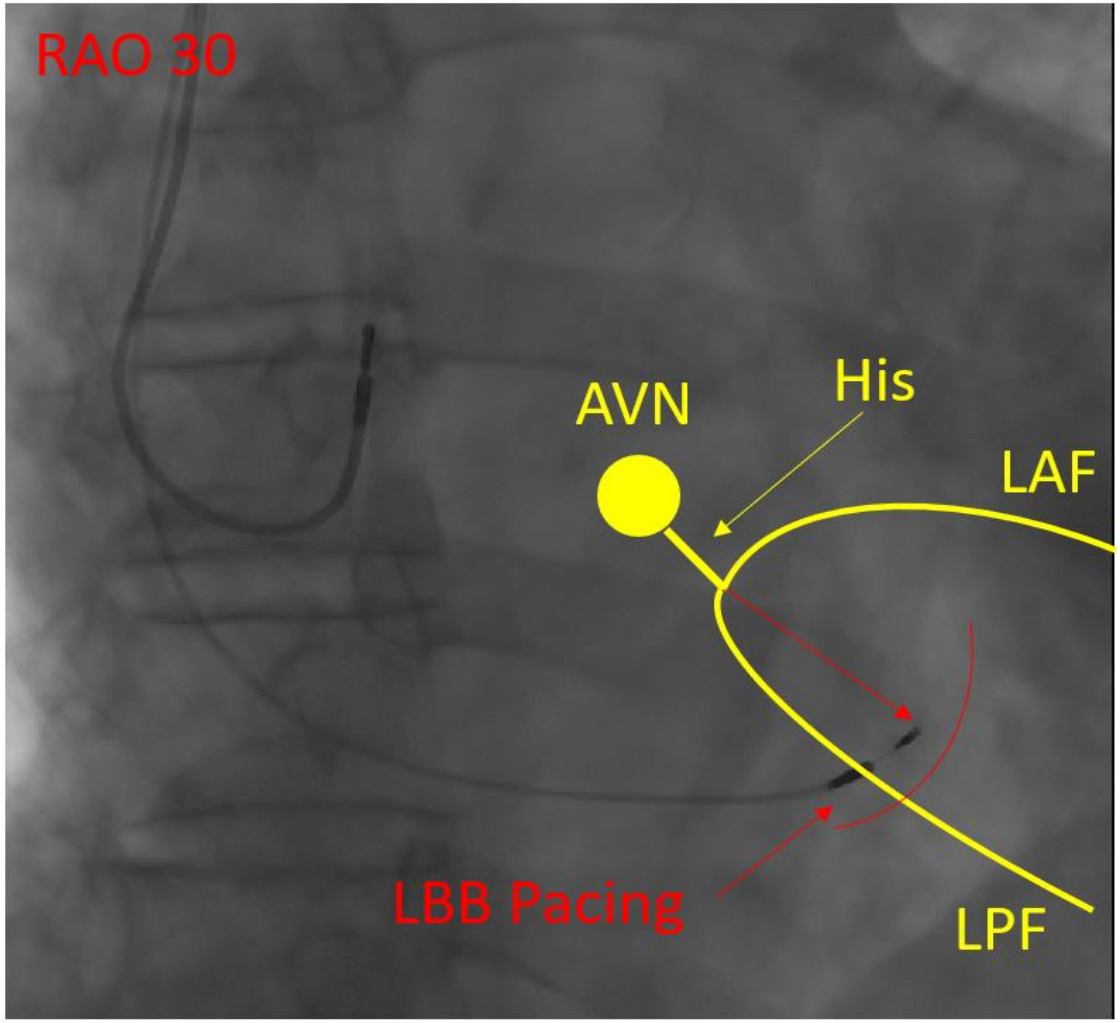
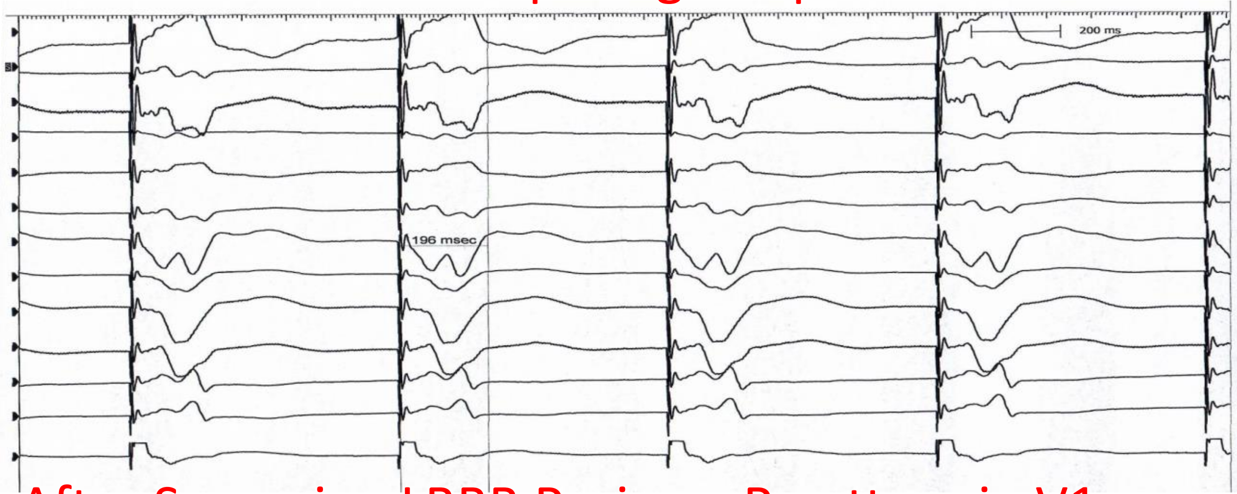
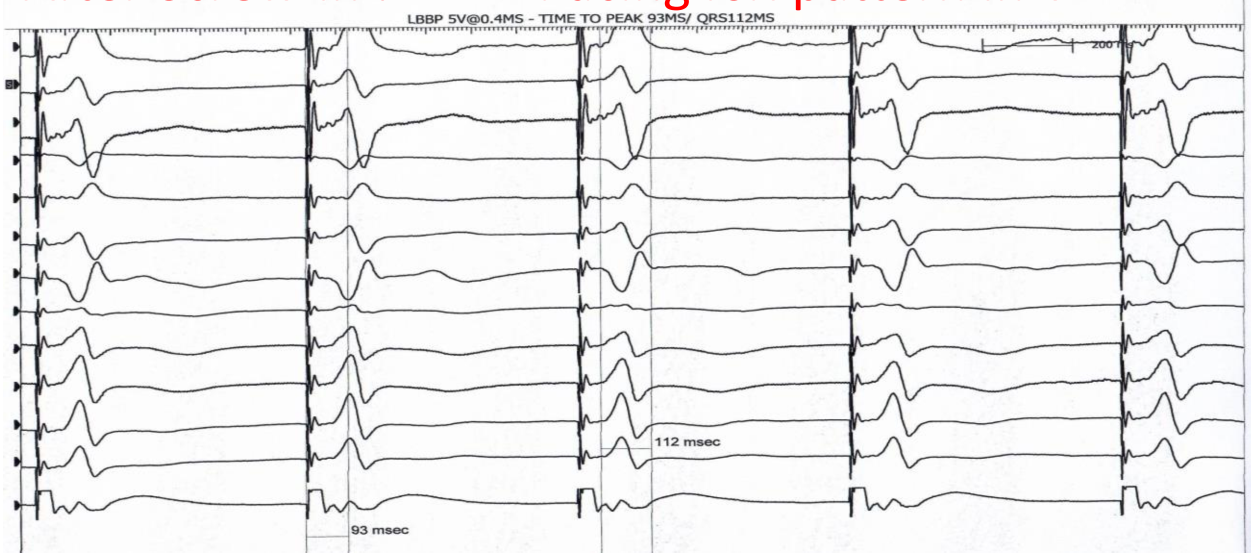


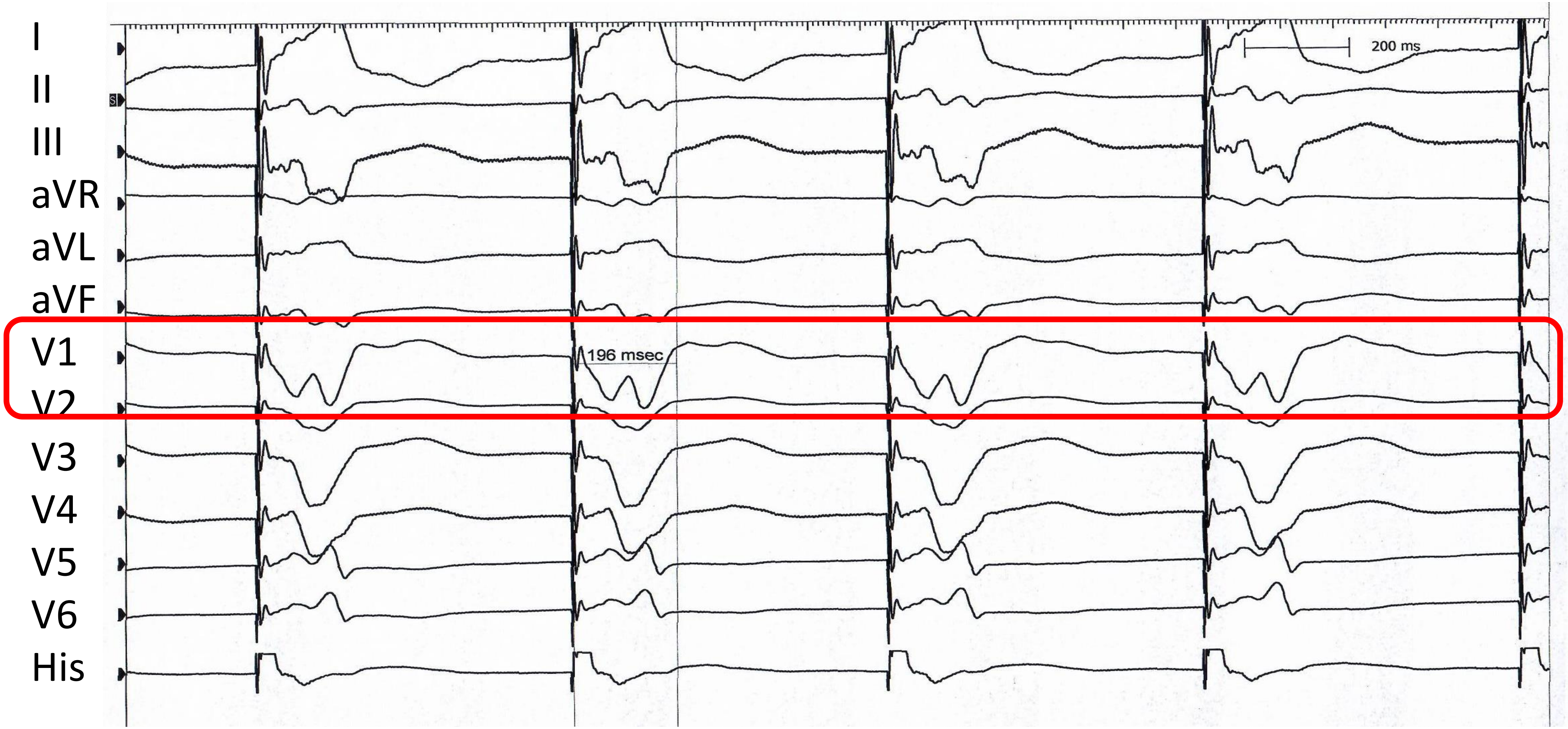
Before Screw-in – RV pacing “W-potential” in V1



After Screw-in : LBBB Pacing rsR pattern in V1



“W Potential” in V1 before Screw-in during pacing from RV septum (Unipolar)



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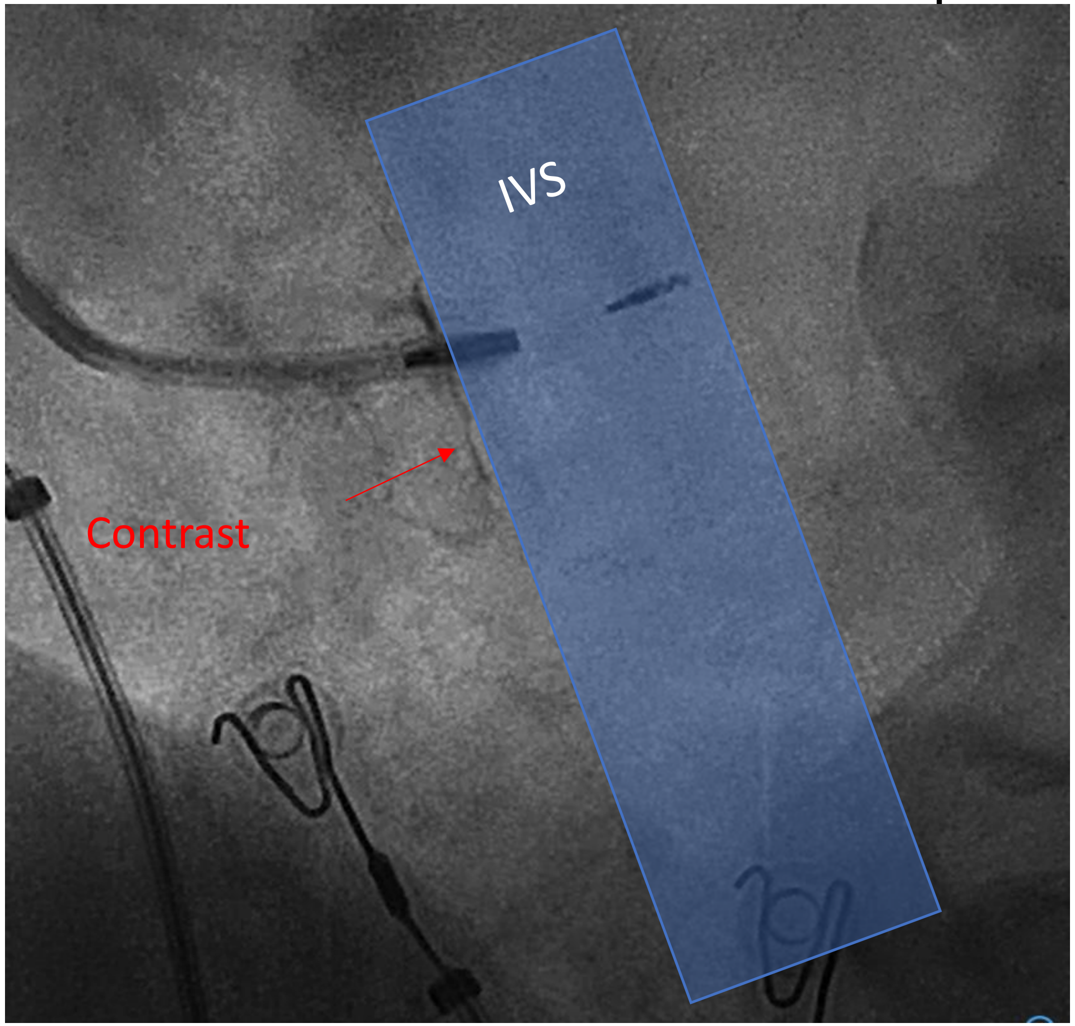
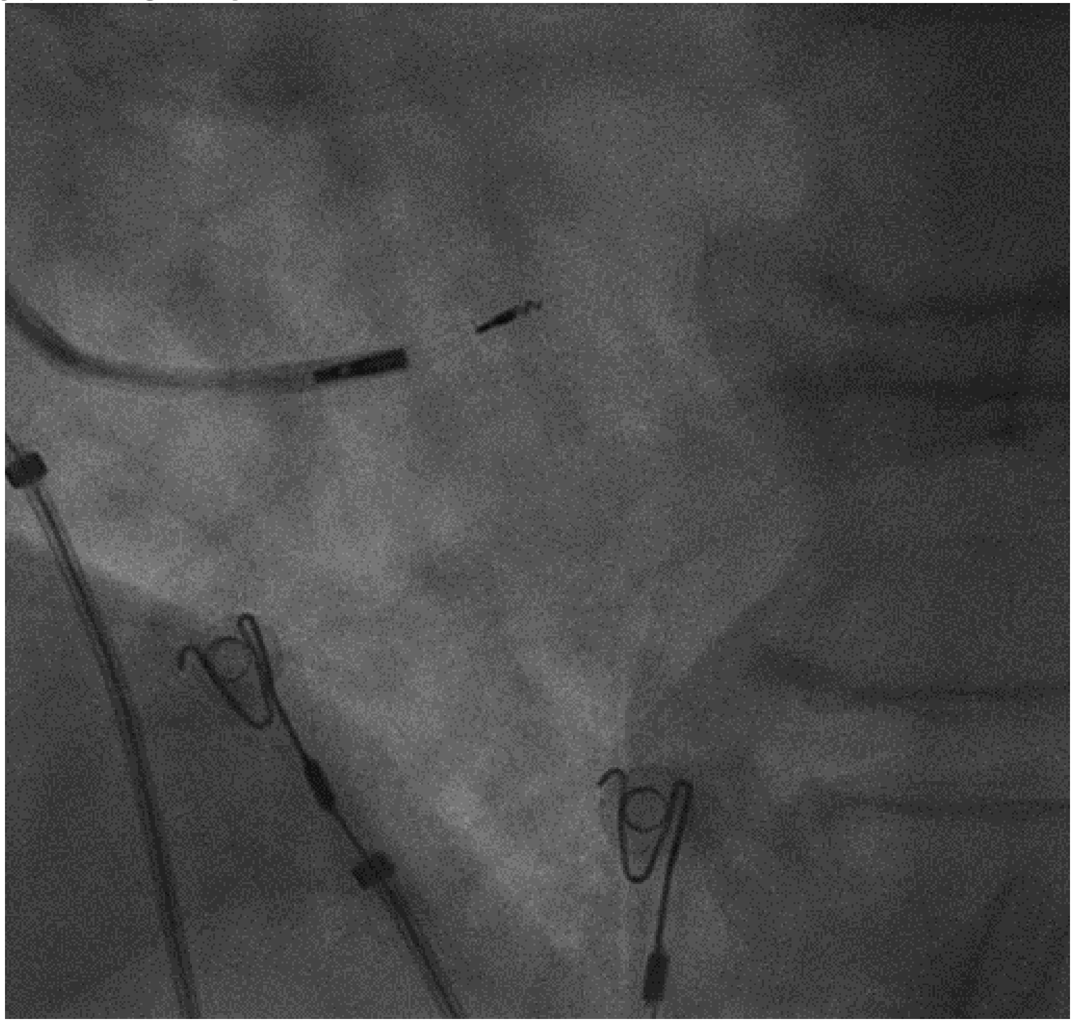
Select Secure 3830 Screw-in: 3-5 clockwise turns/time

https://www.youtube.com/watch?v=0skUko9_us0

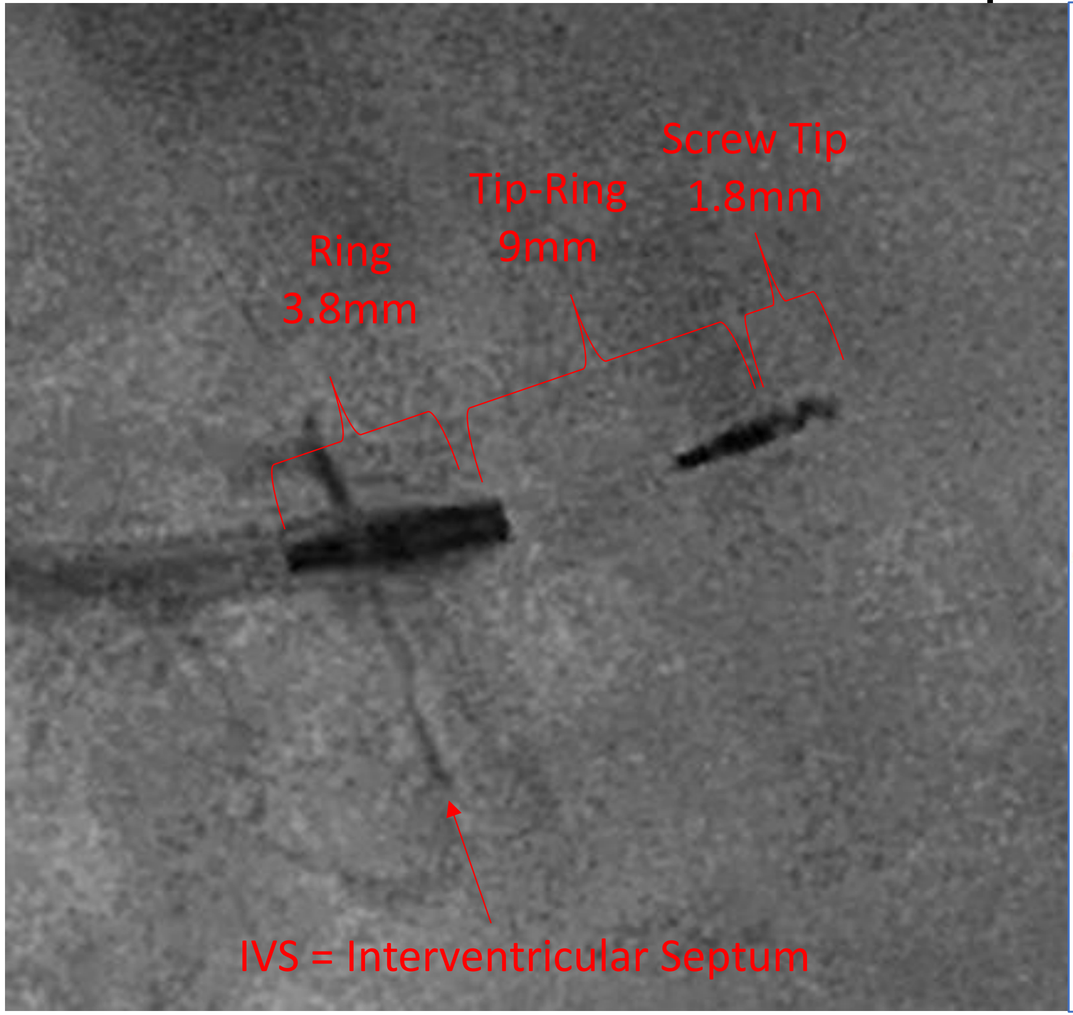
Step 5:
Determine the Depth of Lead Implant – Sheath Angiography
Avoid Implant Depth ≥ 8-10mm



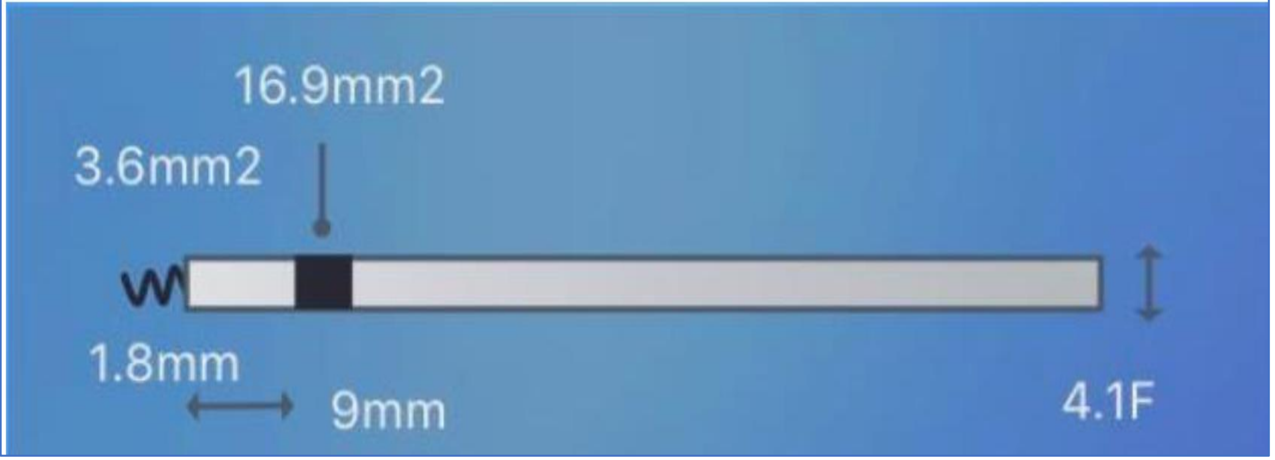


IVS = Interventricular Septum

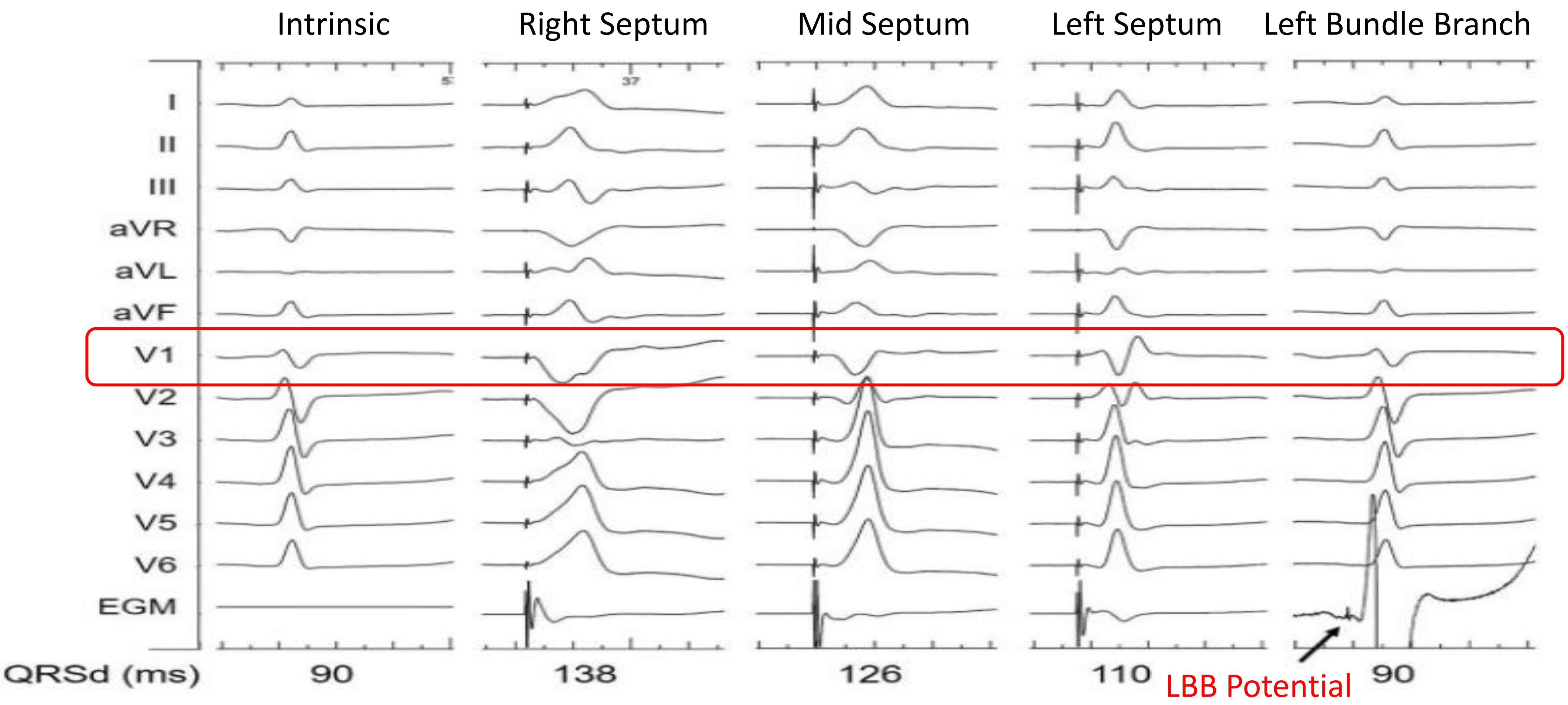
Step 5:
Determine the Depth of Lead Implant – Sheath Angiography
Avoid Implant Depth >8-10mm



- Features of 3830 pacing lead
  - Tip 1.8mm
  - Ring 3.8mm
  - Tip-Ring 9.0mm



Step 5:
Determine the Depth of Lead Implant – Electrical Confirmation
Transition of LBBB Morphology → RBBB Morphology in V1 during Lead Rotation
Pacing in Unipolar Mode at High & Low Output



Keping Chen et al. Europace 2018;0:1-8

Evolution of V1 notching, morphology, QRS width & LVAT during LBBP lead advancement

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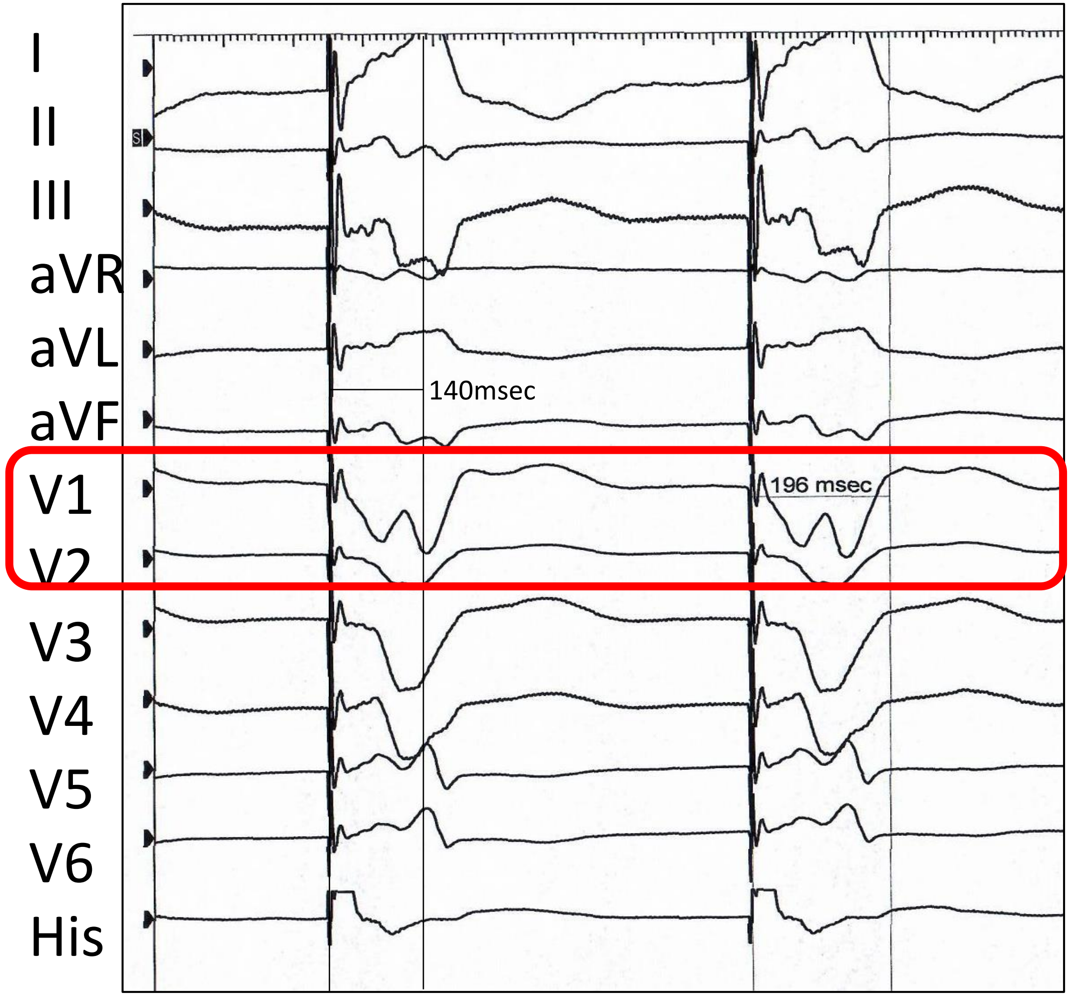
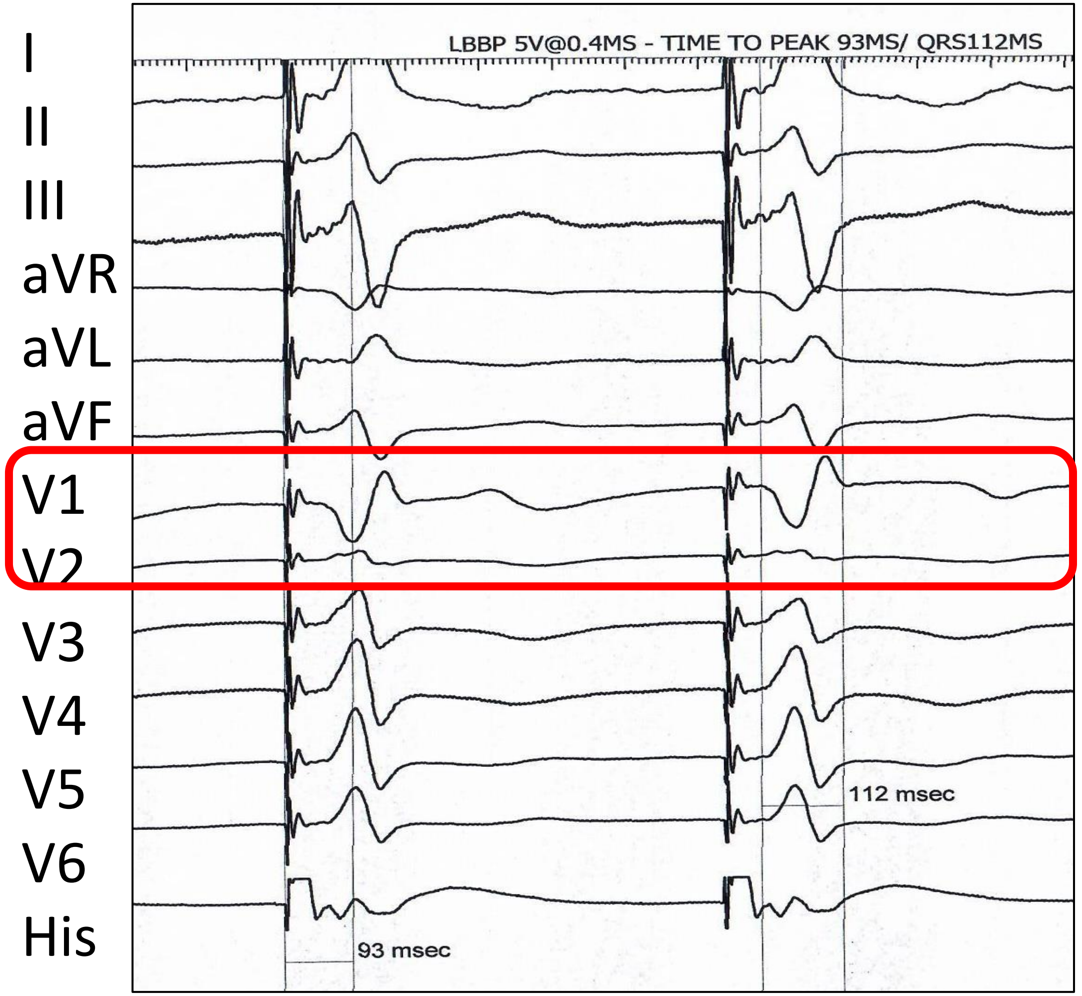
Before Screw-in: “W-potential” in V1
LBBB morphology.
Paced-QRS 196ms. LVAT 140ms



After Screw-in: “rSR pattern” in V1
RBBB morphology.
Paced-QRS 112ms. LVAT 93ms



LVAT = Left Ventricular Activation Time = Interval from pacing stimuli to peak of R wave in V5-V6

Step 5: Determine the Depth of Lead Implant with Serial Impedance Monitoring

- Measure lead impedance in unipolar mode every 3-5 turns
- Stop advancing when impedance ≤ 500 Ω (which signifies increased risk of septal perforation)

Step 6:
Determine Lead Depth & Stability
Sheath Withdrawal into RA – Fulcrum Sign

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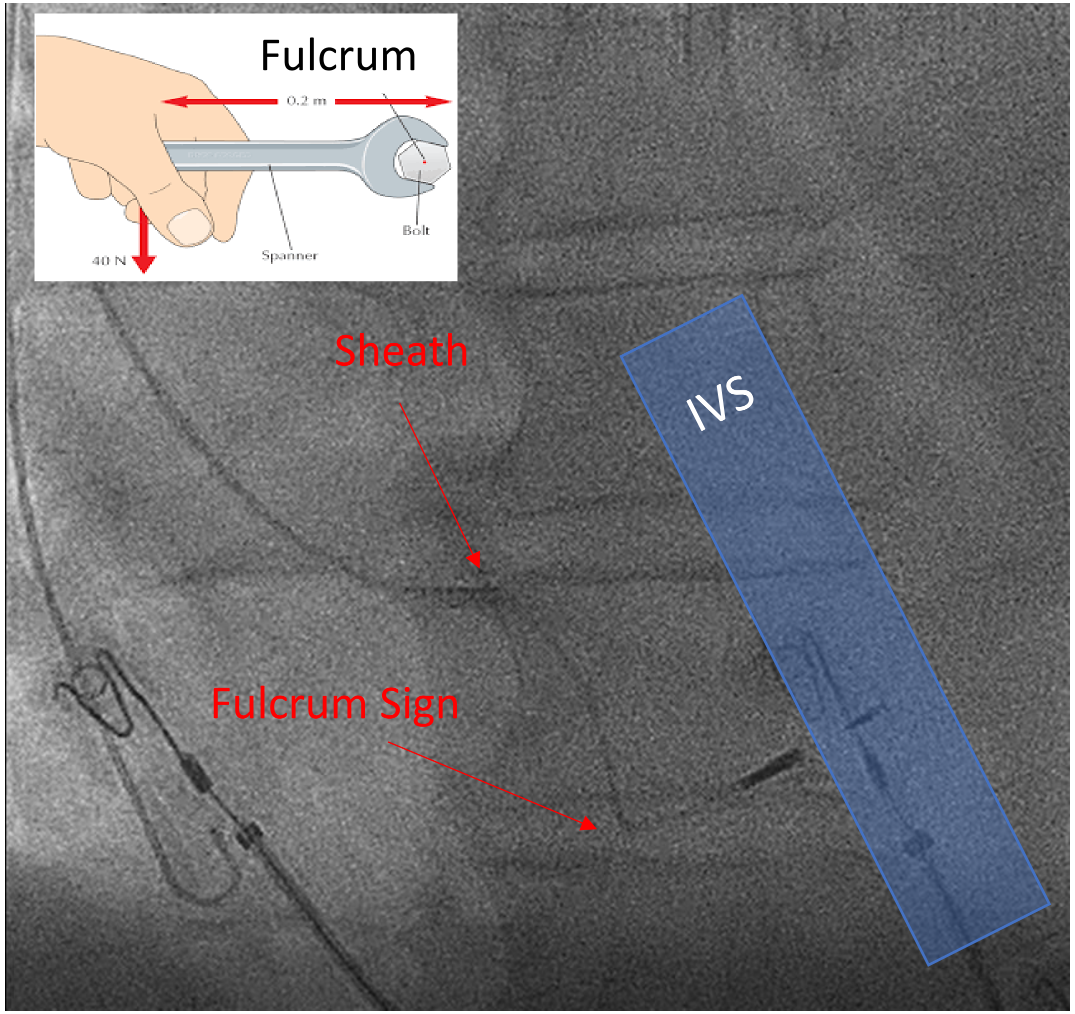
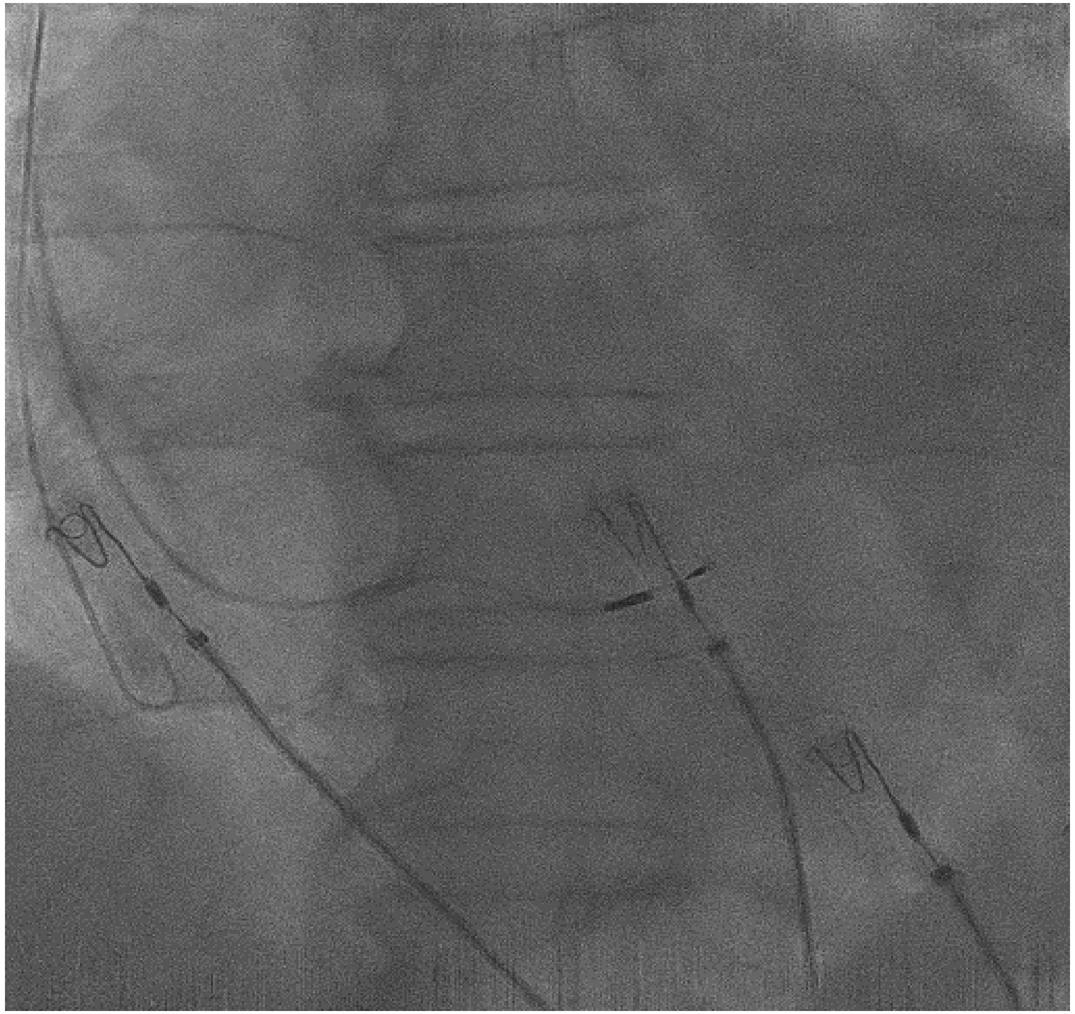
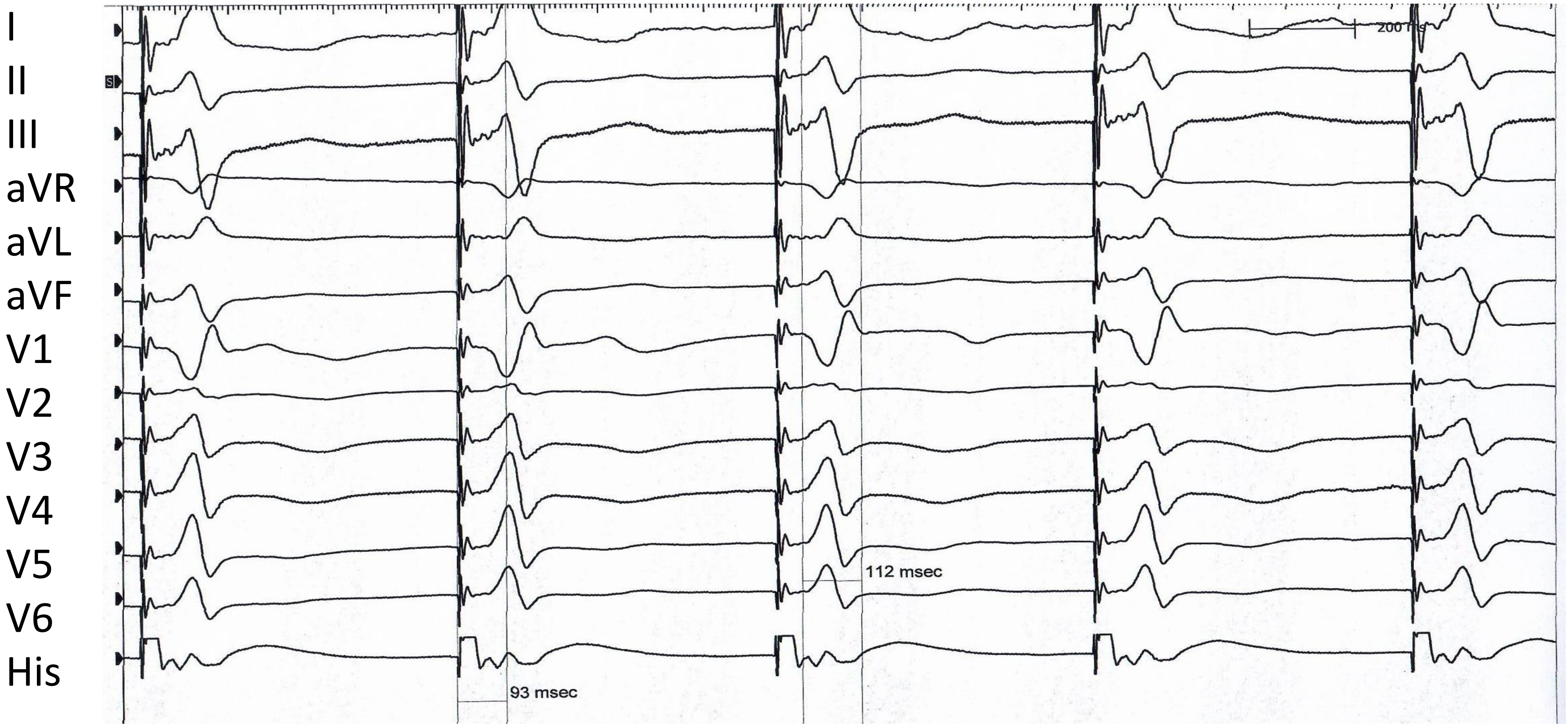


IVS = Interventricular Septum



Step 7: Threshold Testing:
LBB Pacing at high & low output: rsR Pattern in V1.
RBBB morphology. QRS 112ms. Constant & Short LVAT 93ms

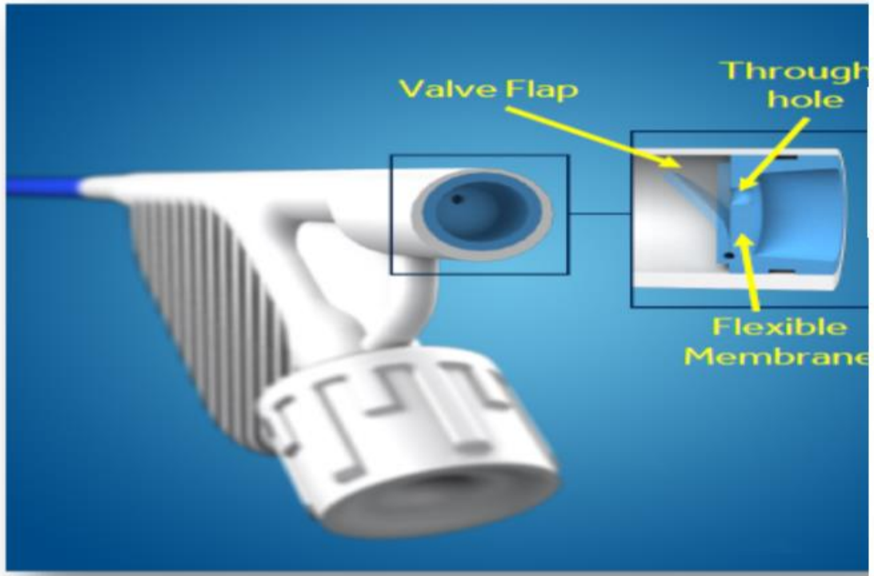


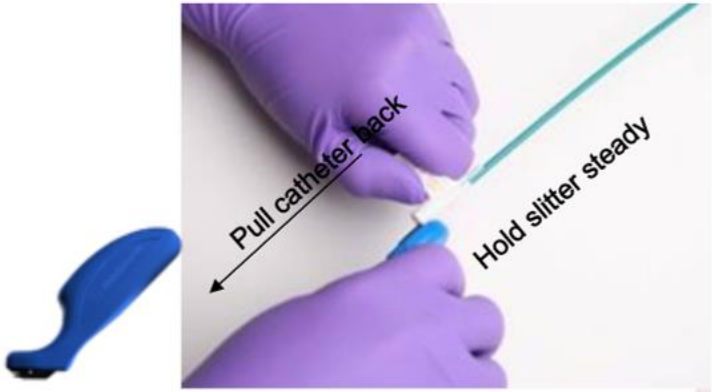
LVAT = Left Ventricular Activation Time = Interval from pacing stimuli to peak of R wave in V5-V6.

Step 8: Slitting of C315 Sheath

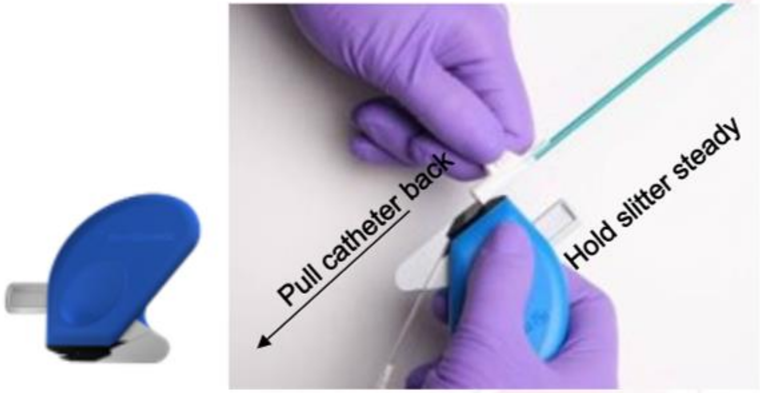
LEADS & CATHETERS
C315 CATHETER ANATOMY

- Flush port
- Slit-through hemostatic valve
- In-line hub (with integrated hemostatic valve)





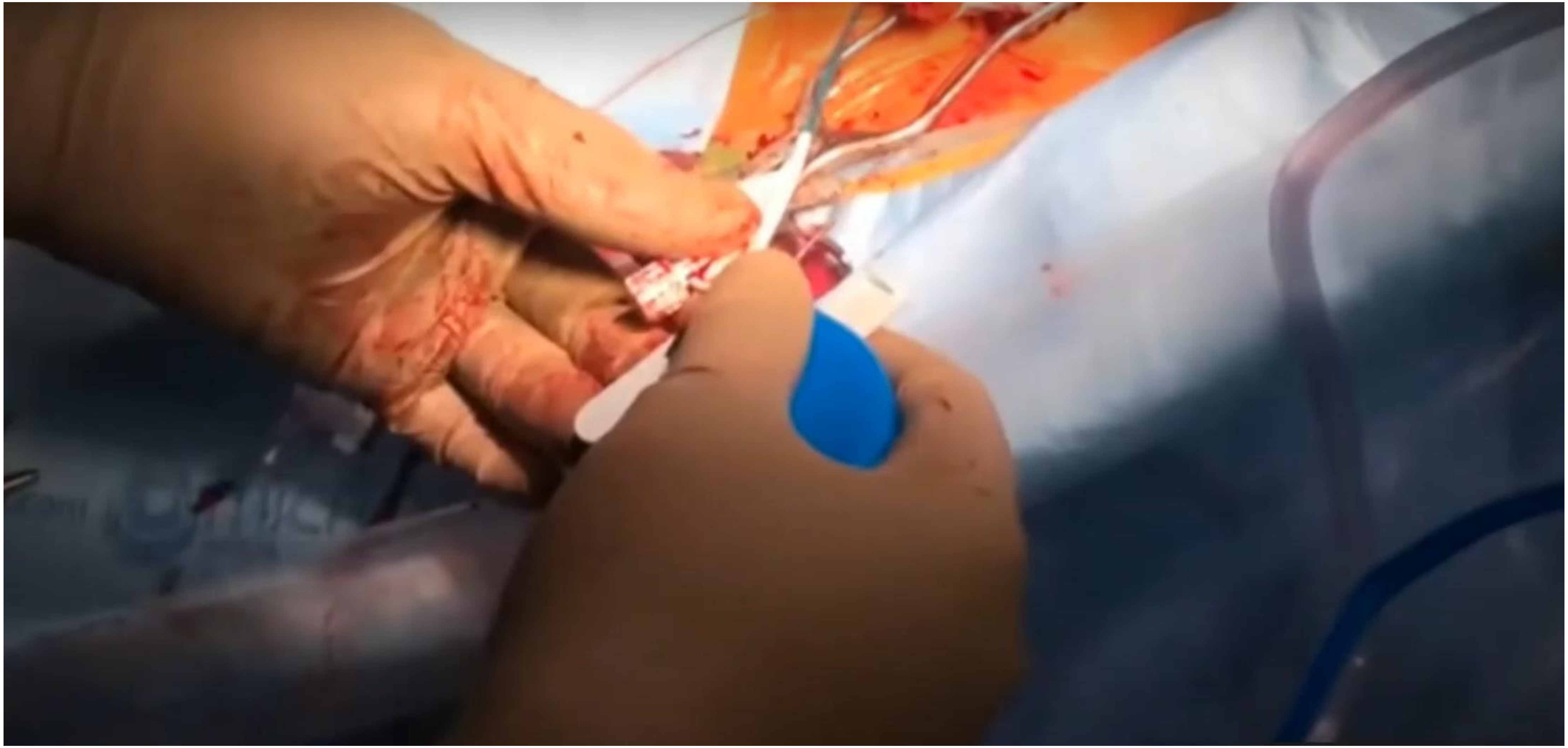
Universal II Slitter



Adjustable Slitter

Medtronic

Slitting of C315 Sheath



https://www.youtube.com/watch?v=0skUko9_us0

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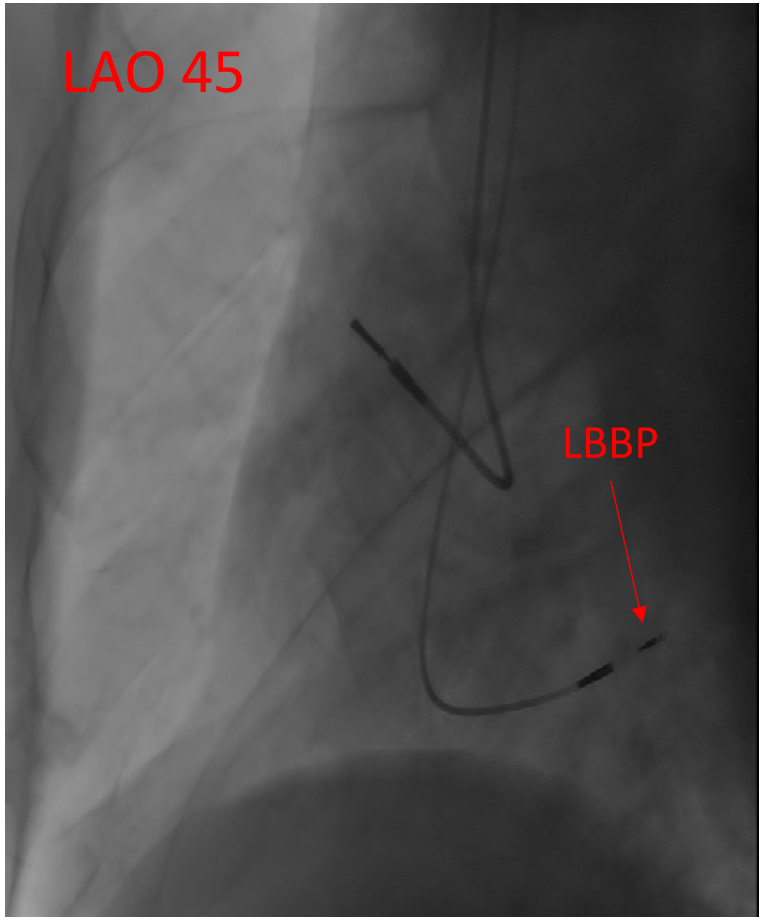
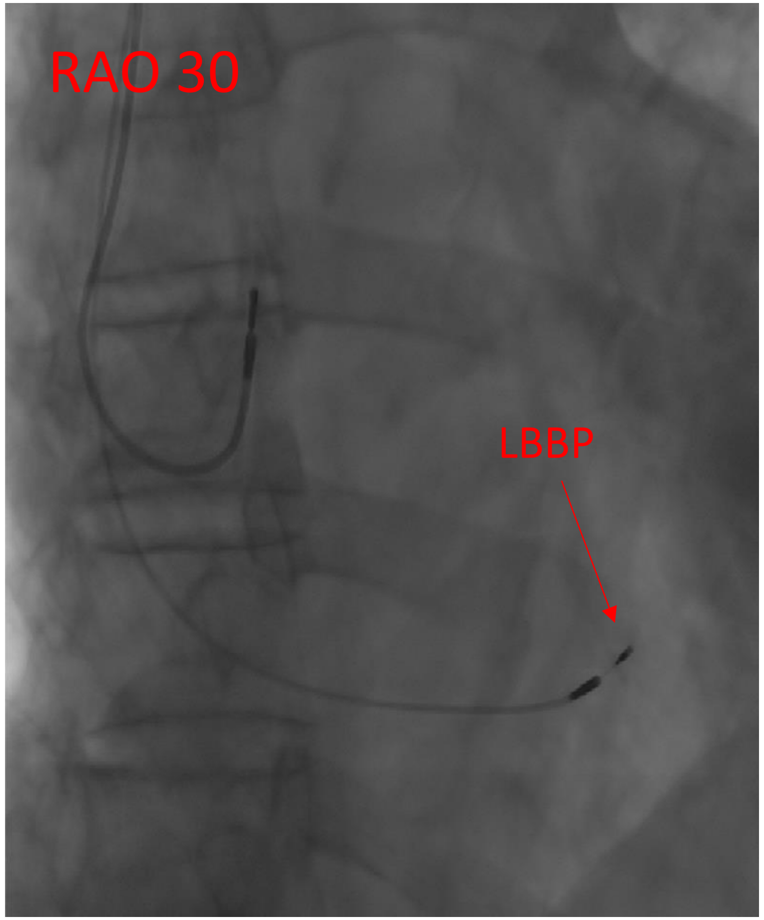
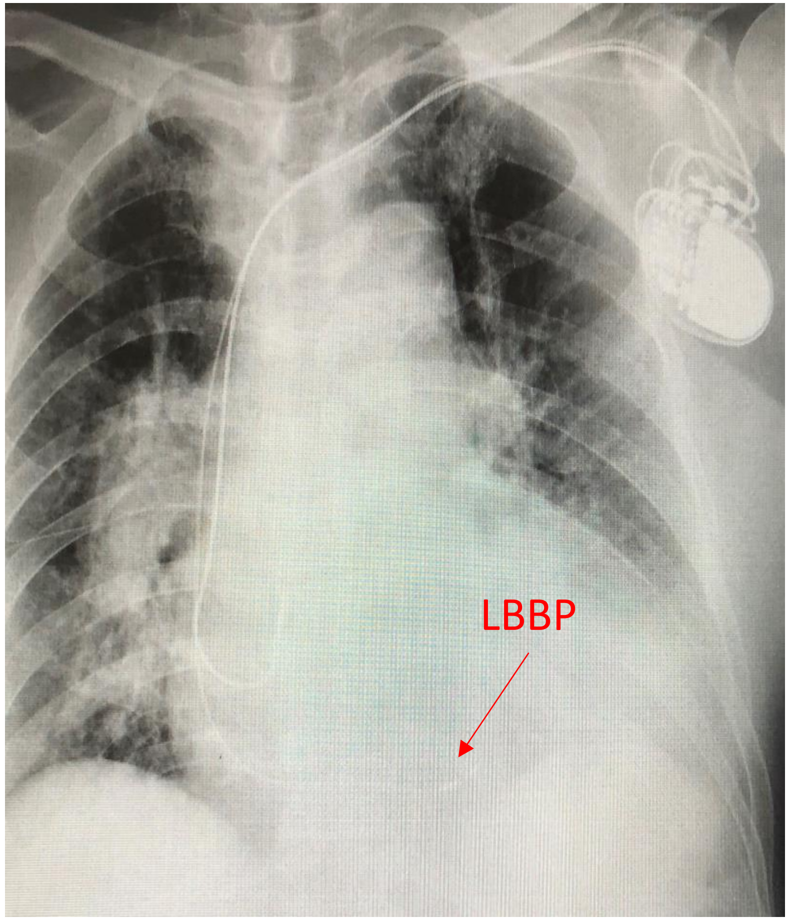
Final fluoroscopic confirmation of Leads Positions in LAO & RAO views







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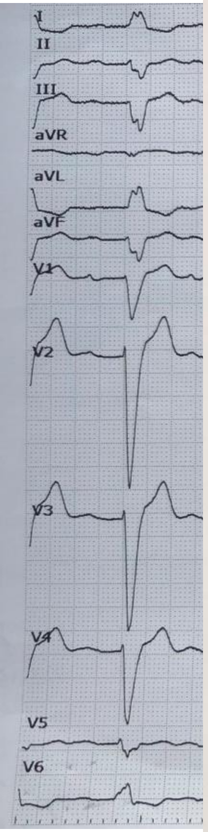
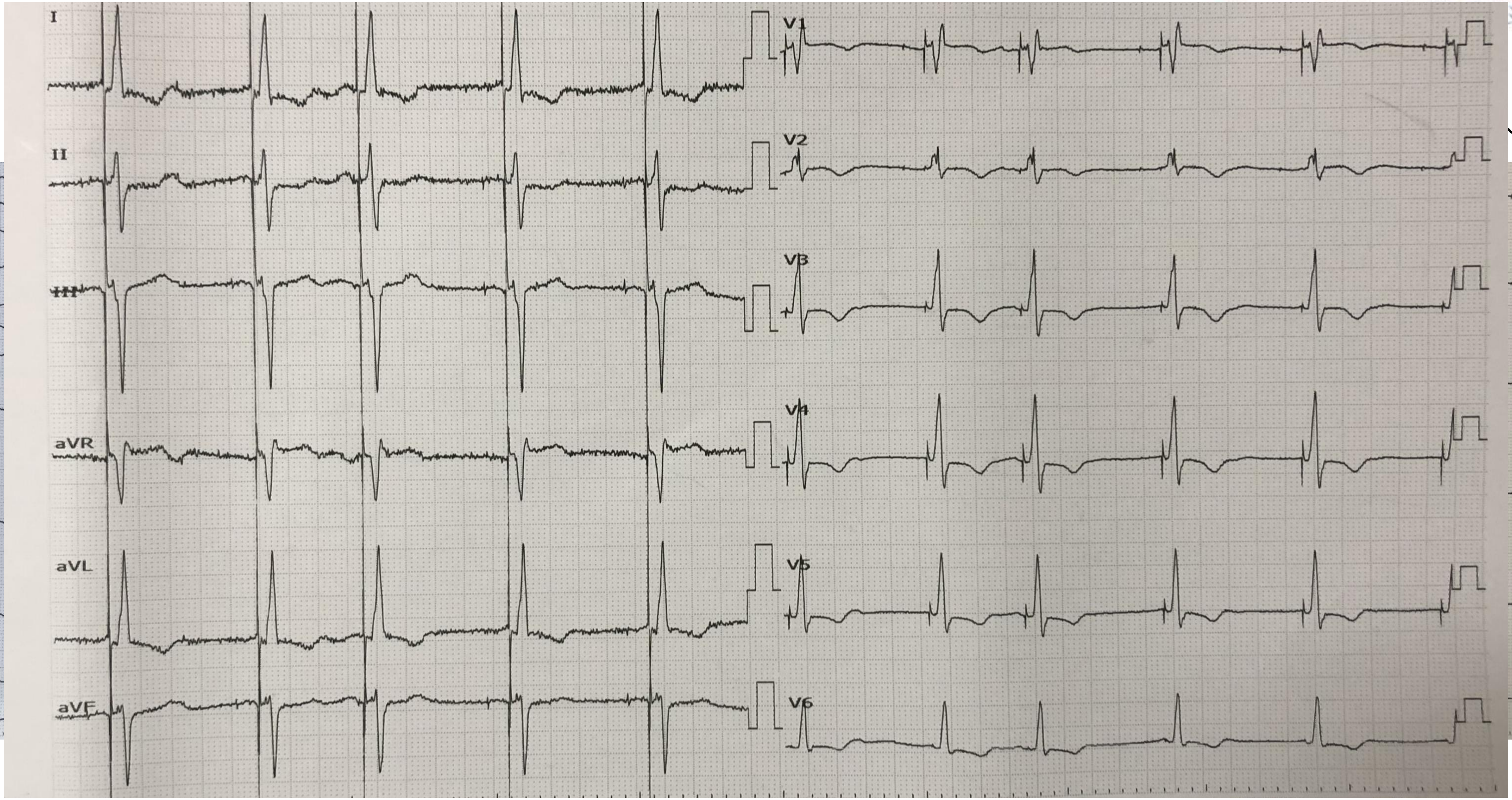
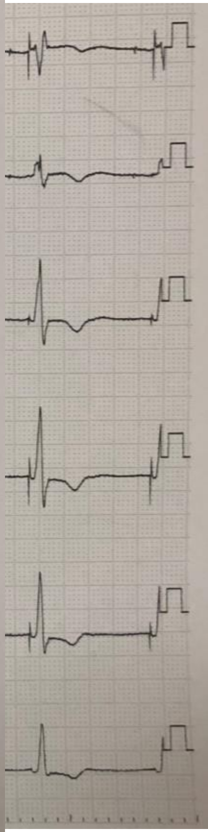
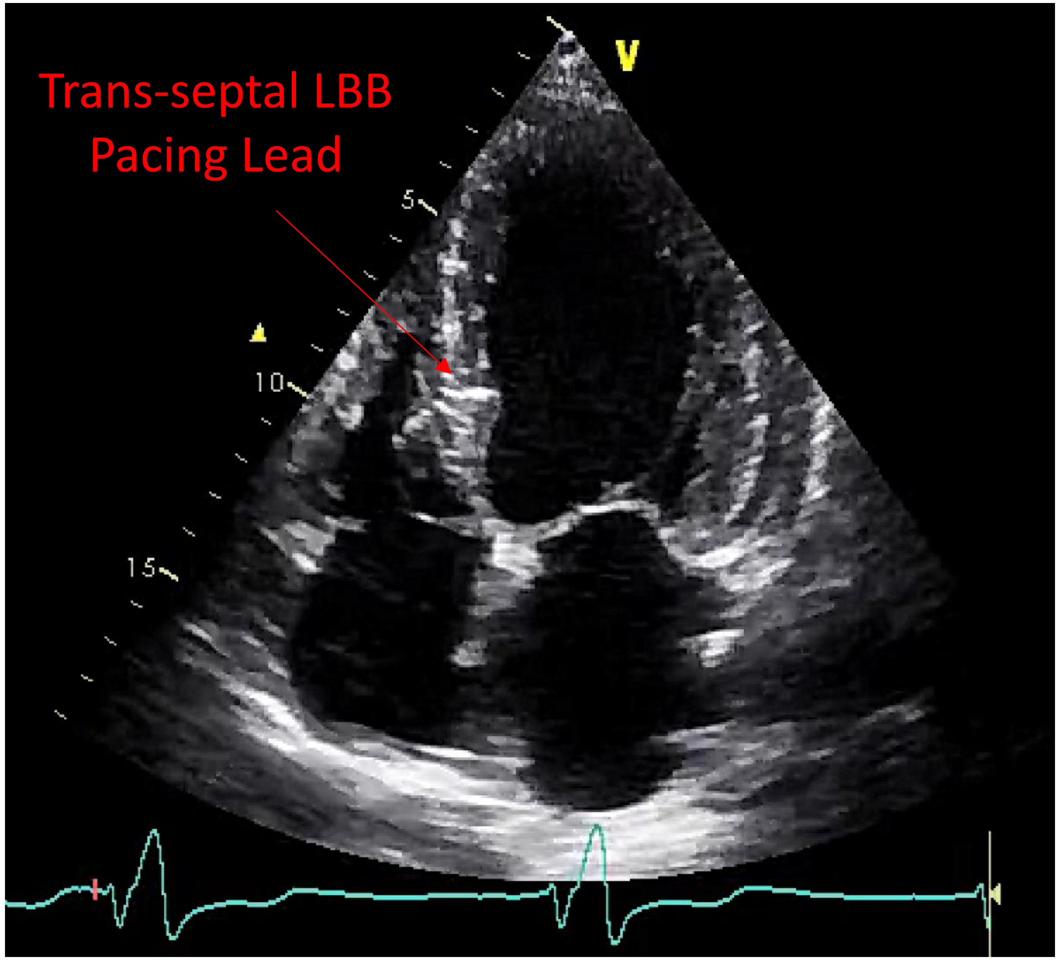
~120ms

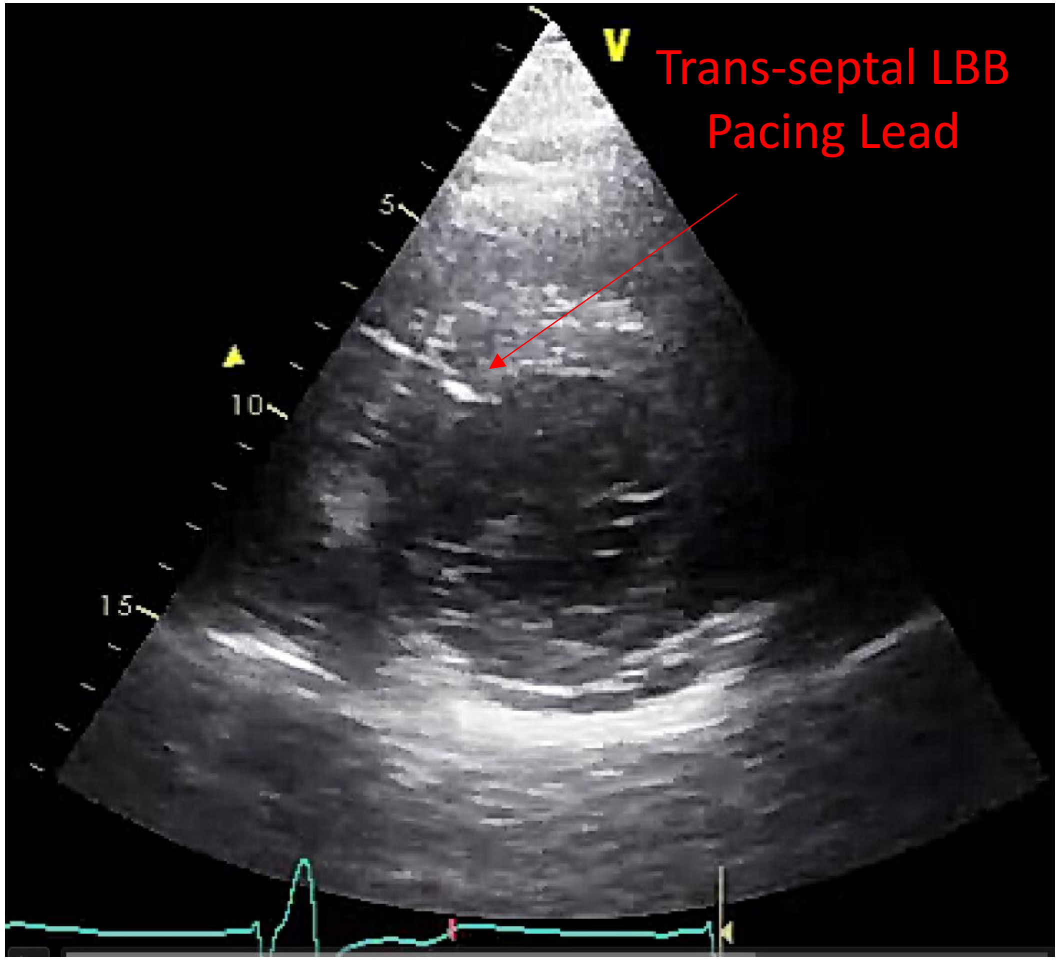






Echocardiographic Confirmation of LBBP Lead Implant Depth





Post LBB Pacing Echo

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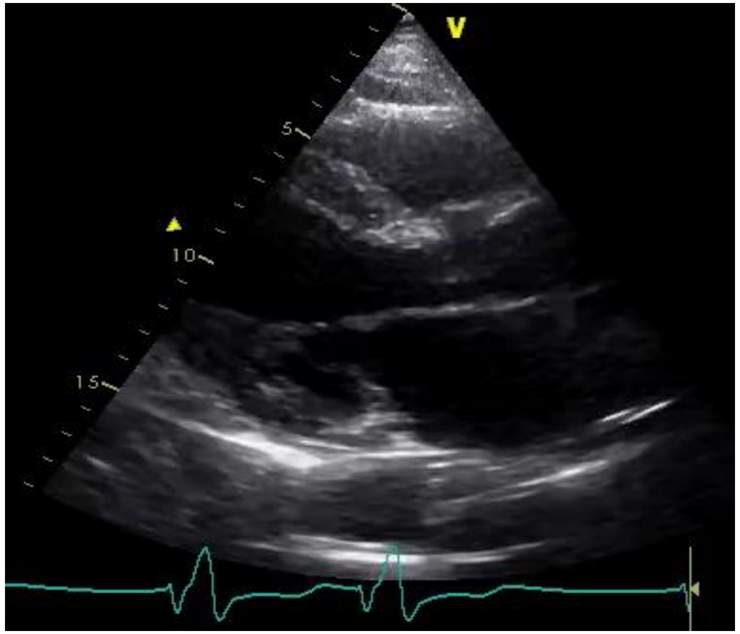
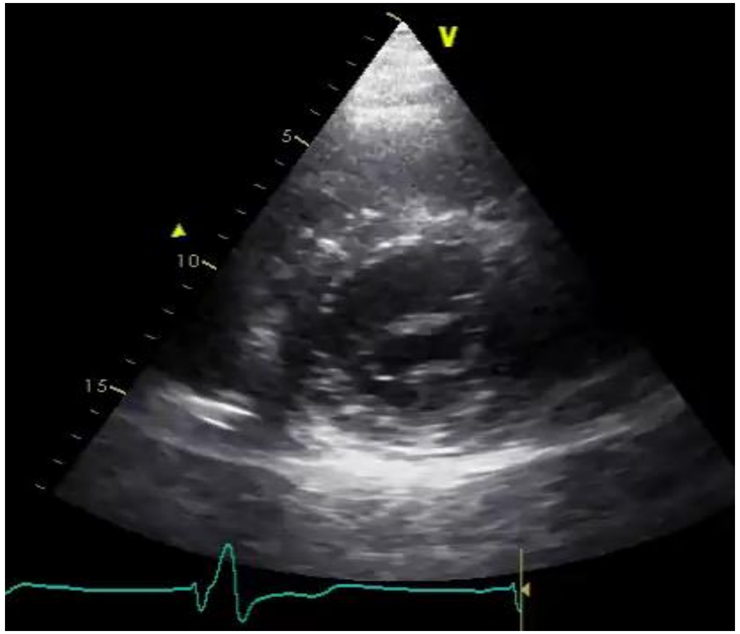
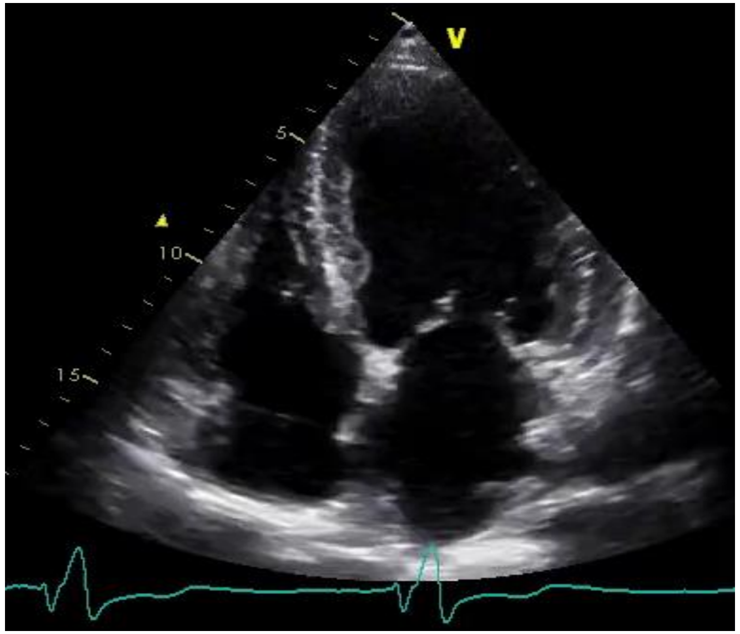
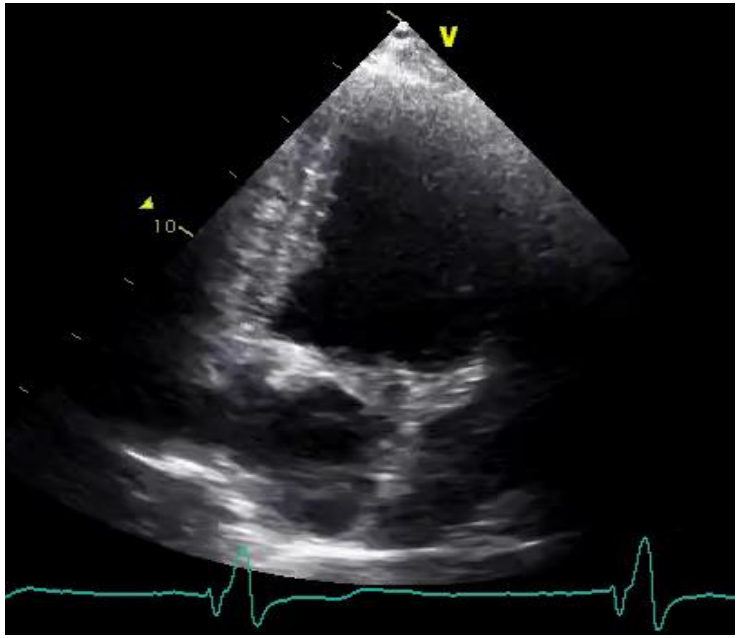
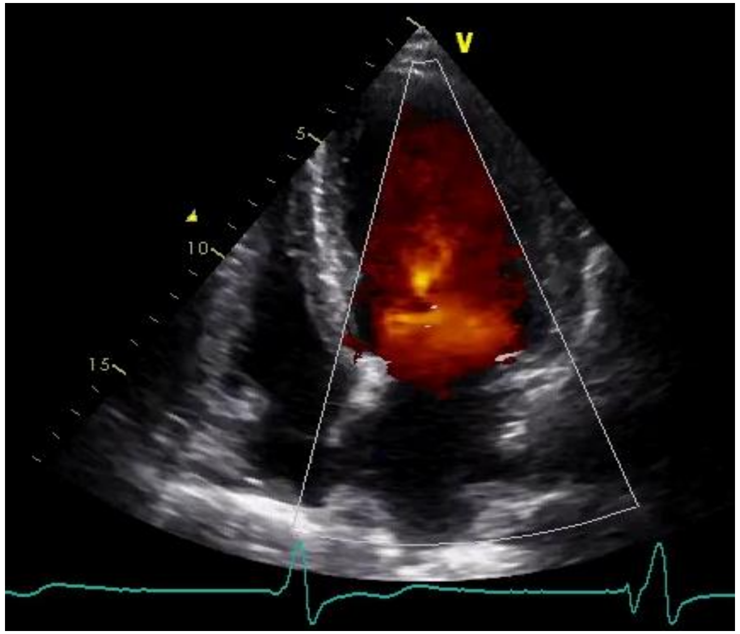




- LVEF Improved to ~40% by Biplane Modified Simpson’s (LVEF ~ 35-40% by Eyeballing)
- MR +++ → ++







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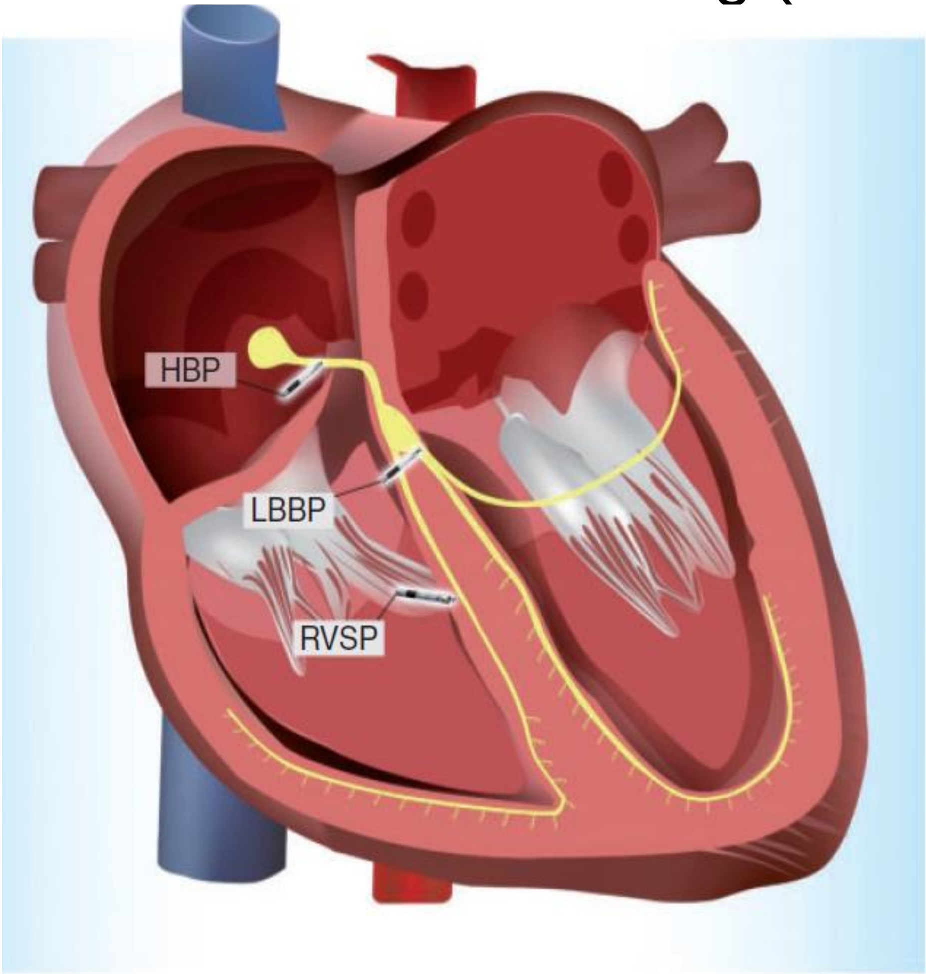
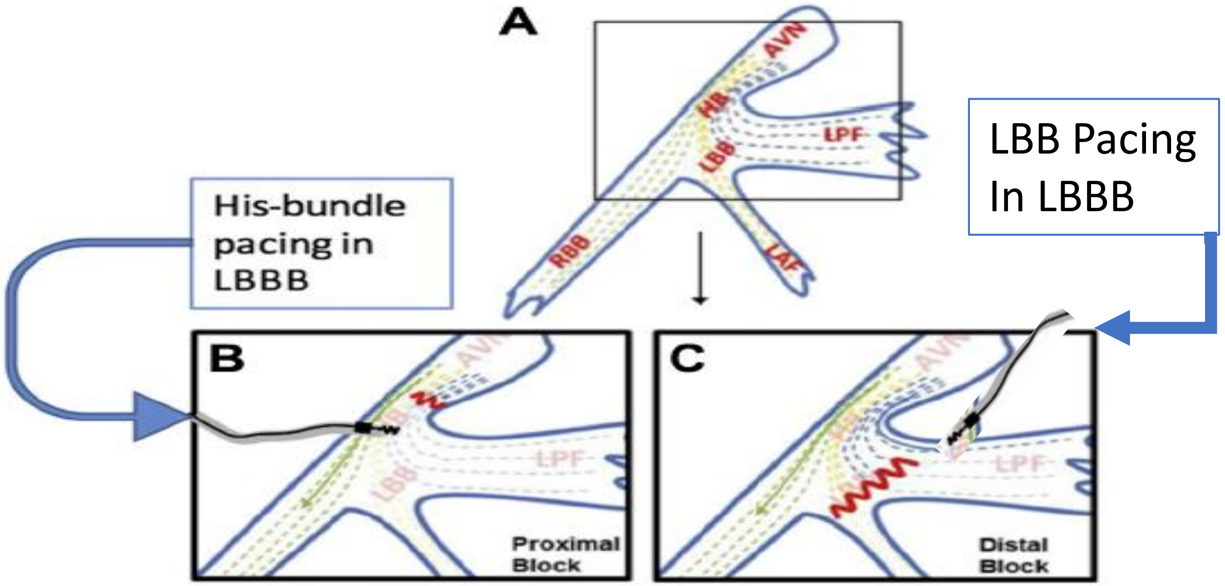
Electrophysiological Mechanism of His Bundle Pacing (HBP) / Left Bundle Branch Pacing (LBBP)



Longitudinal Dissociation of Conduction System:

- Conduction fibers arising early from proximal His Bundle are predestined to the individual bundle branches → HBP & LBB pacing distal to the level of block → allows correction of BBB & restoration of electrical & mechanical synchrony



Europace (2019) 00, 1–9 doi:10.1093/europace/euz188

JACC Clin Electrophysiol. 2017 Nov;3(11):1203-1219.

Prospective evaluation of feasibility and electrophysiologic and echocardiographic characteristics of left bundle branch area pacing

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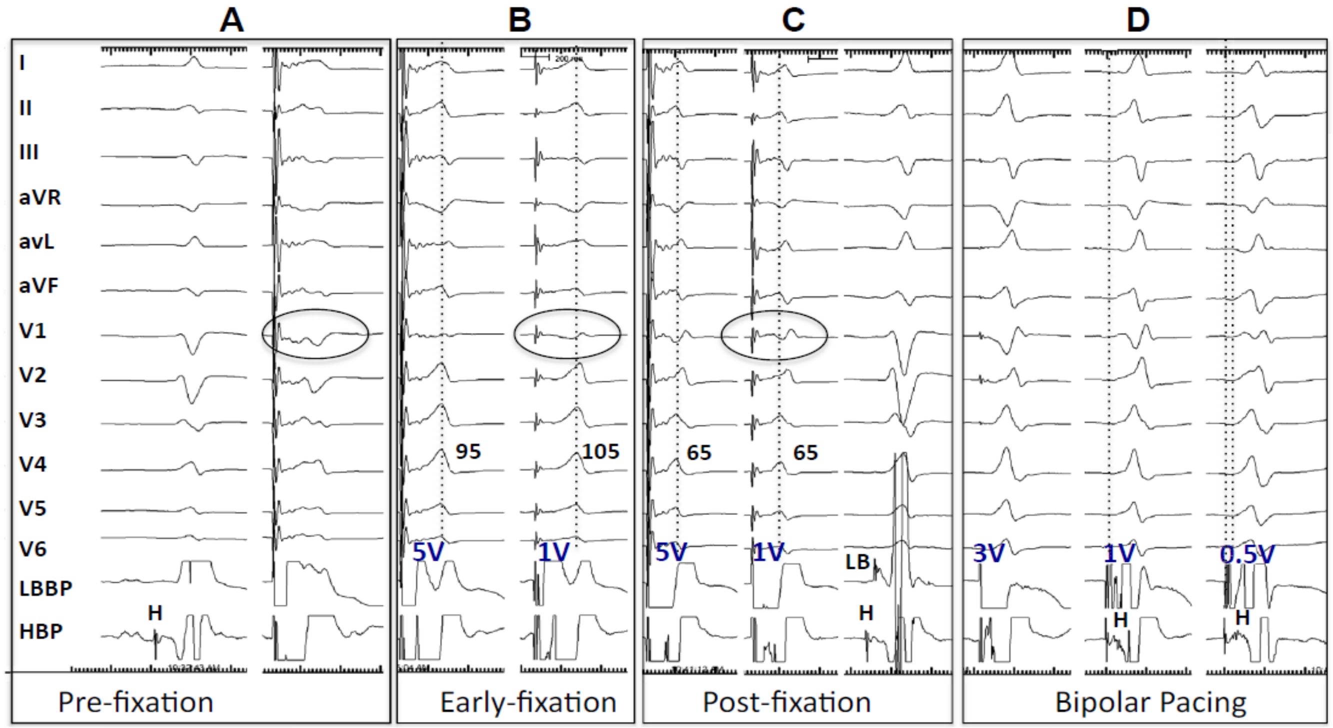


Table 2 Pacing parameters and echocardiographic characteristics

	Pacing parameters					
	Implant (n = 93)	2 weeks (n = 91)	3 months (n = 68)	6 months (n = 40)	9 months (n = 16)	12 months (n = 7)
Threshold (unipolar)	0.66 + 0.48	0.67 + 0.20	0.68 + 0.21	0.66 + 0.11	0.69 + 0.22	0.71 + 0.32
(anodal)	2.2 + 0.7	2.13 + 1.0	2.6 + 1.1	*	*	2.3 + 0.9
R wave (mV)	10.3 + 6.1	13.5 + 6.7	12.3 + 5.7	12.3 + 4	11.1 + 5.2	10.4 + 3.7
Impedance (ohms)	736 + 160	522 + 93	514 + 86	522 + 87	533 + 102	527 + 97

- N = 100.
- AVB 54%. SND 23%.
- LBBB 24% RBBB 25%

- Implant success 93%
- Paced QRS duration: 136±17 ms.

- In patients with LBBB, correction of LBBB with QRS ↓ 162 ± 21ms → 137 ± 19 ms during LBB Pacing (P <0 .001)

- Stability: Stable sensing, threshold & impedance at 12 months

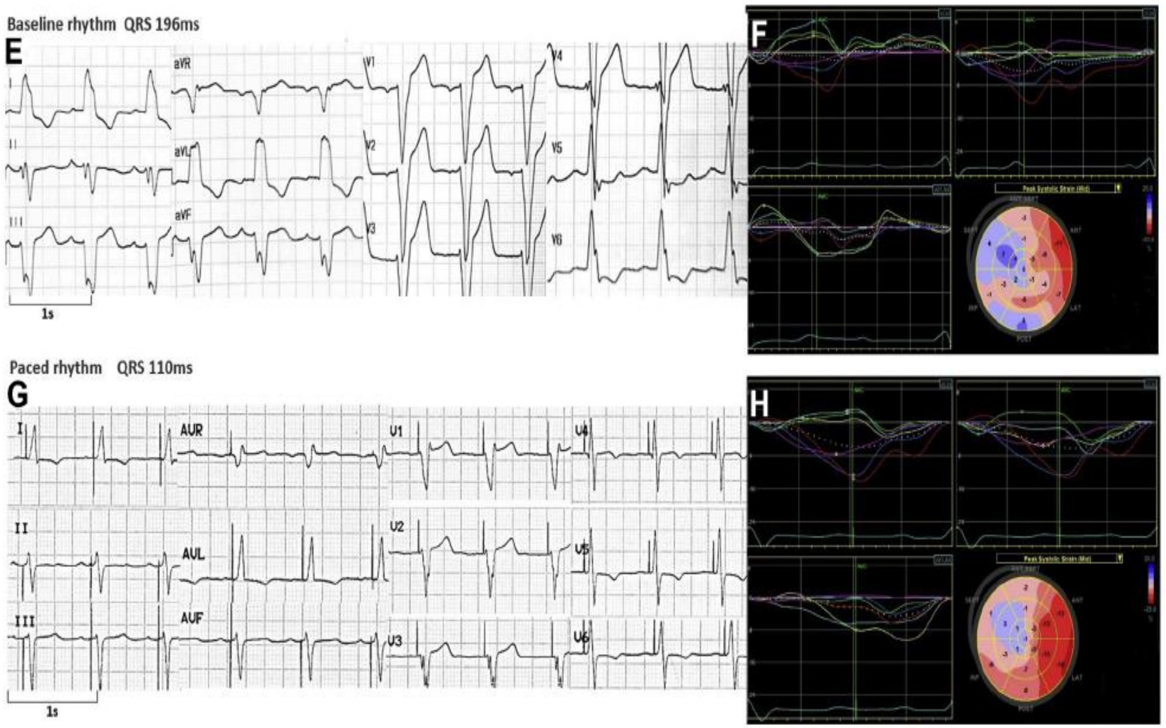
Vijayaraman et al. Heart Rhythm 2019;16:1774–1782

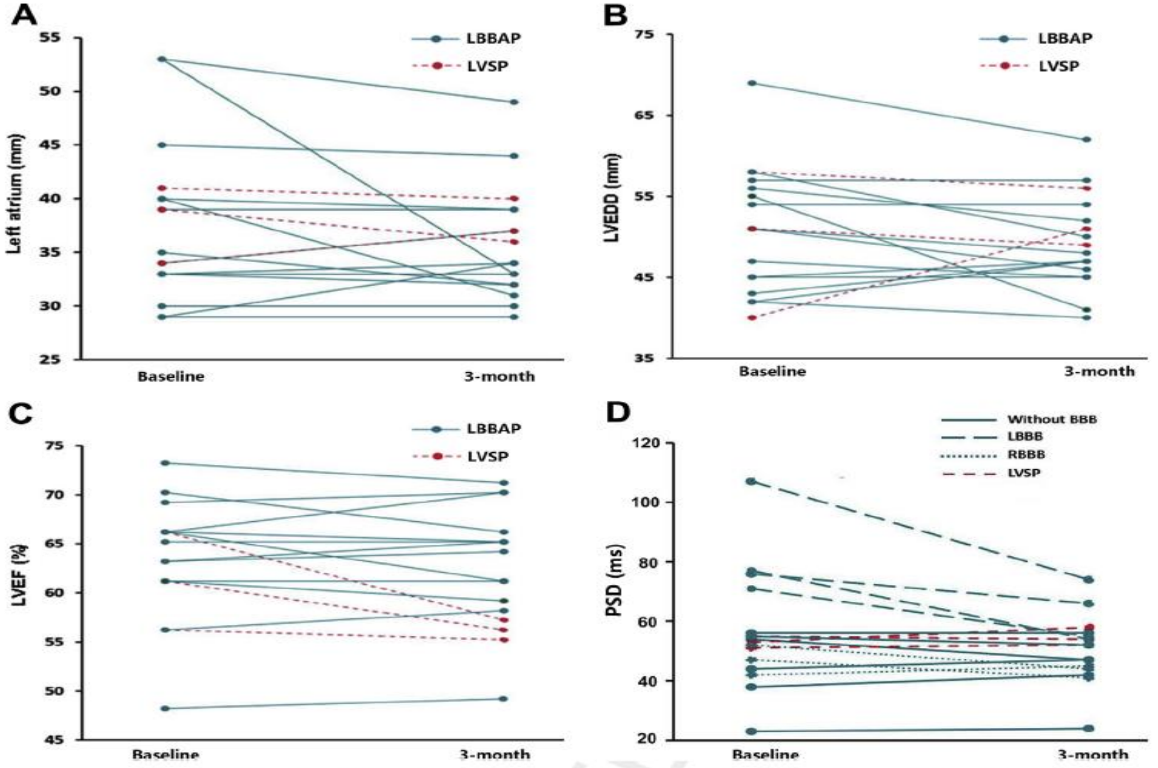
LBB Pacing Corrects LBBB/RBBB
Improves LVEF, LV electrical & mechanical synchrony (strain)

Correction of LBBB / RBBB with success rate of 68.7%

(QRS 153.3 ± 27.8 → 122.2 ± 9.9 ms)

LBB Pacing → ↓ QRS , ↑ LVEF, ↓ LVEDD, ↑ LV synchrony (time to peak strain delay)

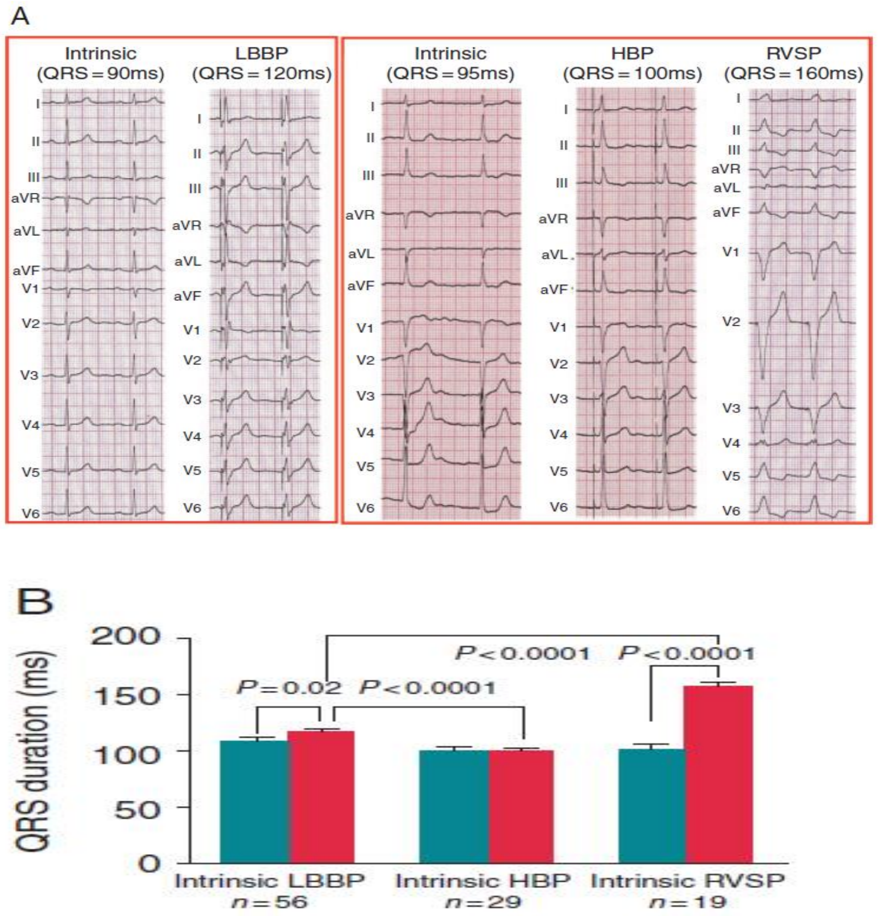


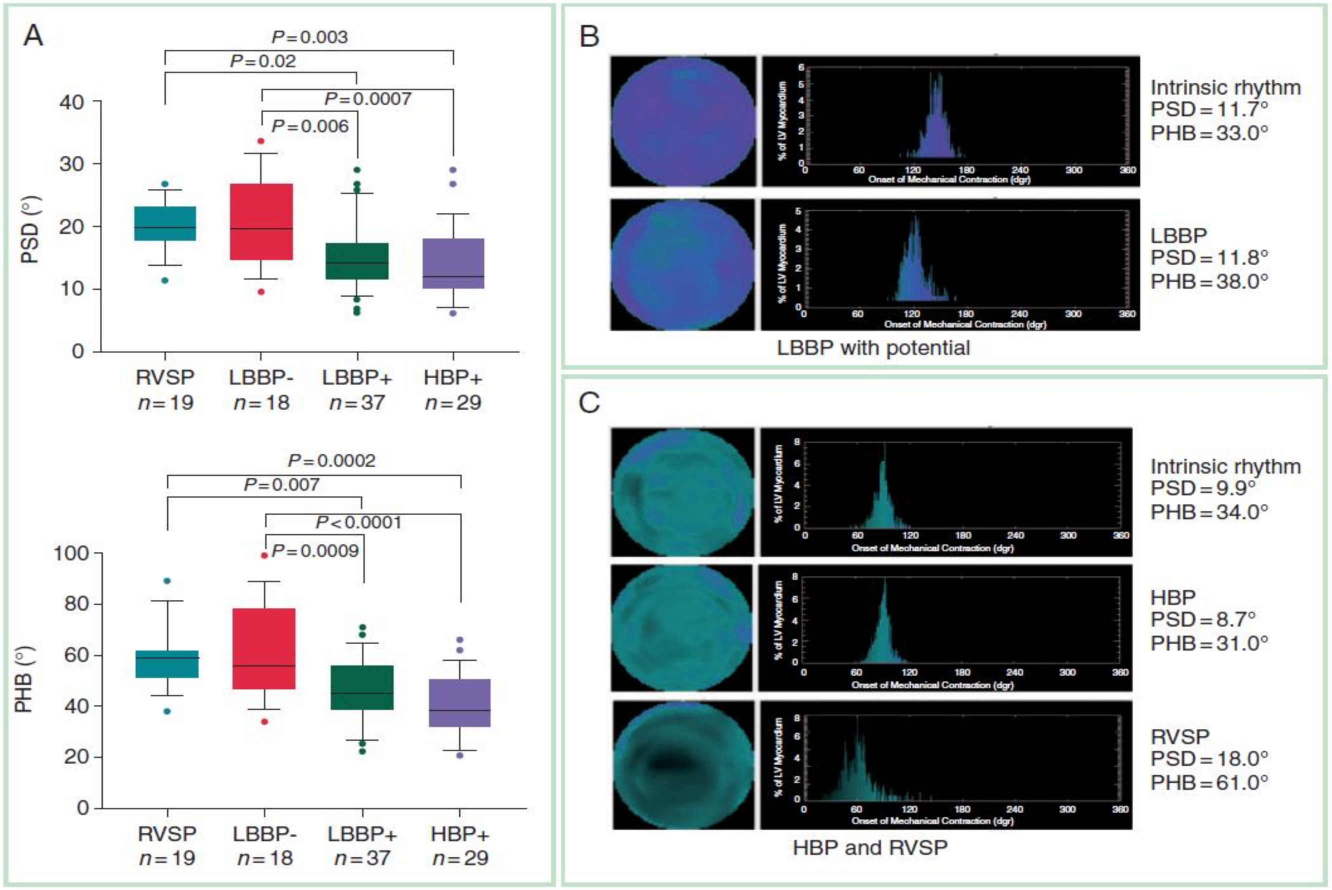


N = 33 AVB Patients. LBB Pacing success 90.9%. Safety: 1 septal lead perforation

Heart Rhythm. 2019 Dec;16(12):1766-1773.

Left bundle branch pacing
Preserves Electrical and LV Mechanical Synchrony
(Gated SPECT MPI Phase Analysis)





Europace (2019) 00, 1–9 doi:10.1093/europace/euz188

2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay

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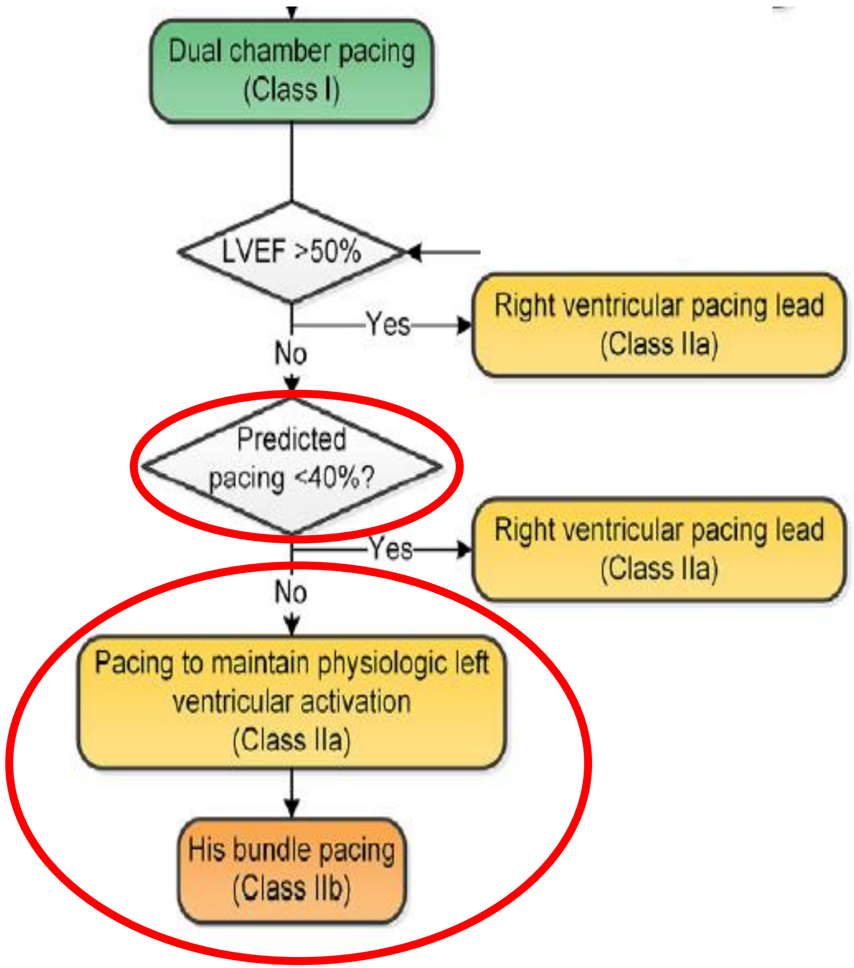
Indications for His Bundle Pacing

In patients with AV block at AVN level, who have an indication for permanent pacing, His Bundle Pacing may be considered to maintain physiologic ventricular activation (II b)



- LVEF 36-50%.
- Predicted Pacing Percentage ≥40%
- → His Bundle Pacing

Comparison of His Bundle Pacing (HBP) & LBB Pacing

	His Bundle Pacing	LBB Pacing
Implant site	His Bundle	Left Bundle Branch
Implant depth	≤ 1.8mm (screw length)	~ 8-10mm (depending on orientation of lead)
Sensing (Cross talk)	Risk of atrial oversensing Cross talk	No cross talk with atrial signal
Pacing threshold	Higher	Lower (translating into longer battery longevity)
Lead stability	Lower	Higher (low risk of lead dislodgment)
Need for RV backup pacing	+/-	No (only temporary RV backup pacing during implant is suggested for patient with LBBB)
Management of loss of HB/LBB capture	Risk of simultaneous loss of His & RV capture (if too close to atrial side); might need lead revision	Increase pacing output to capture RV
AVN ablation for AF patients	Risk of loss of His Bundle Capture after AVN ablation	Allows AVN ablation without affecting capture threshold
Safety	Lower risk of septal perforation	Higher risk of septal perforation (depending on depth of implant)

Conclusion

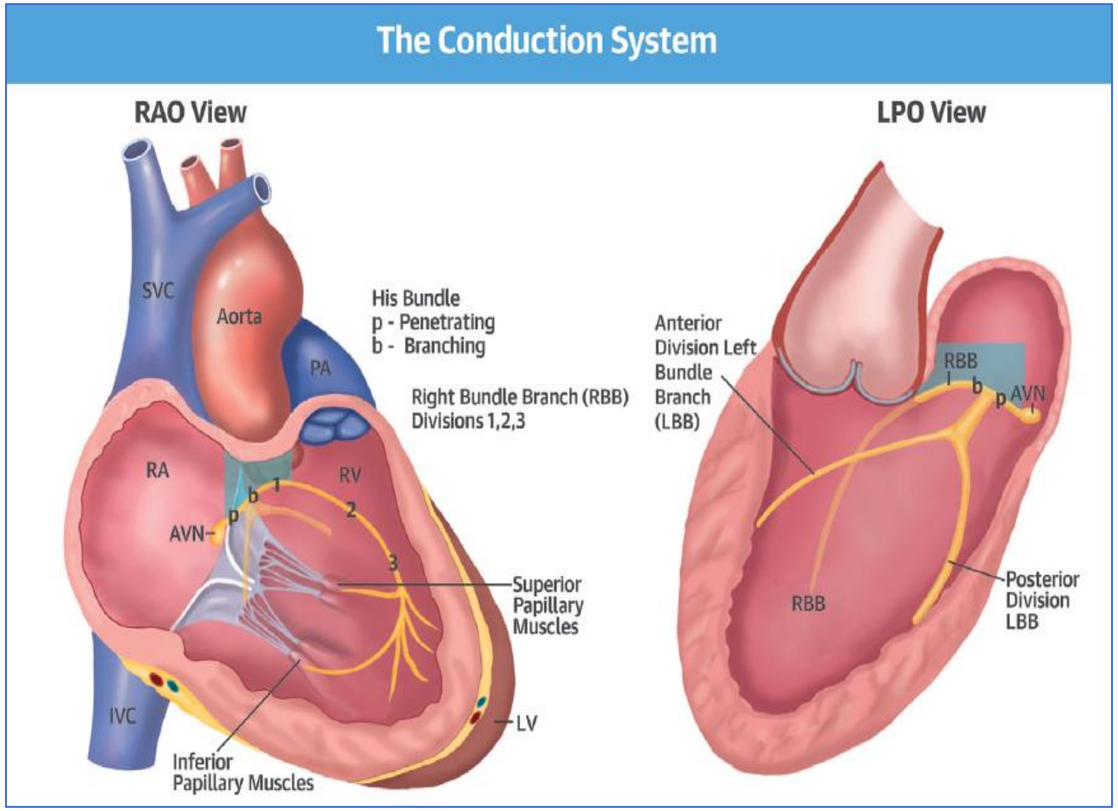
Left bundle branch pacing (LBBP) is a viable physiological pacing alternative to CRT & His Bundle Pacing, in patients with CHF, LV dysfunction, LBBB & high pacing dependence, in improving left ventricular function, electrical and mechanical synchrony, & minimizing pacing induced cardiomyopathy.

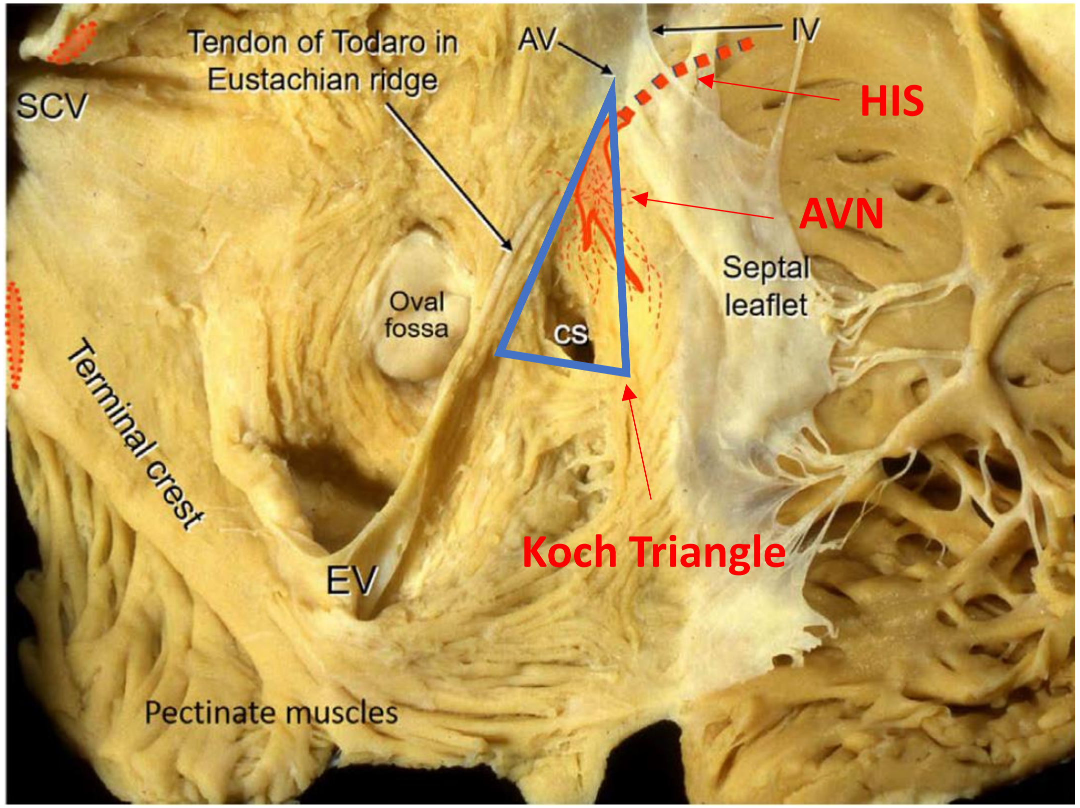
Acknowledgement

- Dr. Zhao Chun Ting
- Dr. Liu Min Ya
- Dr. Jojo Hai

Backup Slides

Cardiac Conduction System Anatomy – His Bundle





Vijayaraman, P. et al. J Am Coll Cardiol. 2018;72(8):927-47.

Circ Arrhythm Electrophysiol. 2019;12:e006897.

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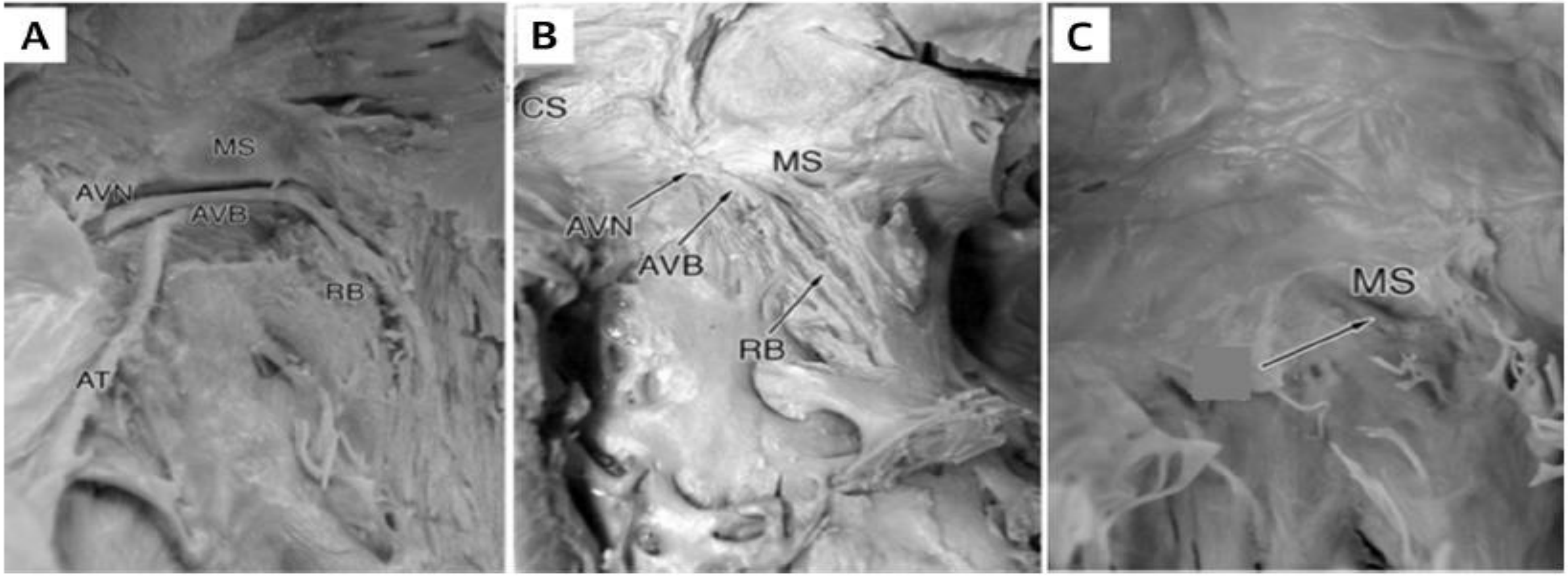
Three Types of Anatomical Variation of His Bundle Anatomy

FIGURE 1 Anatomic Variations of the His Bundle

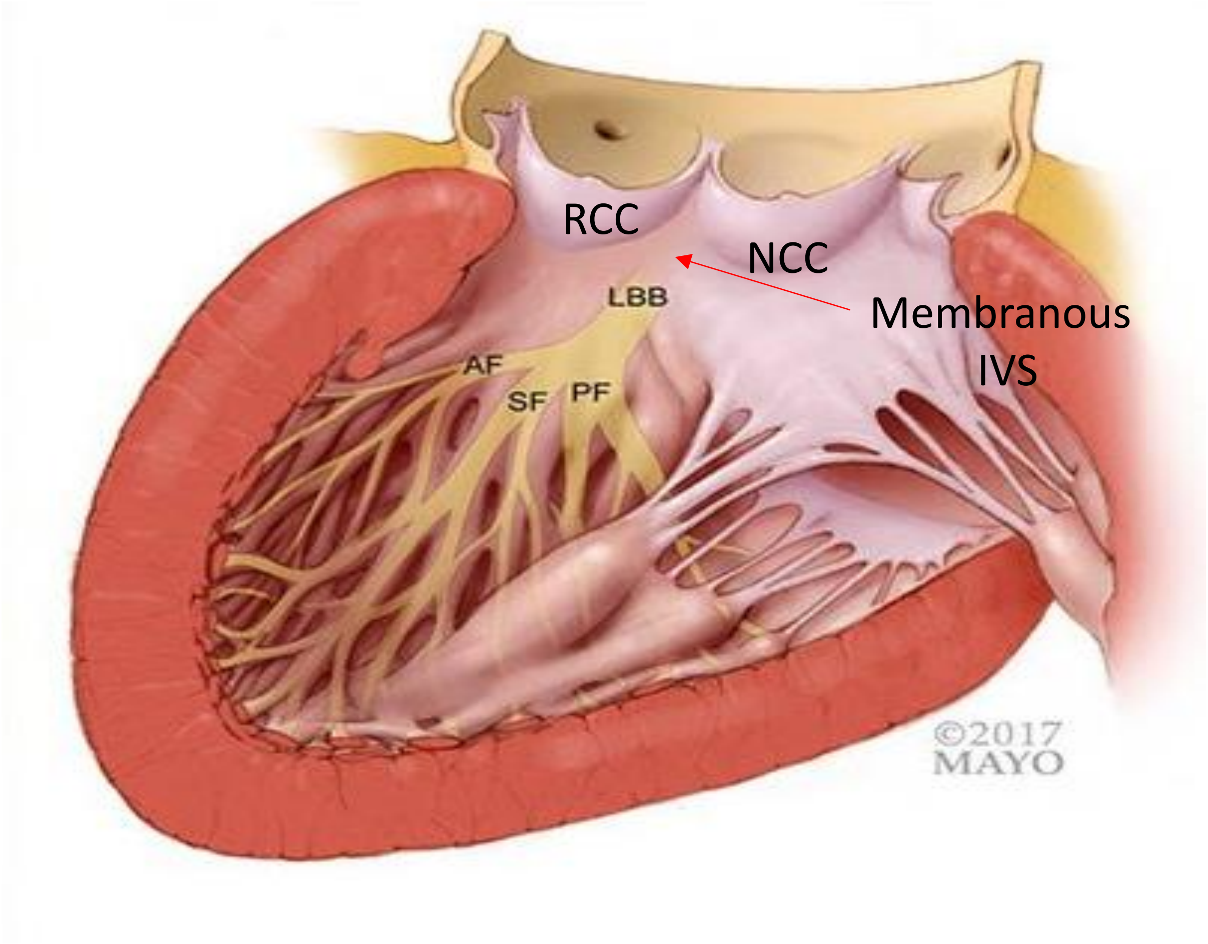
MS = Membranous Septum



Underneath MS | Intramuscular | Beneath Endocardium

J Am Coll Cardiol 2018;72:927 – 47

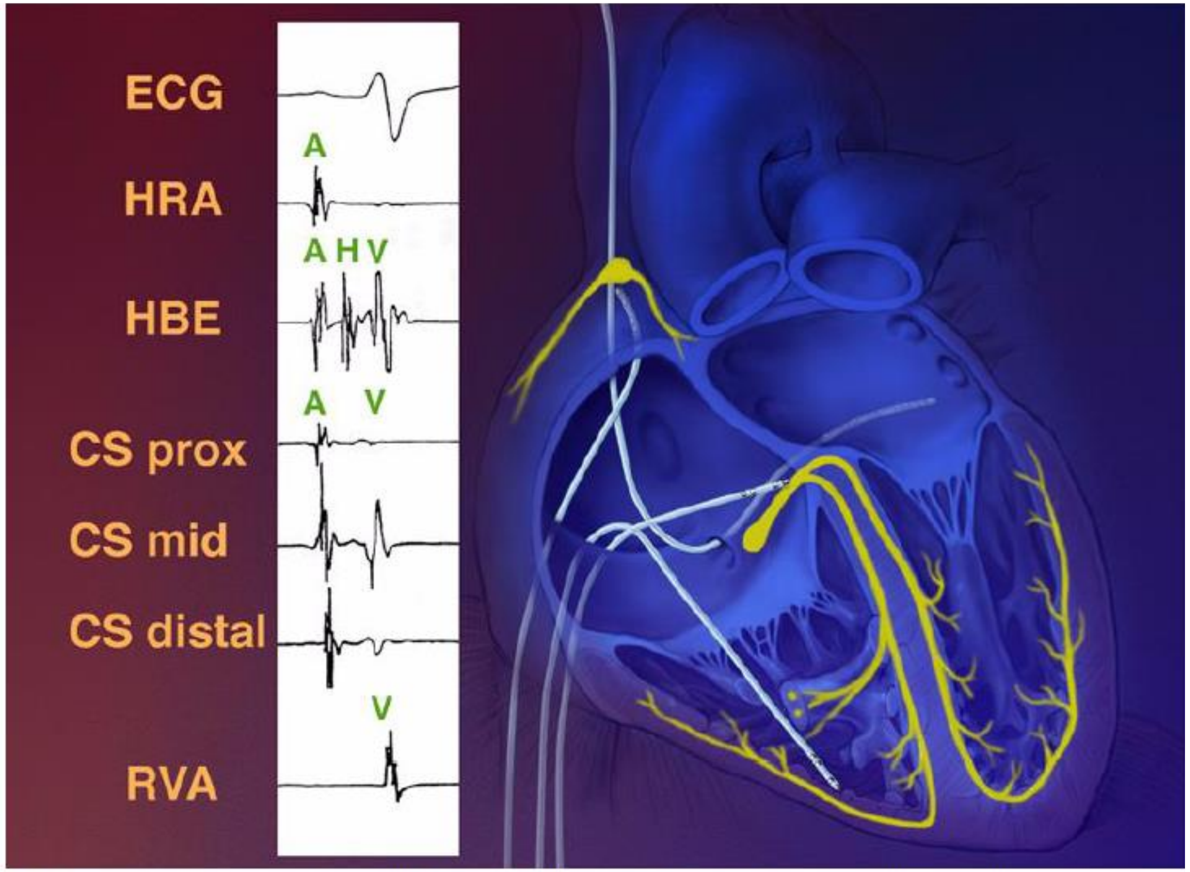
Left Bundle Branch Anatomy



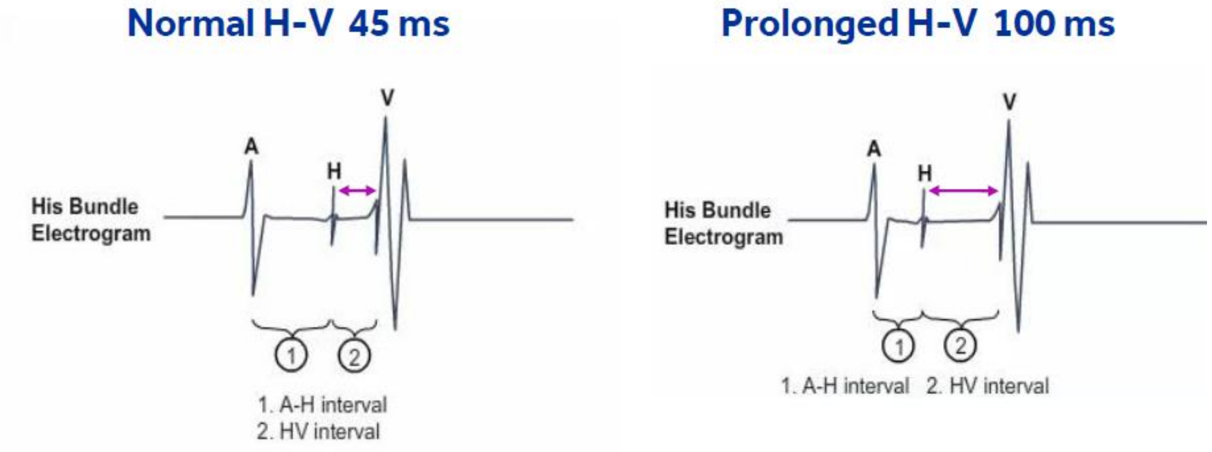
His Bundle arises distal to AVN → runs underneath membranous interventricular septum (IVS) → perforates the membranous IVS beneath the junction of RCC/NCC → gives rise to left bundle branch (LBB), which bifurcates into AF, PF +/- SF

- AF = Anterior Fascicle
- SF = Septal Fascicle
- PF = Posterior Fascicle

Intra-Cardiac Recording: His Bundle Signal



This image is representative of typical catheter placement for an electrophysiology study.

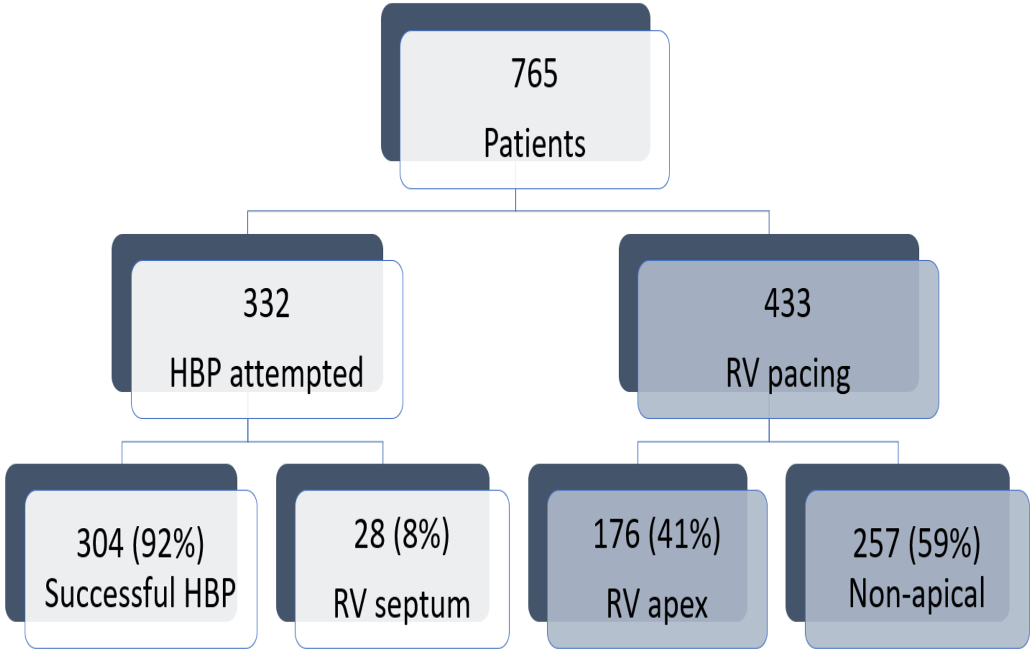


Issa.Z, Miller.J, Zipes.D. *Clinical Arrhythmology and Electrophysiology: A Companion to Braunwald's Heart Disease*. 1st ed. Philadelphia: Saunders/Elsevier; 2009.
Vijayaraman P, Ellenbogen KA. *Hurst's The Heart*. 13th ed. New York: The McGraw-Hill; 2011:1025-1057.
Latcu DG, Saoudi N. *Cardiology*. 3rd ed. Philadelphia: Elsevier; 2010:723-739.

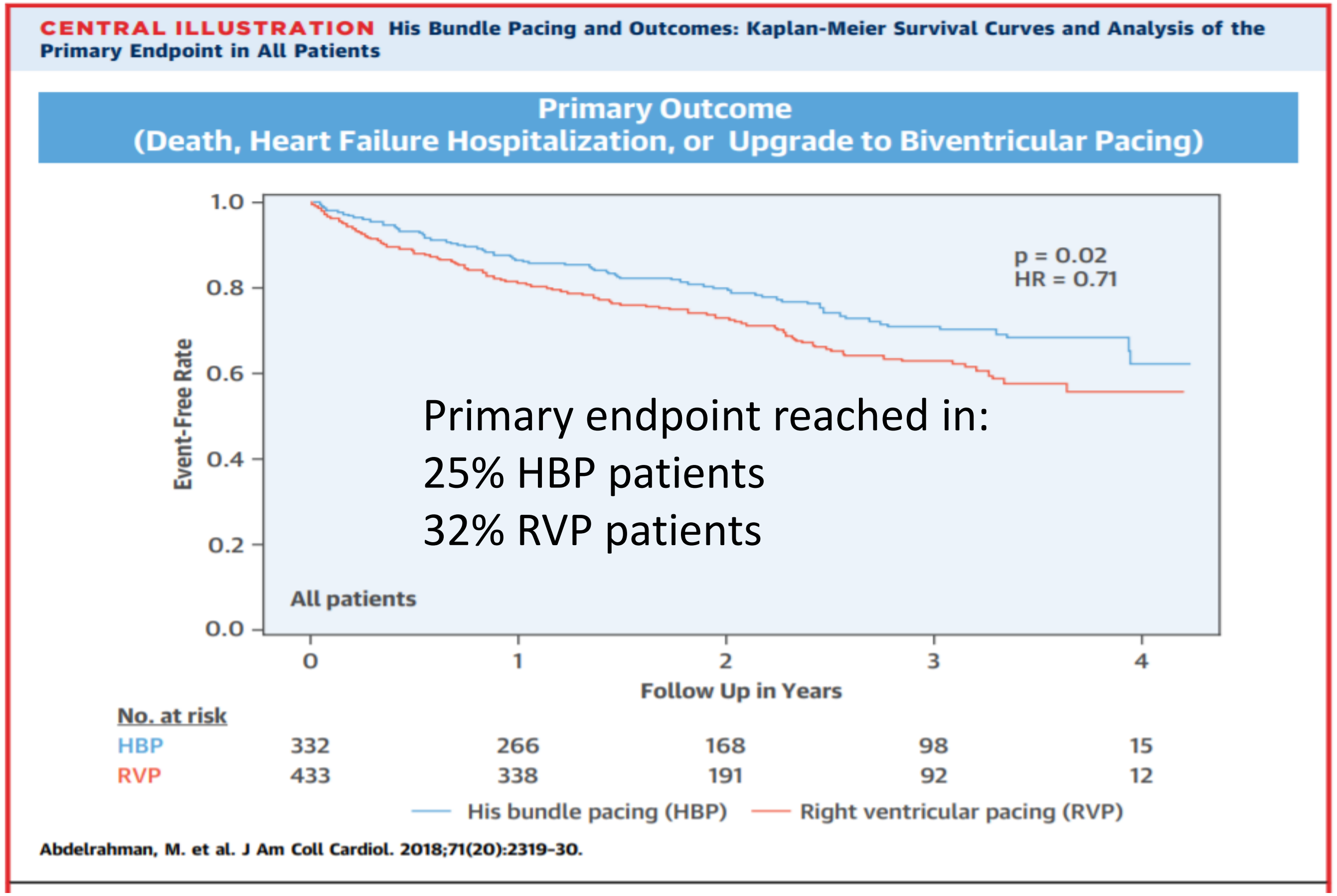
His Bundle Pacing → 30% ↓ Death, CHF Hospitalization or Upgrade to CRT

Benefit primarily seen in patients with RV pacing >20%.

Clinical Outcomes of His Bundle Pacing Compared to Right Ventricular Pacing



- Mean Follow-up duration 725 ±423 days
- HBP = His Bundle Pacing

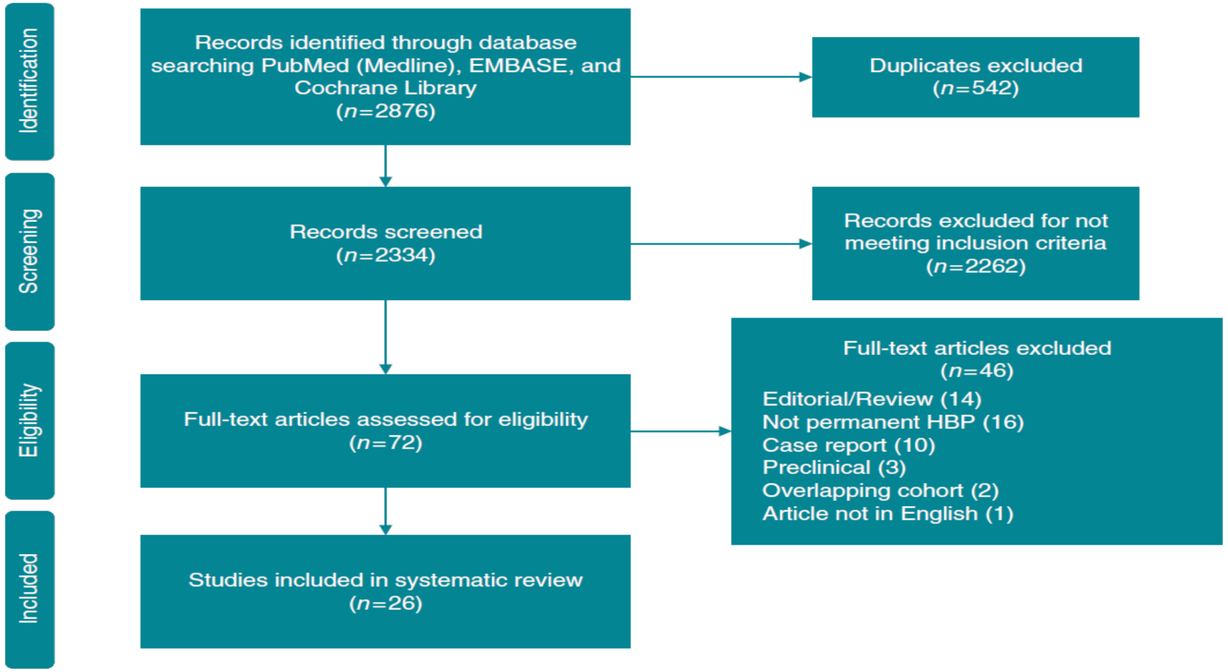


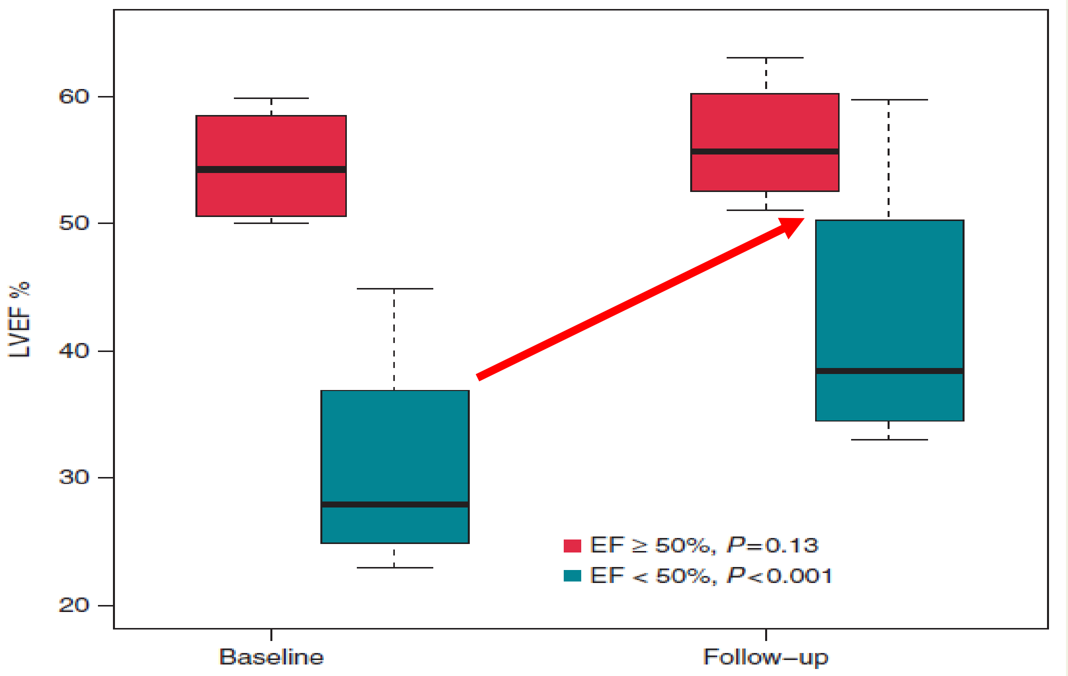
Mortality (HBP 17.2% vs RVP 21.4%. P = 0.06)

His Bundle Pacing Improves Left Ventricular Ejection Fraction

His-Bundle Pacing: ↑ LVEF 5.9% (p=0.001) (42.8% → 49.5%) @ 17months follow-up

Permanent His-bundle pacing: a systematic literature review and meta-analysis





N = 26 Studies (1438 patients). Indication of HBP – 62% for AVB. Implant success 84.8-92.1%.

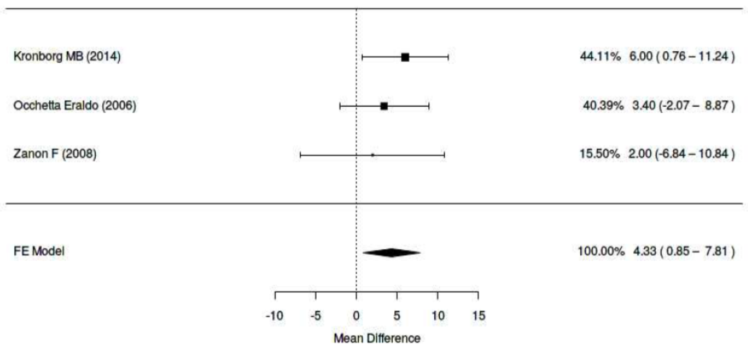
Europace 2018.0;1-8. doi:10.1093/europace/euy058

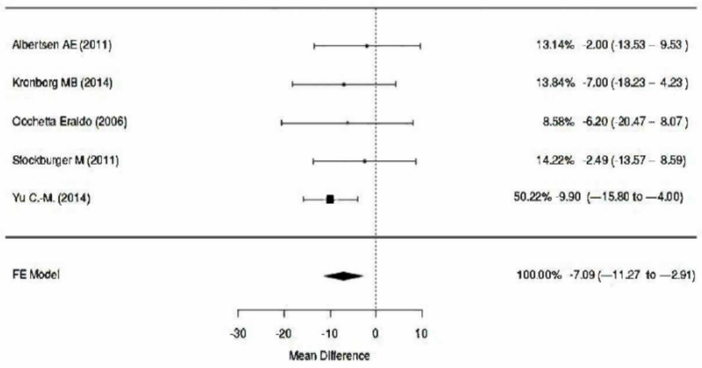
His Bundle Pacing Improves
Left Ventricular Reverse Re-modelling & LVEF

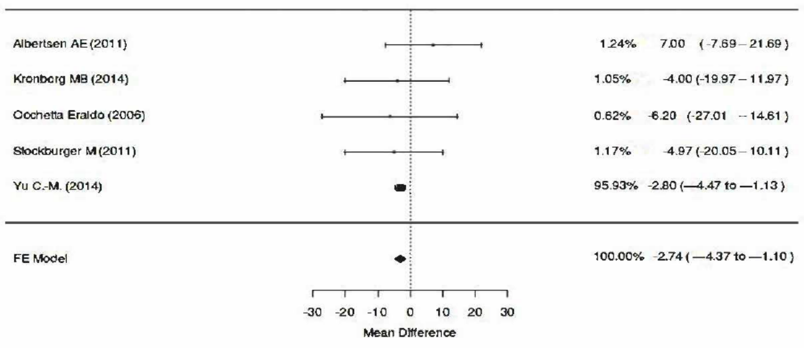
Impact of Physiologic Pacing Versus Right Ventricular Pacing Among Patients With Left Ventricular Ejection Fraction Greater Than 35%

A Systematic Review for the 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay

CRT or HBP → ↓ LVEDV (-2.77ml) & LVESV (-7ml) . Preserved or ↑ LVEF 5.328% @ ~ 1.6y
Patients with LVEF >35% - ≤52% or AVN ablation + Pacemaker →
more likely to benefit from CRT or HBP vs RV pacing.







LVEDV = Left ventricular end diastolic volume
LVESV = Left ventricular end systolic volume

J Am Coll Cardiol. 2019 Aug 20;74(7):988-1

Canadian Journal of Cardiology 33 (2017) 1736.e1−1736.e3 www.onlinecjc.ca

Case Report

A Novel Pacing Strategy With Low and Stable Output: Pacing the Left Bundle Branch Immediately Beyond the Conduction Block

Weijian Huang, MD, FHRS,[a] Lan Su, MD,[a] Shengjie Wu, MD,[a] Lei Xu, MD,[a] Fangyi Xiao, MD,[a] Xiaohong Zhou, MD,[b] and Kenneth A. Ellenbogen, MD, FHRS[c]

[a] *Department of Cardiology, First Affiliated Hospital of Wenzhou Medical University, Key Lab of Cardiovascular Disease of Wenzhou, Wenzhou, China*

[b] *CRHF Division, Medtronic PLC, Mounds View, Minnesota, USA*

[c] *Department of Cardiology, Virginia Commonwealth University Health System, Richmond, Virginia, USA*

The first case report to describe LBB pacing correcting LBBB

Left bundle branch pacing is the best approach to physiological pacing

Santosh K. Padala, MD, Kenneth A. Ellenbogen, MD, FHRS

From the Department of Cardiac Electrophysiology, Virginia Commonwealth University, Richmond, Virginia.

Table 1 Published studies on left bundle branch area pacing

Study (year)	Design	Sample size	Study population	Success rate	Mean paced QRSd (ms)	Mean LVAT (ms)	LBB potential	Follow-up (mo)	Lead complications	Outcomes
Chen et al (2018)	Prospective LBBAP vs RVP	20	SND: 75% AV/infranodal block: 20%	NR	111 ± 10	69 ± 9	55%	3	A/C: None	Stable lead parameters
Zhang et al (2019)	Prospective LBBAP vs RVP	23	SND: 48% AVB: 38%	87%	112 ± 12	NR	NR	NR	A: None C: NR	Acute success rate and pacing characteristics
Hou et al (2019)	Prospective	56	SND: 29% AVB: 37% AF with SVR: 34%	NR	118 ± 11	76 ± 14	67%	4.5	A: 1 lead dislodgment intraoperative C: None	Stable lead parameters LBBAP patients with potential had LV mechanical synchrony similar to that of HBP based on phase analysis of gated SPECT MPI Stable LVEF
Li et al (2019)	Retrospective	33	AVB: 100%	91%	113 ± 11	82 ± 15	26.7%	3	A: 1 LV septal perforation C: None	Stable lead parameters Stable LVEF
Li et al (2019)	Prospective	87	SND: 68% AVB: 32%	80%	113 ± 10	79.7 ± 8.5	66%	3	A/C: None	Stable lead parameters
Vijayaraman et al (2019)	Prospective	100	SND: 23% AVB: 54% AVN ablation: 7% CRT: 11% HBP failure: 7%	93%	136 ± 17	75 ± 16	63%	3	A: 3 lead dislodgments within 24 h requiring revision; 3 LV septal perforations C: None	Stable lead parameters
Zhang et al (2019)	Prospective	11	HF with reduced EF and LBBB: 100%	NR	129 ± 16	80.9 ± 9.95	0%	6.7	A/C: None	Stable lead parameters Improvement in LVEF by >5% from baseline in all, >20% from baseline in 7 patients Improvement in LV synchrony by pulsed-wave Doppler and tissue synchronization imaging

Heart Rhythm Open Access 2020;1:59–67

PERSPECTIVES IN CONTRAST

Left bundle branch pacing is the best approach to physiological pacing

Santosh K. Padala, MD, Kenneth A. Ellenbogen, MD, FHRS

From the Department of Cardiac Electrophysiology, Virginia Commonwealth University, Richmond, Virginia.

Hasumi et al (2019)	Retrospective	21	Advanced AVB: 100% Failed HBP	81%	116 ± 8.3	NR	NR	6	A/C: None	Stable lead parameters
Cai et al (2020)	Prospective Observational LBBAP vs RVP	40	SND: 100%	90%	101 ± 8.79	LBBAP with normal axis: 59 ± 6; left-axis deviation: 64 ± 4.5	80%	Echocardiogram on day 3	NR	LBBAP preserved mechanical synchrony similar to native conduction LBBAP leads to favorable hemodynamic effects RVP resulted in electrical and mechanical dyssynchrony and worse hemodynamic effects
Jiang et al (2020)	Retrospective	73	BBB with QRSd >130 ms Atypical BBB:13.6% 5 LBBB and 5 RBBB Typical BBB: 86.4% 30 LBBB and 33 RBBB	30% 82.5%	133 ± 14 118 ± 14	103 ± 23 85 ± 15	10% 28.6%	NR	A: 4 LV septal perforations C: None	Typical BBB morphology (Strauss criteria) predicts successful QRS correction with LBBAP
Wang et al (2020)	Prospective Randomized LBBAP vs RVP	66	SND: 32% AVB: 54% AF with SVR: 14%	94%	121 ± 9.8	67.8 ± 6.8	75%	6	A: 1 lead perforation at 1 month requiring revision C: 2 lead dislodgments (1 at 2 mo, 1 at 4 mo)	Stable lead parameters LBBAP resulted in narrower QRSd, shorter QT and QTc interval, lower QTD and QTcD shorter $T_{peak\text{-}end}$ interval compared with RVP, suggesting better depolarization-repolarization reserve
Total		530							6 lead dislodgments 9 septal perforations	

A = acute; AF with SVR = atrial fibrillation with slow ventricular rate; AV = atrioventricular; AVN = atrioventricular node; AVB = atrioventricular block; BBB = bundle branch block; C = chronic; CRT = cardiac resynchronization therapy; EF = ejection fraction; HBP = His-bundle pacing; HF = heart failure; LBB = left bundle branch; LBBAP = left bundle branch area pacing; LBBB = left bundle branch block; LV = left ventricle; LVAT = left ventricular activation time; LVEF = left ventricular ejection fraction; NR = not reported; QTc = corrected QT interval; QTD = QT dispersion; QTcD = corrected QT dispersion; RBBB = right bundle branch block; RVP = right ventricular pacing; SND = sinus node dysfunction; SPECT MPI = single photon emission computed tomography myocardial perfusion imaging.

Heart Rhythm Open Access 2020;1:59–67

Left bundle branch pacing for symptomatic bradycardia: Implant success rate, safety, and pacing characteristics

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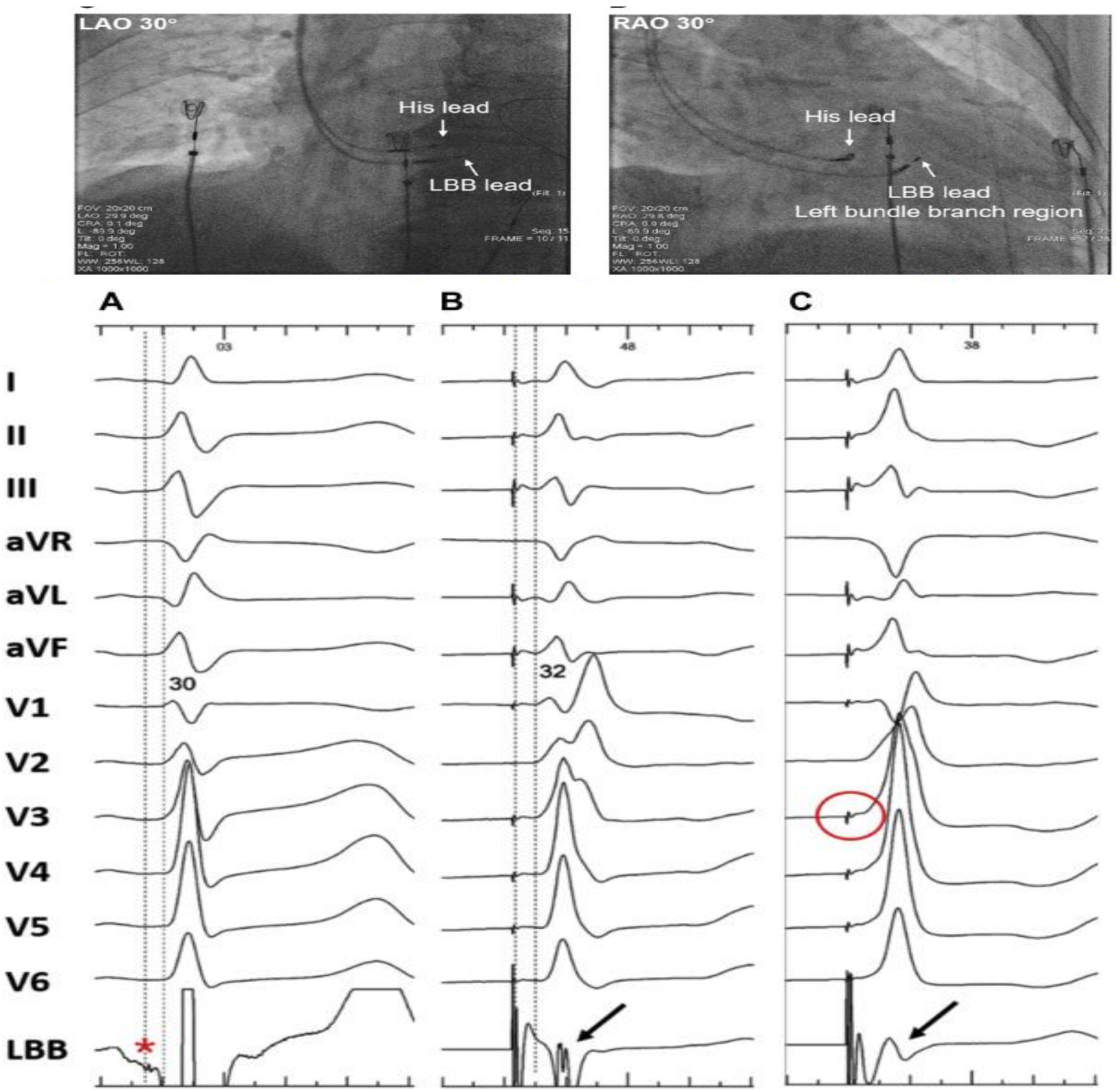


- N = 87 patients (AVB 32.2%. SND 67.8%)
- LBB Pacing implant success 80.5%
- LBBP produced narrower QRS than RV septal pacing (113.2 ± 9.9 ms vs 144.4 ± 12.8 ms; P <0.001).
- The pacing threshold was low (0.76 ± 0.22 V at implantation and 0.71 ± 0.23 V at 3 months), with no loss of capture or lead dislodgment observed.
- No major implantation-related complications

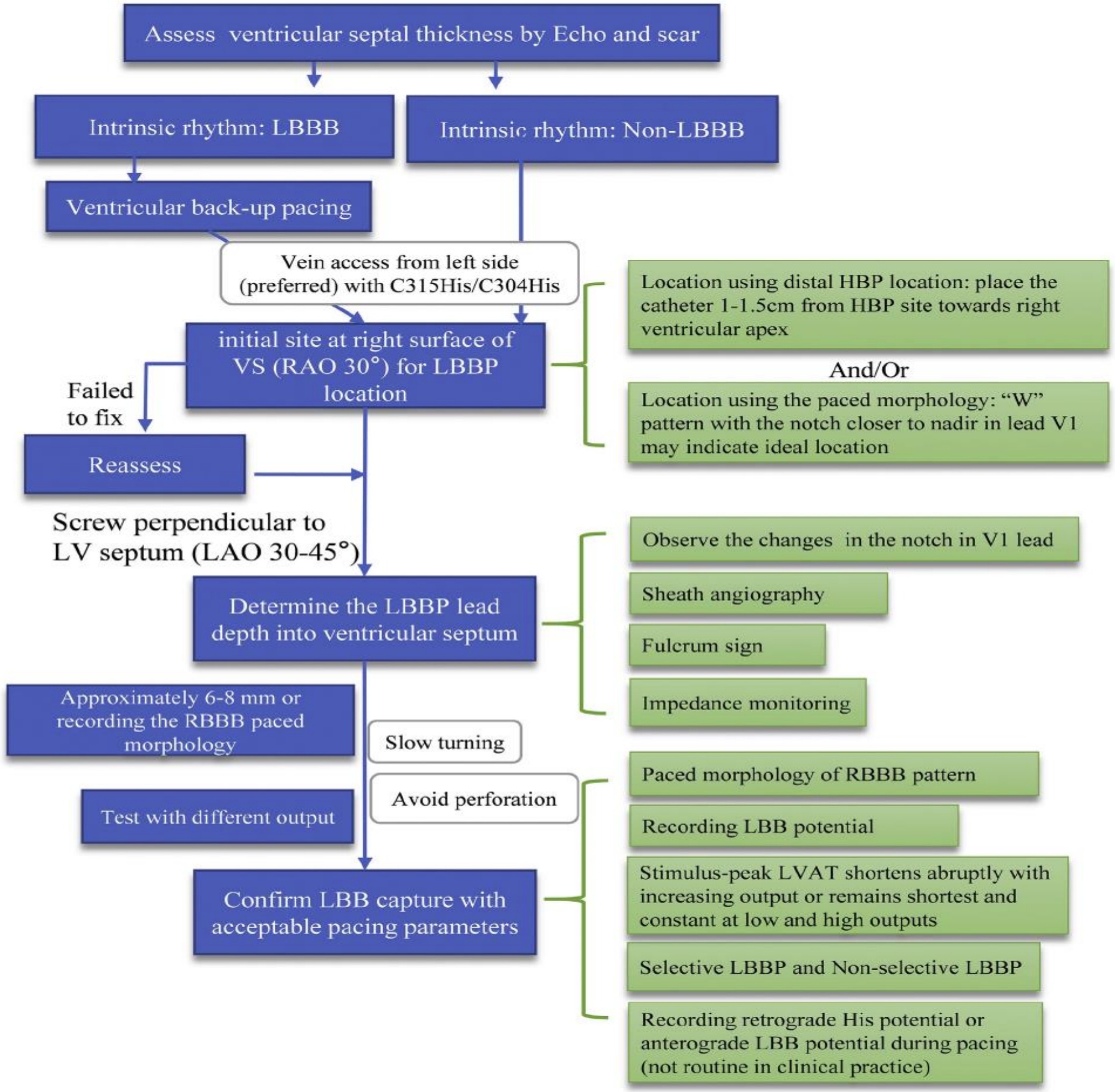
Y Li..., M Gold, S Zhang et al. Heart Rhythm. 2019 Dec;16(12):1758-1765.

HANDS ON

A beginner's guide to permanent left bundle branch pacing

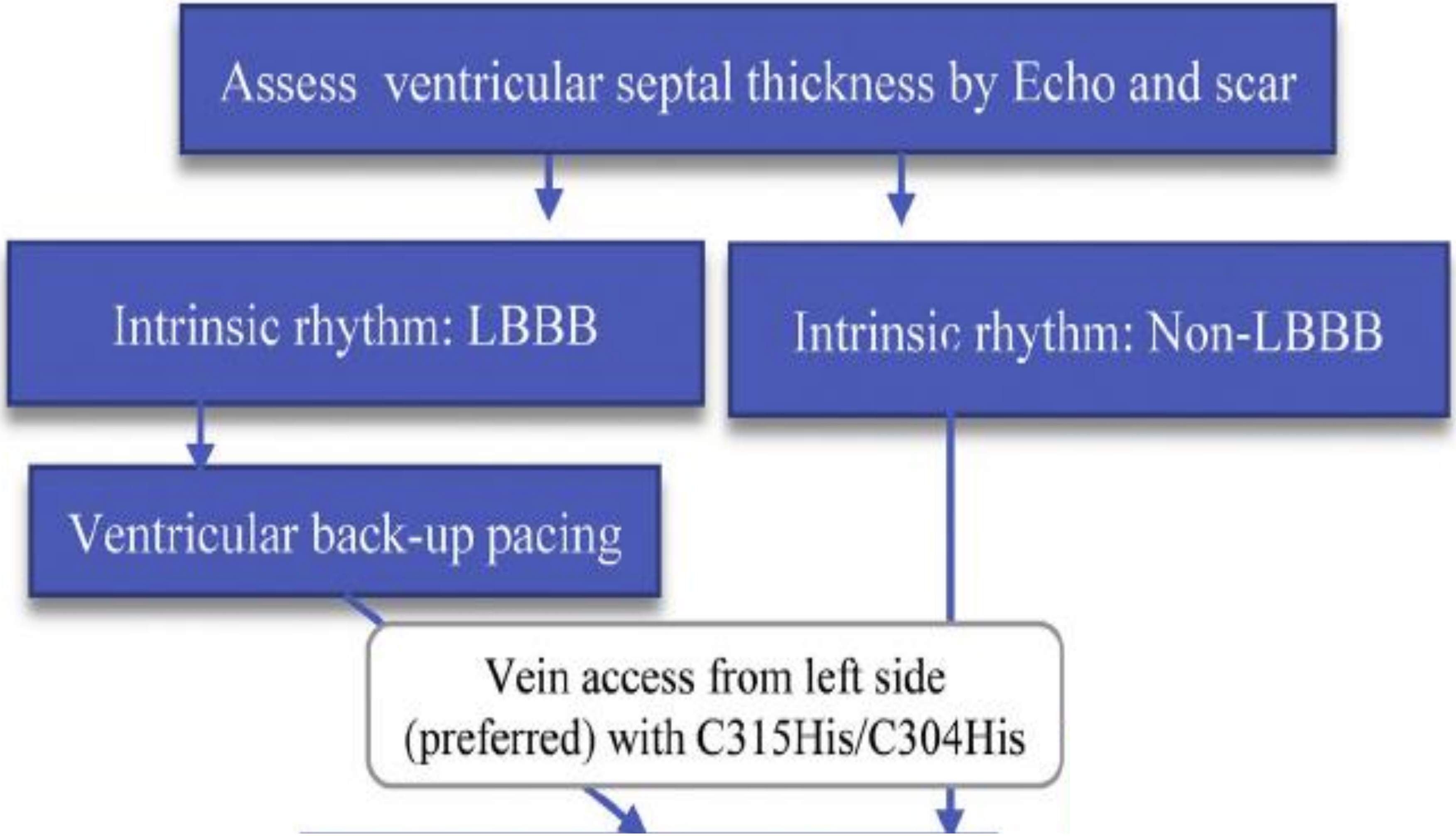
Weijian Huang, MD, FHRS,*† Xueying Chen, MD, PhD,‡ Lan Su, MD,*† Shengjie Wu, MD,*† Xue Xia, MD,*† Pugazhendhi Vijayaraman, MD, FHRS§

PRO-CARE 心滙 Heart Clinic 心臟專科診所



Heart Rhythm 2019;16:1791–1796

LBB Pacing: Step 1 (Venous Access)



Heart Rhythm 2019;16:1791–1796

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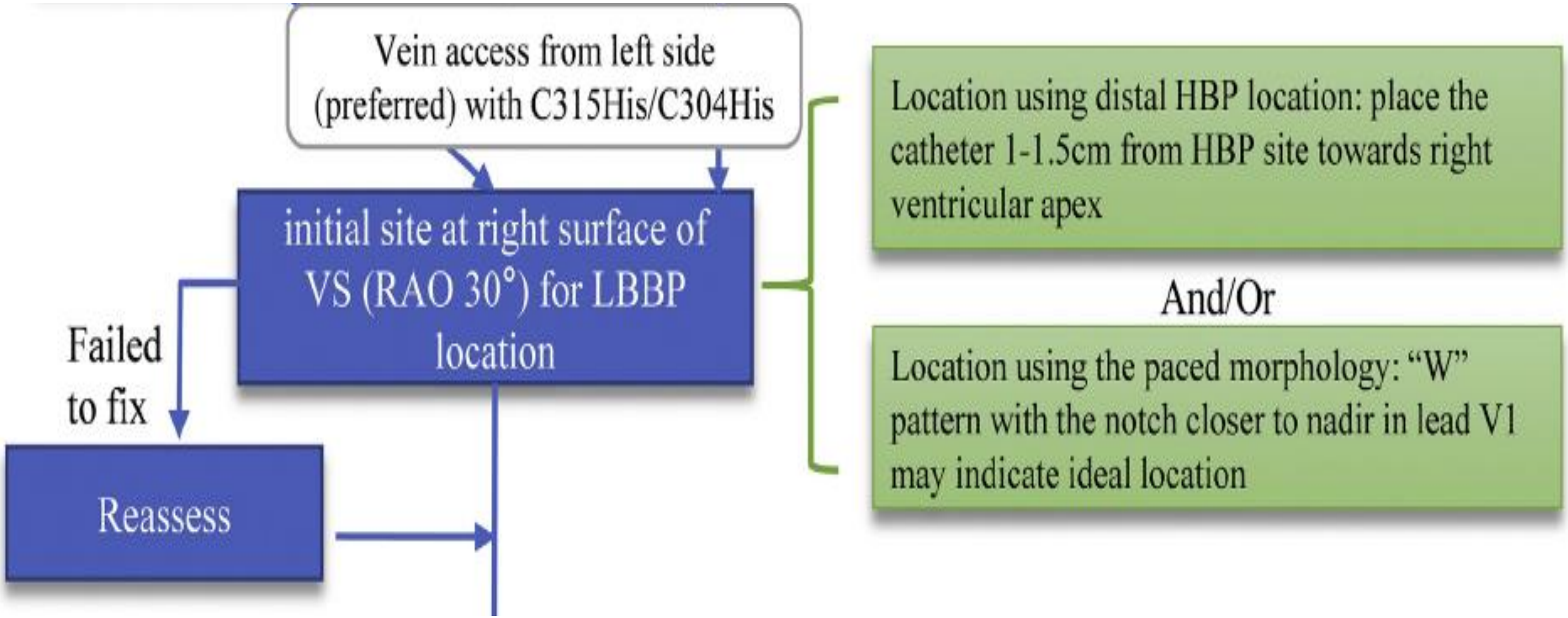
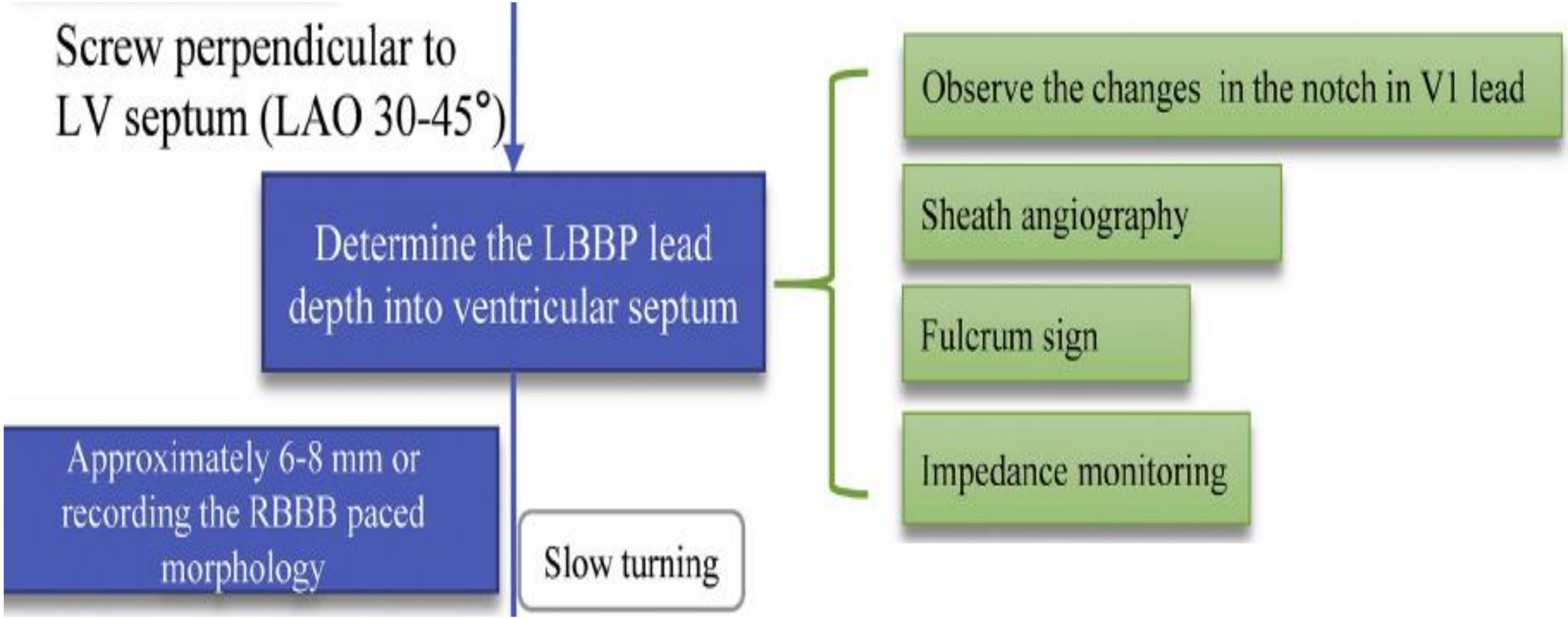
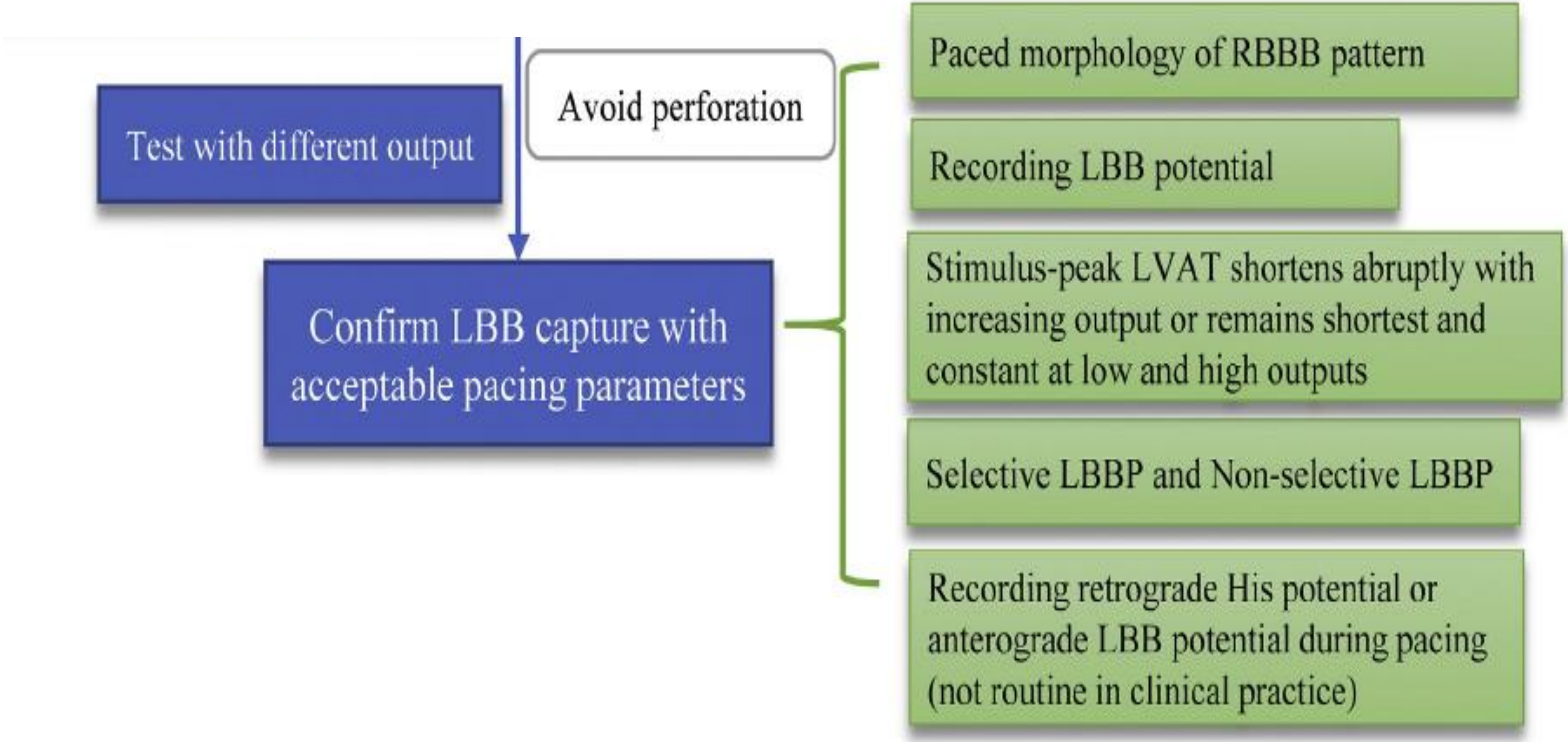
LBB Pacing: Step 2 (Locating the His & LBB)



LBB Pacing: Step 3
(Determining the Depth of Lead Implant)



LBB Pacing: Step 4
(Threshold Testing & Confirmation of LBB Capture)

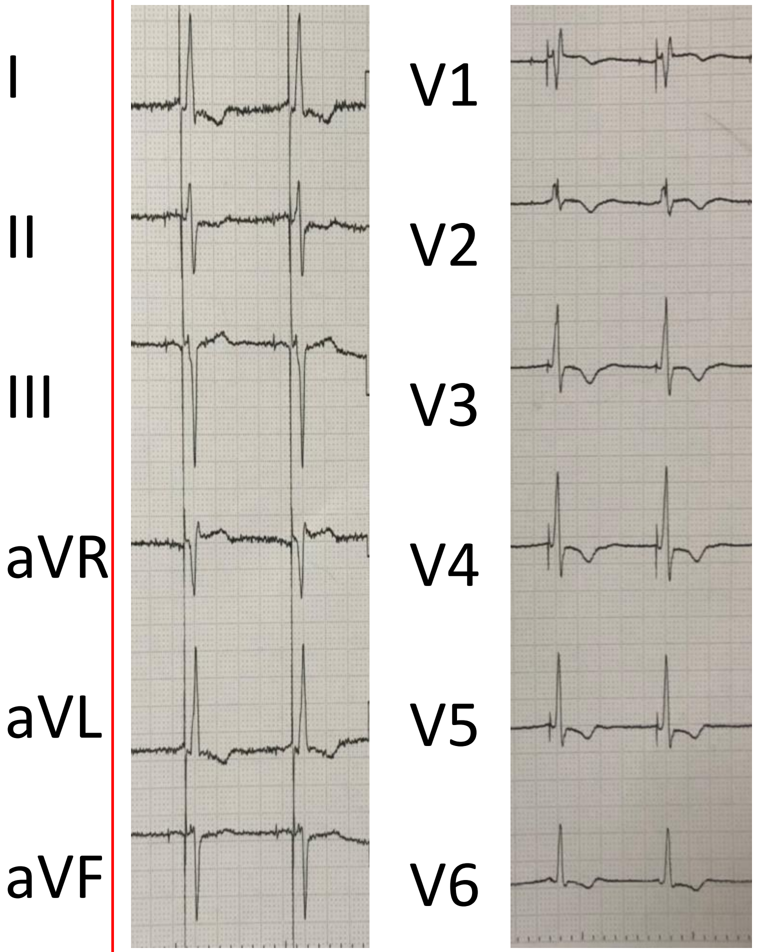


Determining the Depth of Lead Implant When to Stop Screwing ?

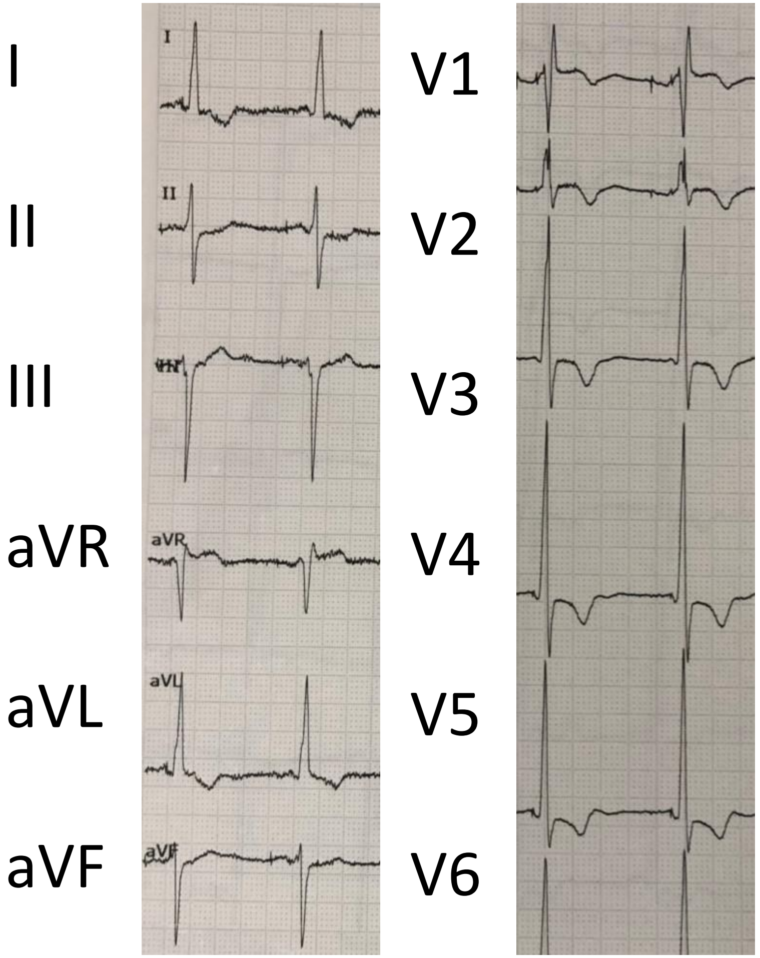
- Continuously monitor the following parameters every 3-5 turns of lead rotation:
- Electrically
  - V1 morphology changed from LBBB → RBBB; with QRS narrowing
  - LVAT (Pacing stimuli to peak of R wave in V5-6) ≤ 80-90ms
  - Constant LBB capture morphology & short/constant LVAT at high & low output
  - LBBB potential detected in pacing lead
  - Unipolar impedance ≤ 500-600 ohms
- Anatomically
  - Lead depth ≥ 8-10mm

Programming: LBB Pacing in Unipolar / Bipolar mode at various output
Choose the lowest output with narrowest QRS

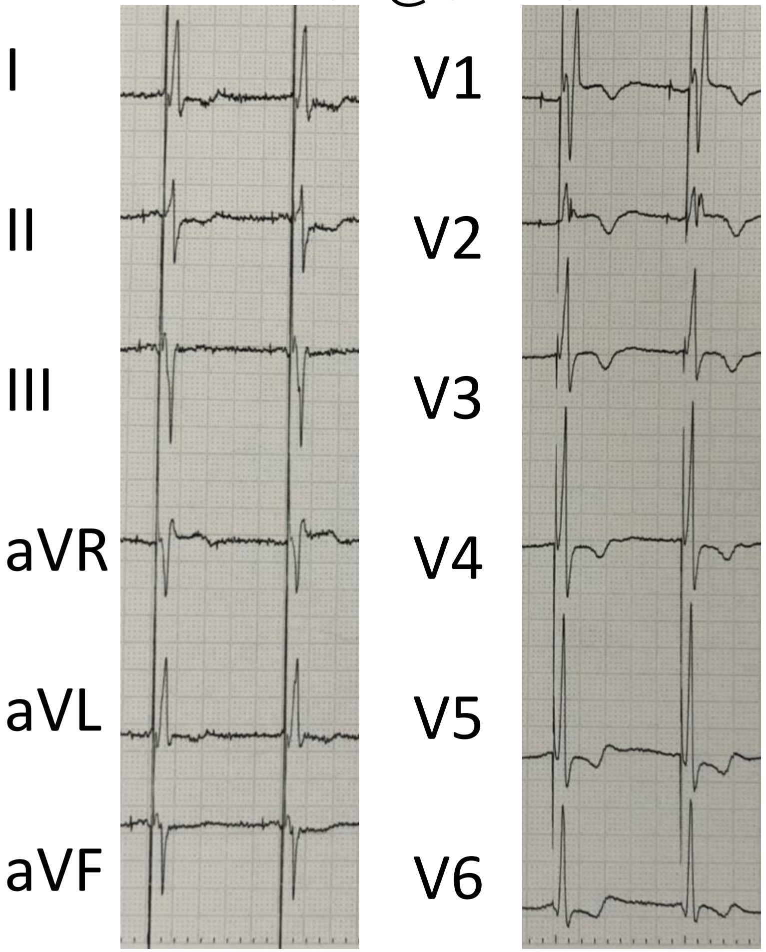
AV 150/130ms
2.5V@0.4ms



AV 150/130ms
2.5V@0.4ms



AV 130/150ms
7.5V@0.4ms



Programming – Choose the optimal AV delay with narrowest QRS
LBB Pacing at various AV interval at constant output