CSP en 2025 : tips and tricks pour les cas difficiles

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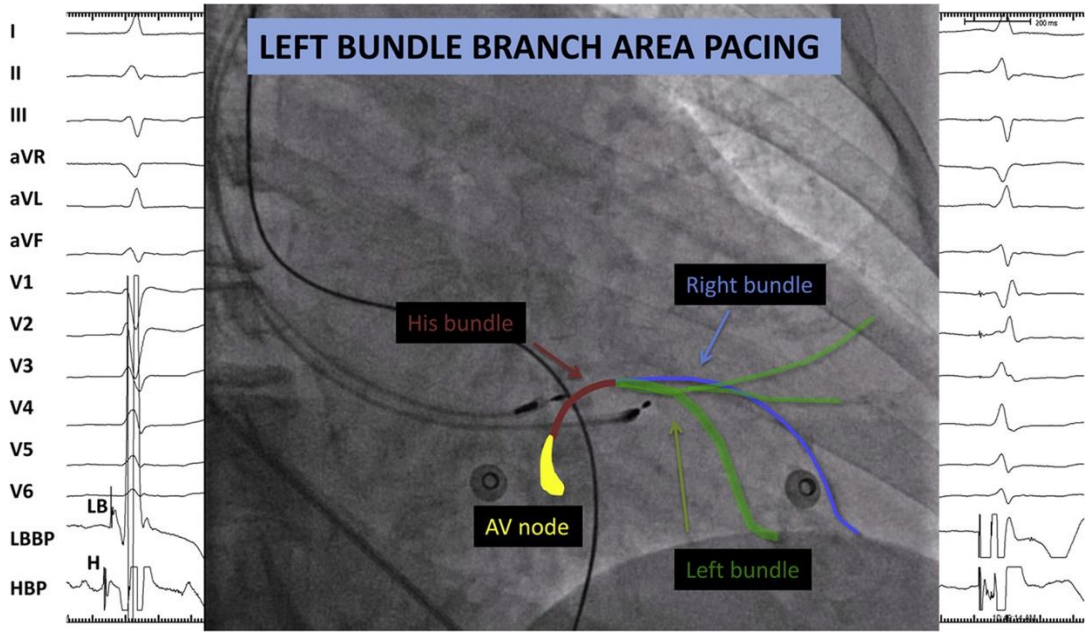
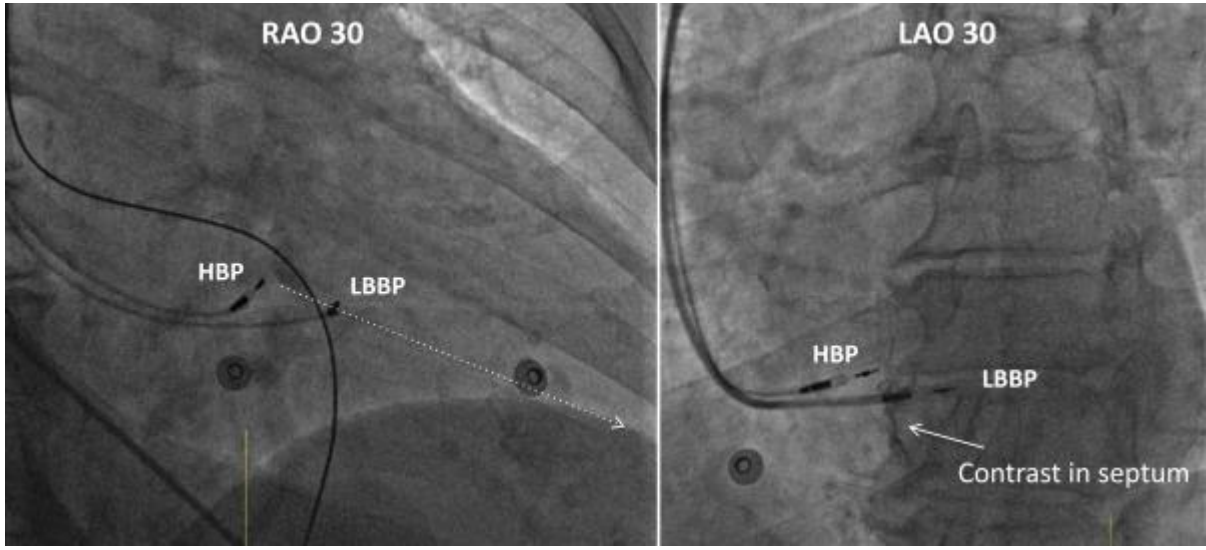
LBBAP concept





Vijayaraman, *Heart Rhythm*, 2019

CSP concept and definitions

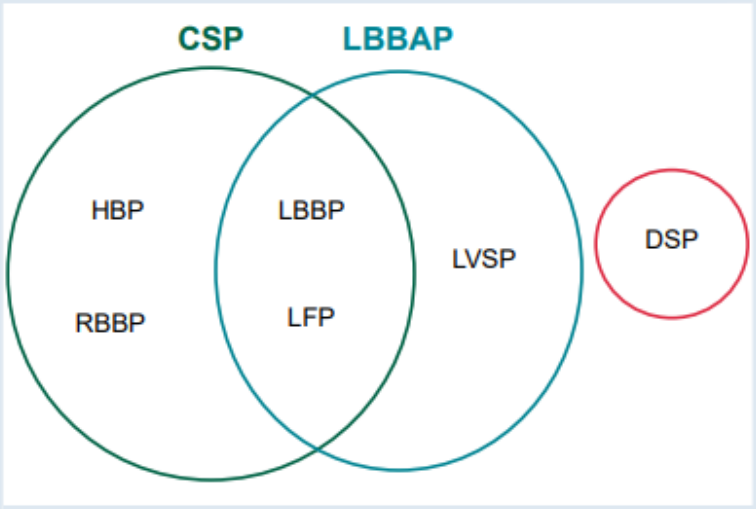
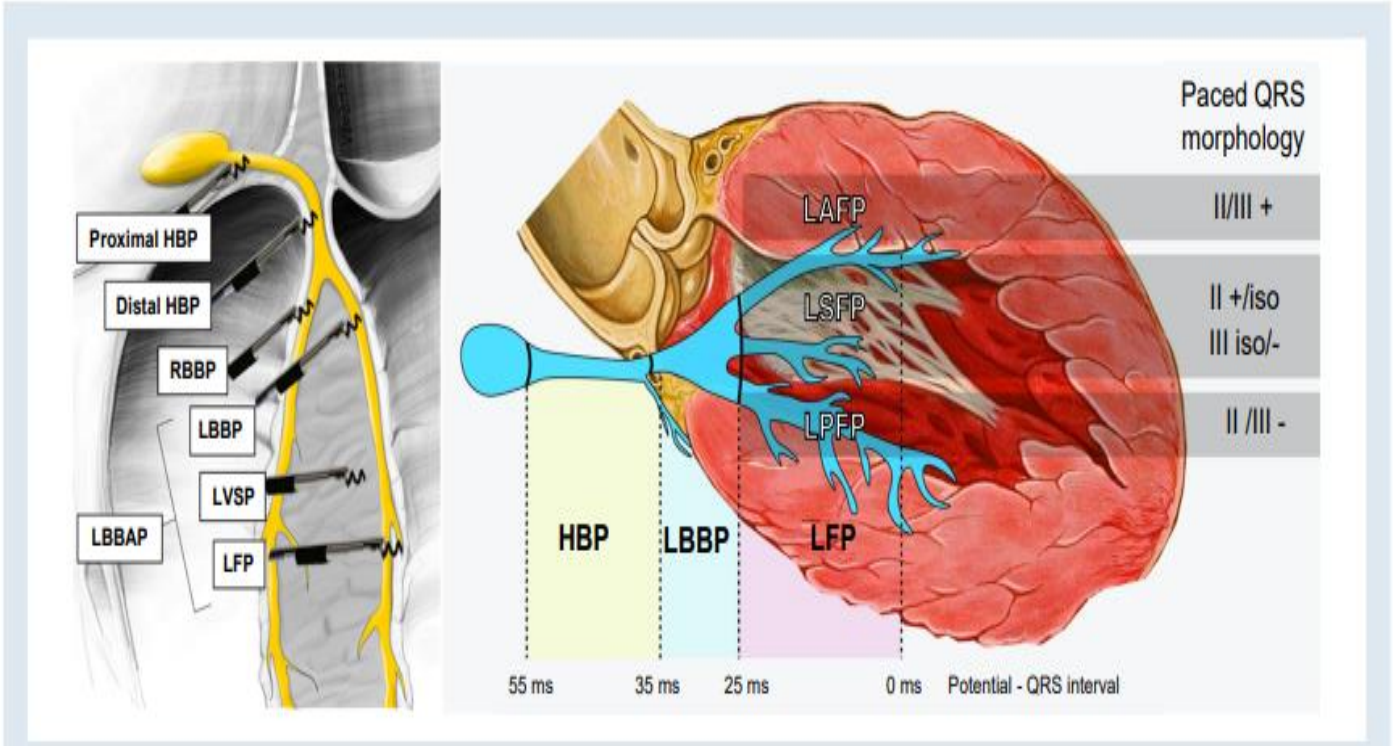
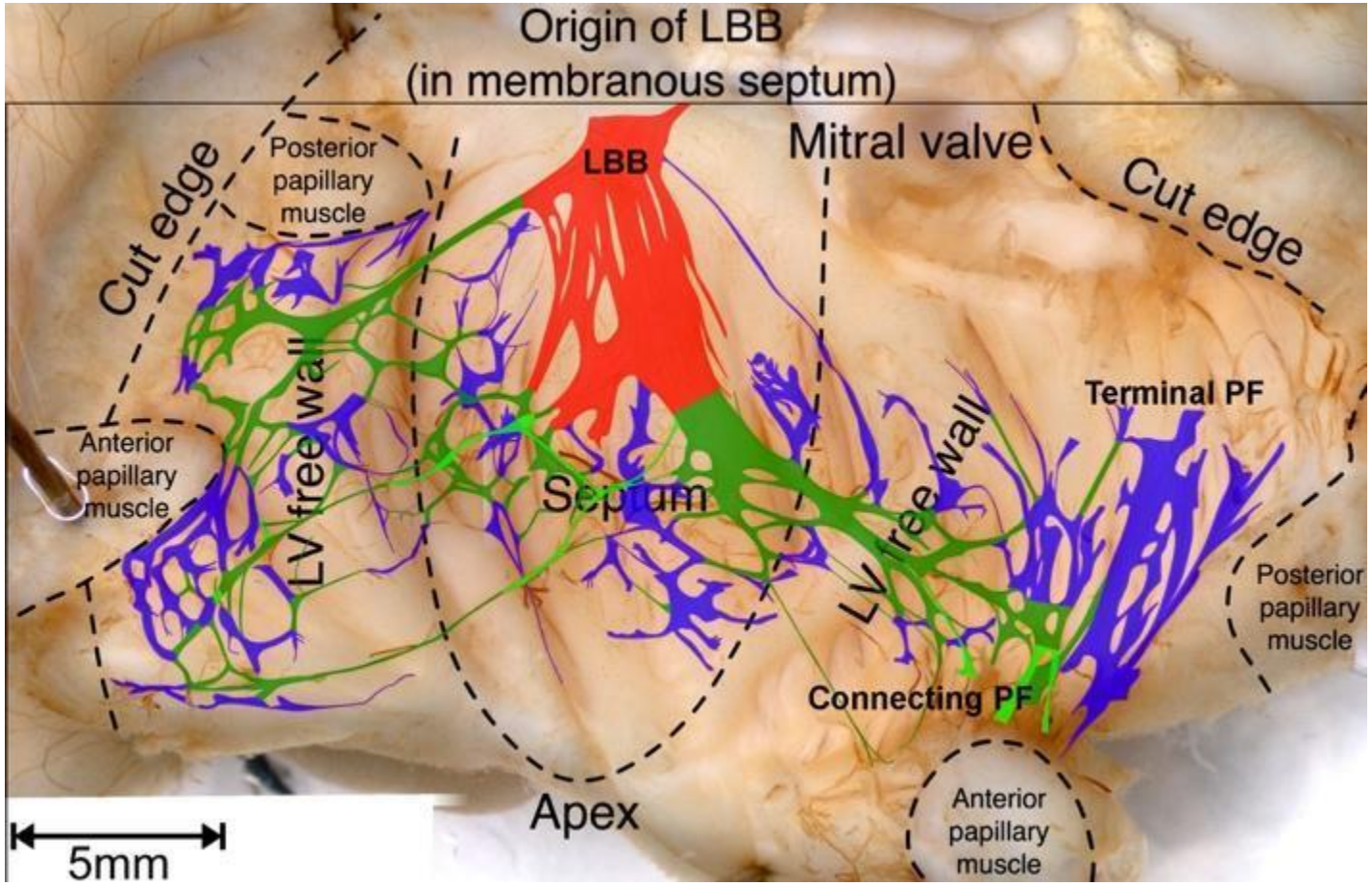


Figure 2 Synopsis of different entities of CSP and related forms of stimulation. CSP = conduction system pacing; DSP = deep septal pacing; HBP = His bundle pacing; LBBAP = left bundle branch area pacing; LBPP = left bundle branch pacing; LFP = left fascicular pacing; LVSP = left ventricular septal pacing; RBBP = right bundle branch pacing.



Burri et al, *Europace*, 2023

The left bundle area



Belgian registry

	SDL-LBBAP *n* = 353
Implant success	334 (95)
Procedural characteristics	
Screw attempts, *n*	2.2 ± 1.9
Implant depth, mm	13 ± 2
Procedural time, min	60 [60–80]
Total fluoroscopy time, min	7 [4–11]
Electrophysiological characteristics	
Paced QRS duration, ms	126 ± 21
Stimulus to LVAT, ms	74 ± 17
LBB potential, *n* (%)	48 (14)
LBBAP capture type	
NS-LBBP, *n* (%)	192 (57)
S-LBBP, *n* (%)	52 (16)
LVSP, *n* (%)	90 (27)
Pacing characteristics at implant	
Unipolar pacing threshold at 0.4 ms, V	0.6 ± 0.4
Bipolar pacing threshold at 0.4 ms, V	0.9 ± 1.7
Unipolar R wave amplitude, mV	10 ± 5
Bipolar R wave amplitude, mV	11 ± 5
Unipolar impedance, ohms	441 ± 106
Bipolar impedance, ohms	607 ± 94

Pacing characteristic	Implant	1 Month	6 Months	12 Months	*p* value
Number of patients, *n*	353	349	259	67	
Pacing threshold at 0.4 ms, V	0.6 ± 0.4	0.6 ± 0.2	0.7 ± 0.2	0.7 ± 0.3	.291
R-wave sensing, mV	11 ± 5	12 ± 5	12 ± 5	13 ± 6	.061
Unipolar impedance, Ohms	441 ± 106	399 ± 90	384 ± 74	397 ± 75	.115

Received: 21 February 2022 | Revised: 10 May 2022 | Accepted: 19 May 2022

DOI: 10.1111/jce.15558

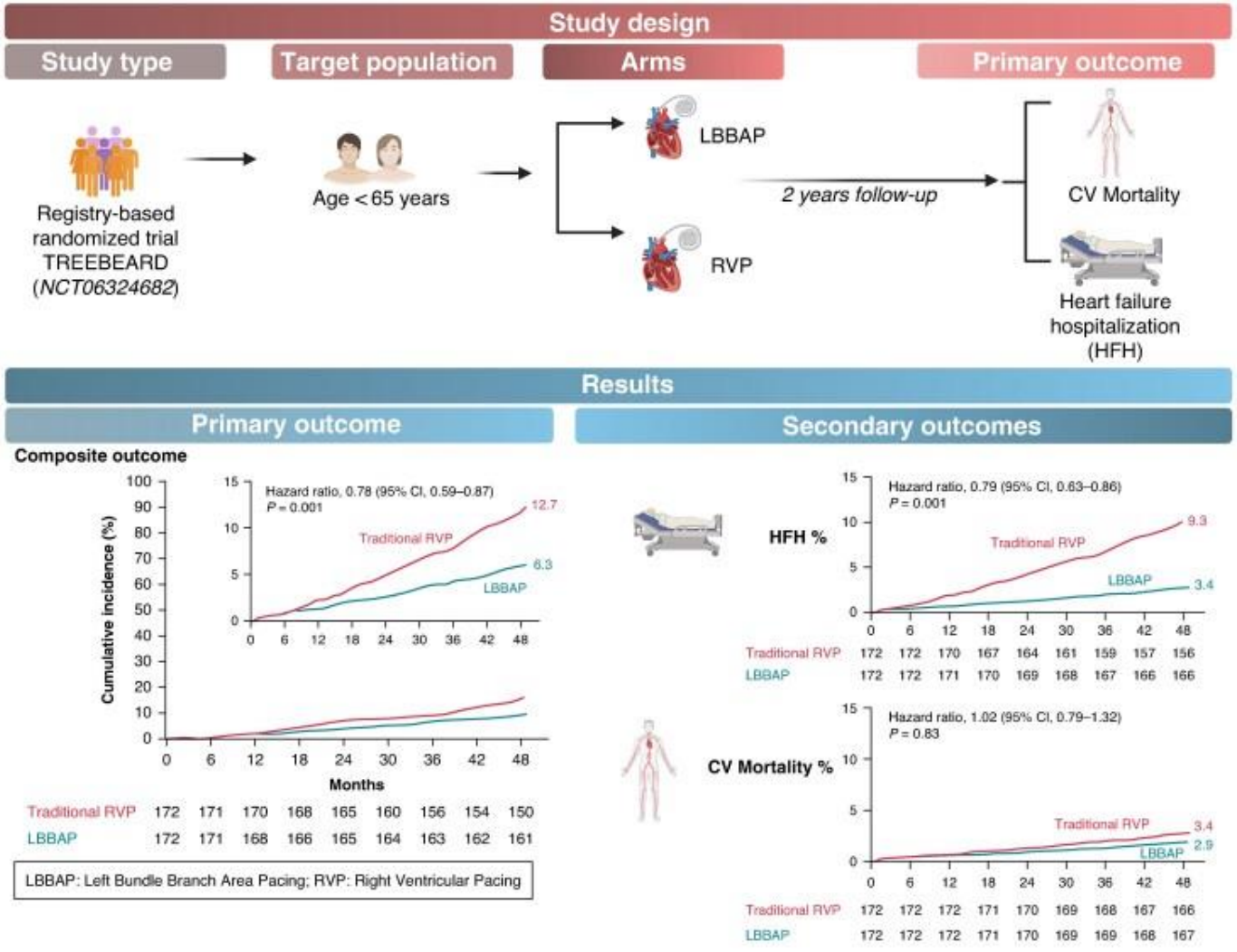
ORIGINAL ARTICLE

WILEY

Initial experience of left bundle branch area pacing using stylet-driven pacing leads: A multicenter study

Jan De Pooter MD, PhD[1] | Emine Ozpak MD[1] | Simon Calle MD[1] | Peter Peytchev MD[2] | Ward Heggermont MD, PhD[2] | Sebastien Marchandise MD[3] | Frank Provenier MD, PhD[4] | Bart Francois MD[4] | Wim Anné MD, PhD[5] | Peter Pollet MD, PhD[5] | Cynthia Barbraud MD[6] | Kris Gillis MD, PhD[7] | Frank Timmermans MD, PhD[1] | Frederic Van Heuverswyn MD[1] | Roderick Tung MD[8] | Aurélien Wauters MD, PhD[3,9] | Jean-Benoit le Polain de Waroux MD, PhD[7]

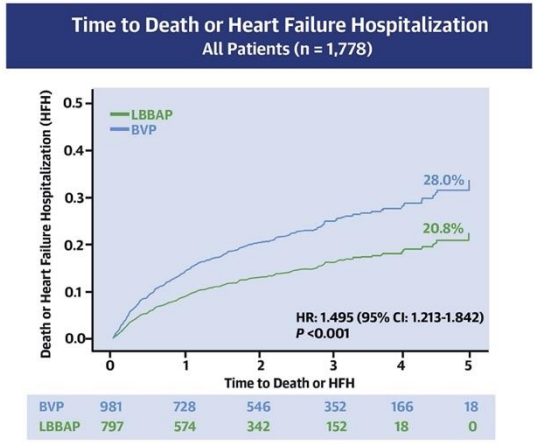
CSP in young adults



Bertini et al, *Europace*, 2025

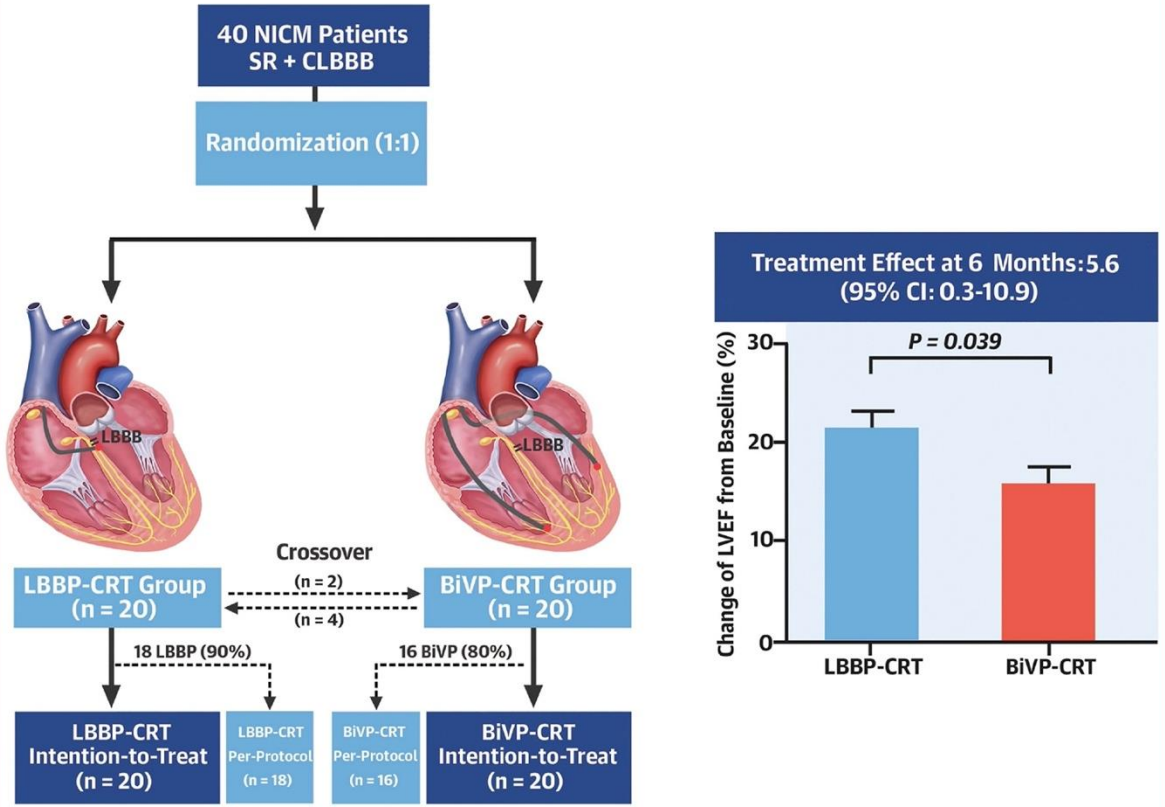
LBBAP vs BVP

CENTRAL ILLUSTRATION: Death or Heart Failure Hospitalization



Vijayaraman P, et al. J Am Coll Cardiol. 2023;82(3):228-241.

CENTRAL ILLUSTRATION: Left Bundle Branch Pacing vs Biventricular Pacing for cardiac Resynchronization Therapy



Wang Y, et al. J Am Coll Cardiol. 2022;80(13):1205-1216.

LBBAP vs BVP

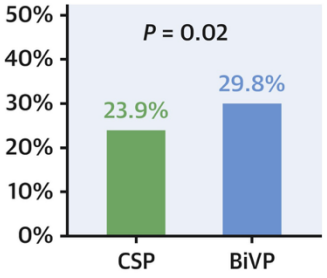
CENTRAL ILLUSTRATION: Primary and Secondary Endpoints of the CONSYST-CRT Trial (Intention-to-Treat)

CONSYST-CRT Trial

Noninferiority of CSP Compared to BiVP at 12-Month Follow-Up:

Primary Endpoint

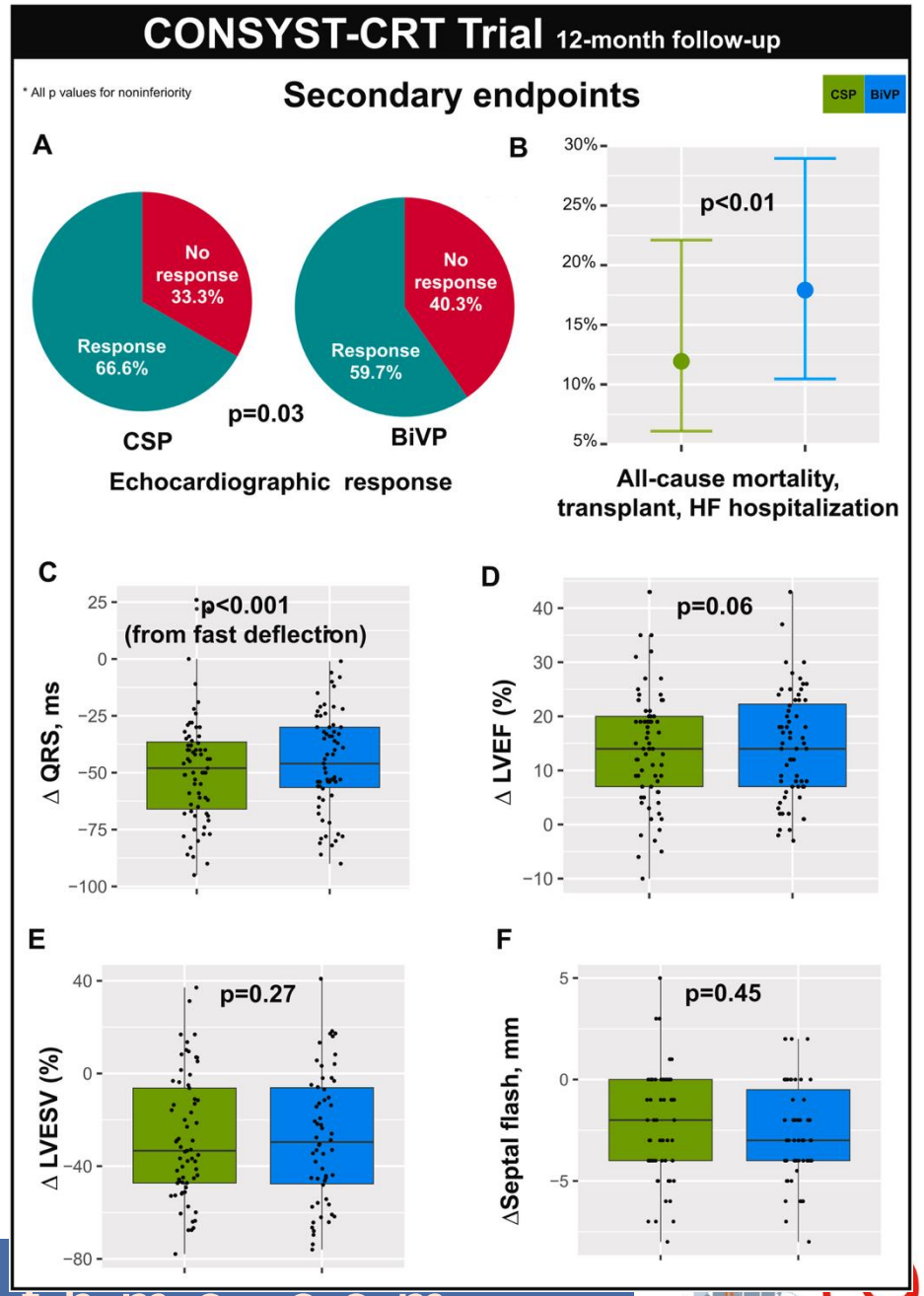
All-cause mortality, cardiac transplant, heart failure hospitalization, or LVEF improvement <5 points



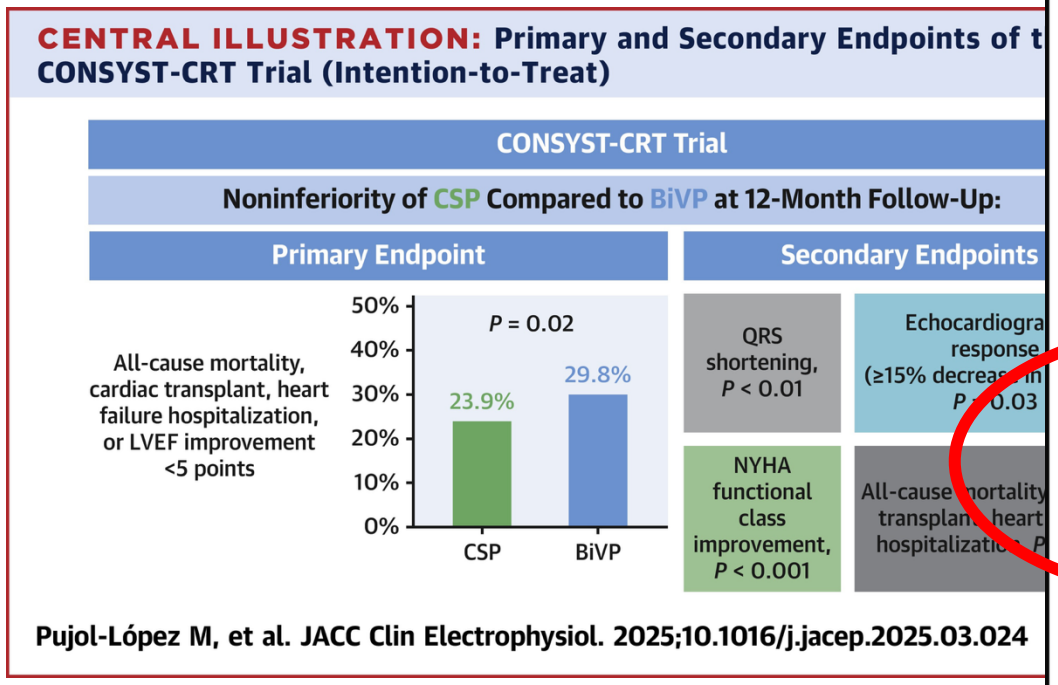
Secondary Endpoints

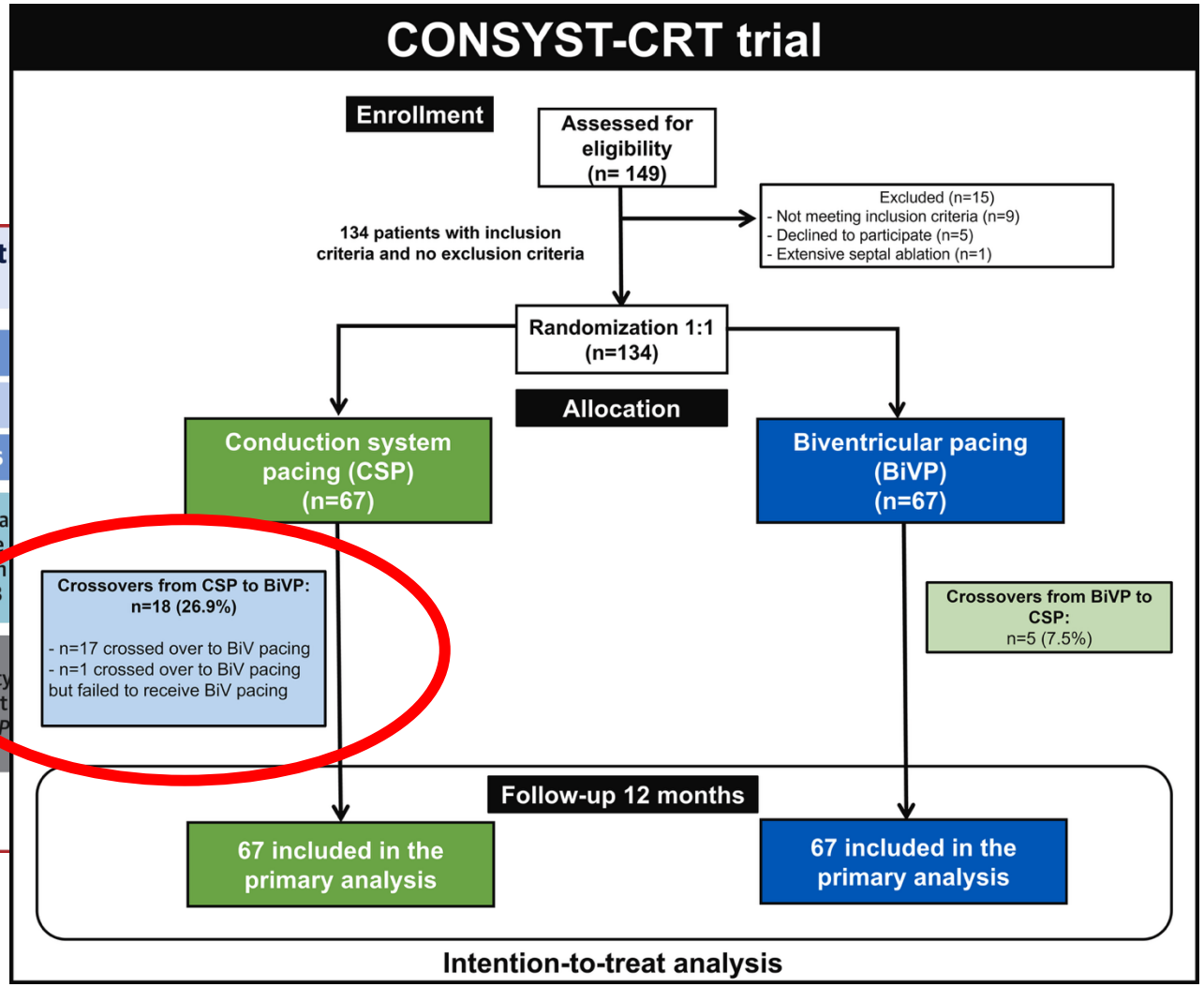
- QRS shortening, $P < 0.01$
- Echocardiographic response (≥15% decrease in LVESV), $P = 0.03$
- NYHA functional class improvement, $P < 0.001$
- All-cause mortality, cardiac transplant, heart failure hospitalization, $P < 0.01$

Pujol-López M, et al. JACC Clin Electrophysiol. 2025;10.1016/j.jacep.2025.03.024

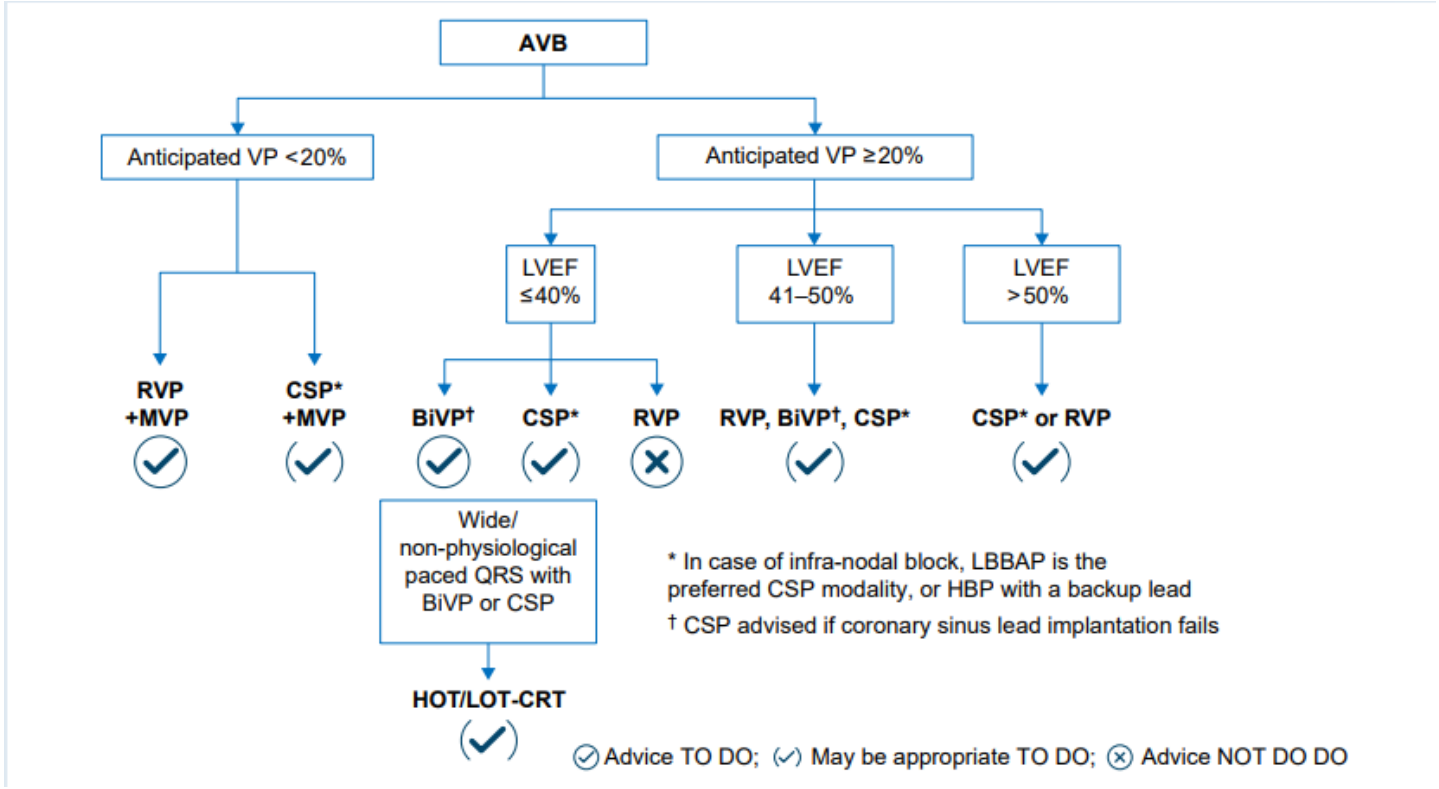


LBBAP vs BVP


CENTRAL ILLUSTRATION: Primary and Secondary Endpoints of t
CONSYST-CRT Trial (Intention-to-Treat)
CONSYST-CRT Trial
Noninferiority of CSP Compared to BiVP at 12-Month Follow-Up:
Primary Endpoint
Secondary Endpoints
All-cause mortality, cardiac transplant, heart failure hospitalization, or LVEF improvement <5 points
50%
40%
30%
20%
10%
0%
P = 0.02
23.9%
29.8%
CSP
BiVP
QRS shortening, P < 0.01
NYHA functional class improvement, P < 0.001
Pujol-López M, et al. JACC Clin Electrophysiol. 2025;10.1016/j.jacep.2025.03.024

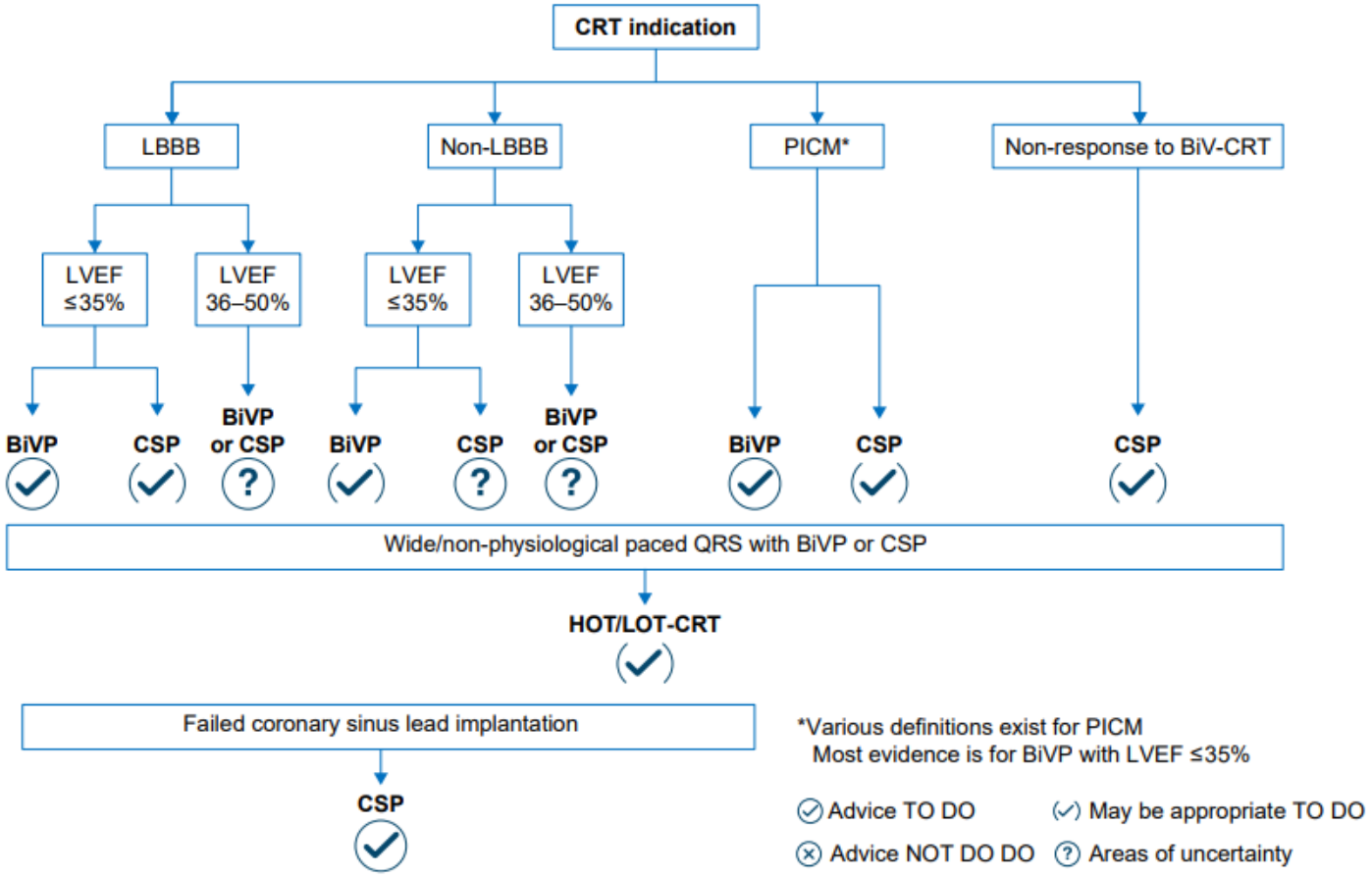

CONSYST-CRT trial
Enrollment
Assessed for eligibility (n= 149)
Excluded (n=15)
- Not meeting inclusion criteria (n=9)
- Declined to participate (n=5)
- Extensive septal ablation (n=1)
134 patients with inclusion criteria and no exclusion criteria
Randomization 1:1 (n=134)
Allocation
Conduction system pacing (CSP) (n=67)
Biventricular pacing (BiVP) (n=67)
Crossovers from CSP to BiVP: n=18 (26.9%)
- n=17 crossed over to BiV pacing
- n=1 crossed over to BiV pacing but failed to receive BiV pacing
Crossovers from BiVP to CSP: n=5 (7.5%)
Follow-up 12 months
67 included in the primary analysis
67 included in the primary analysis
Intention-to-treat analysis

EHRA consensus paper



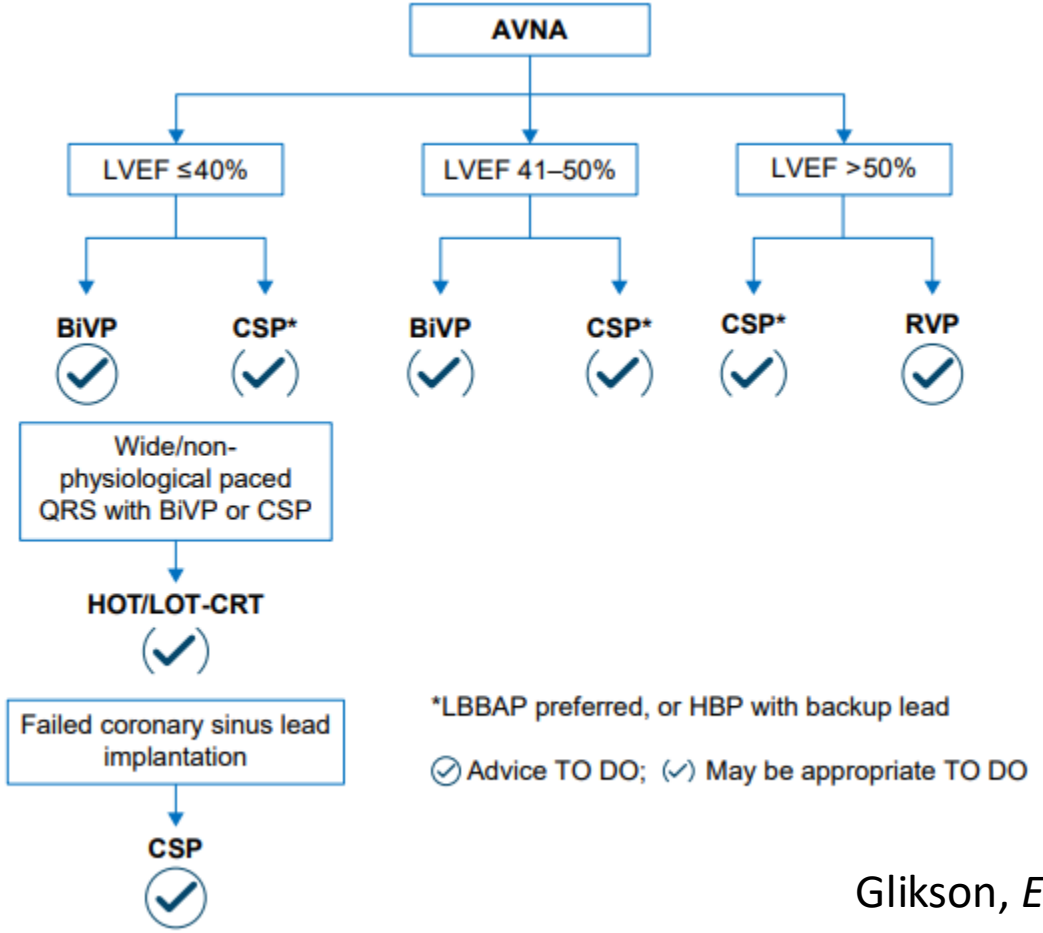
Glikson, *Europace*, 2025

EHRA consensus paper



Glikson, *Europace*, 2025

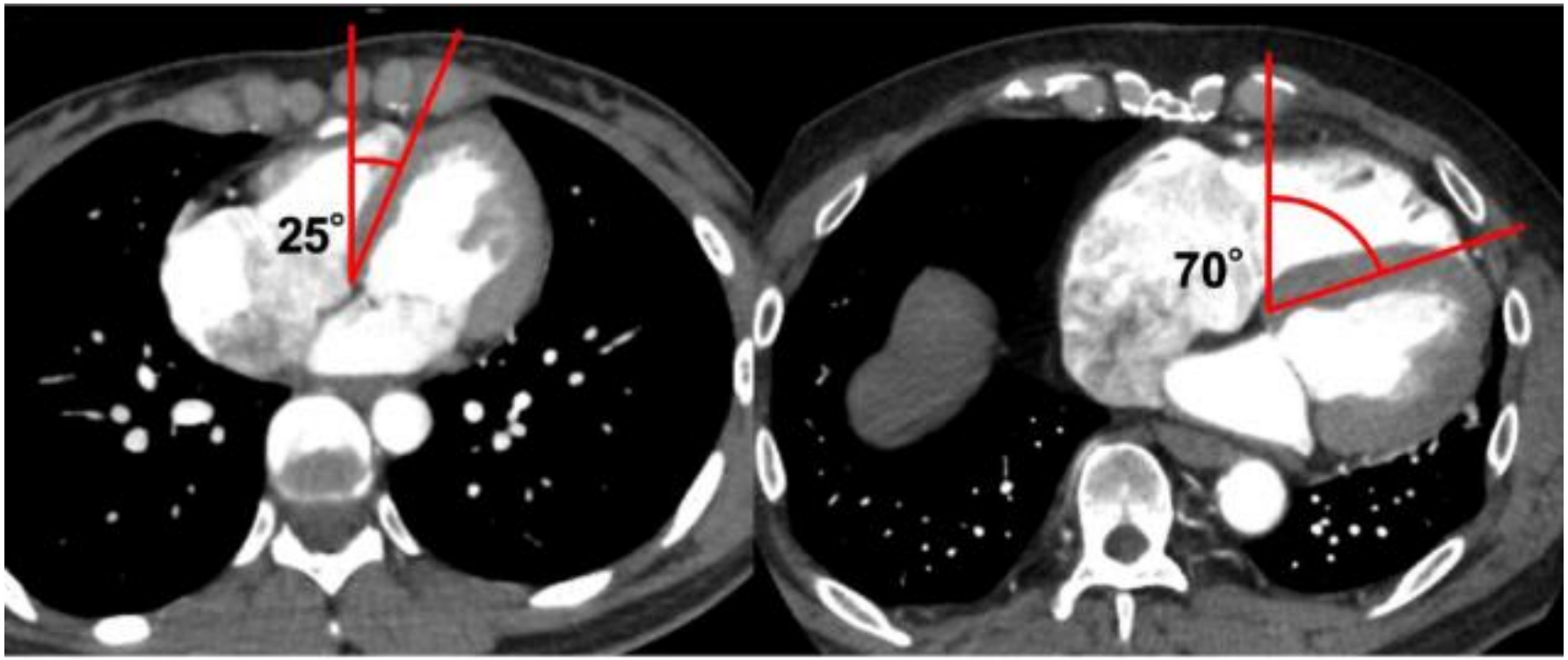
EHRA consensus paper



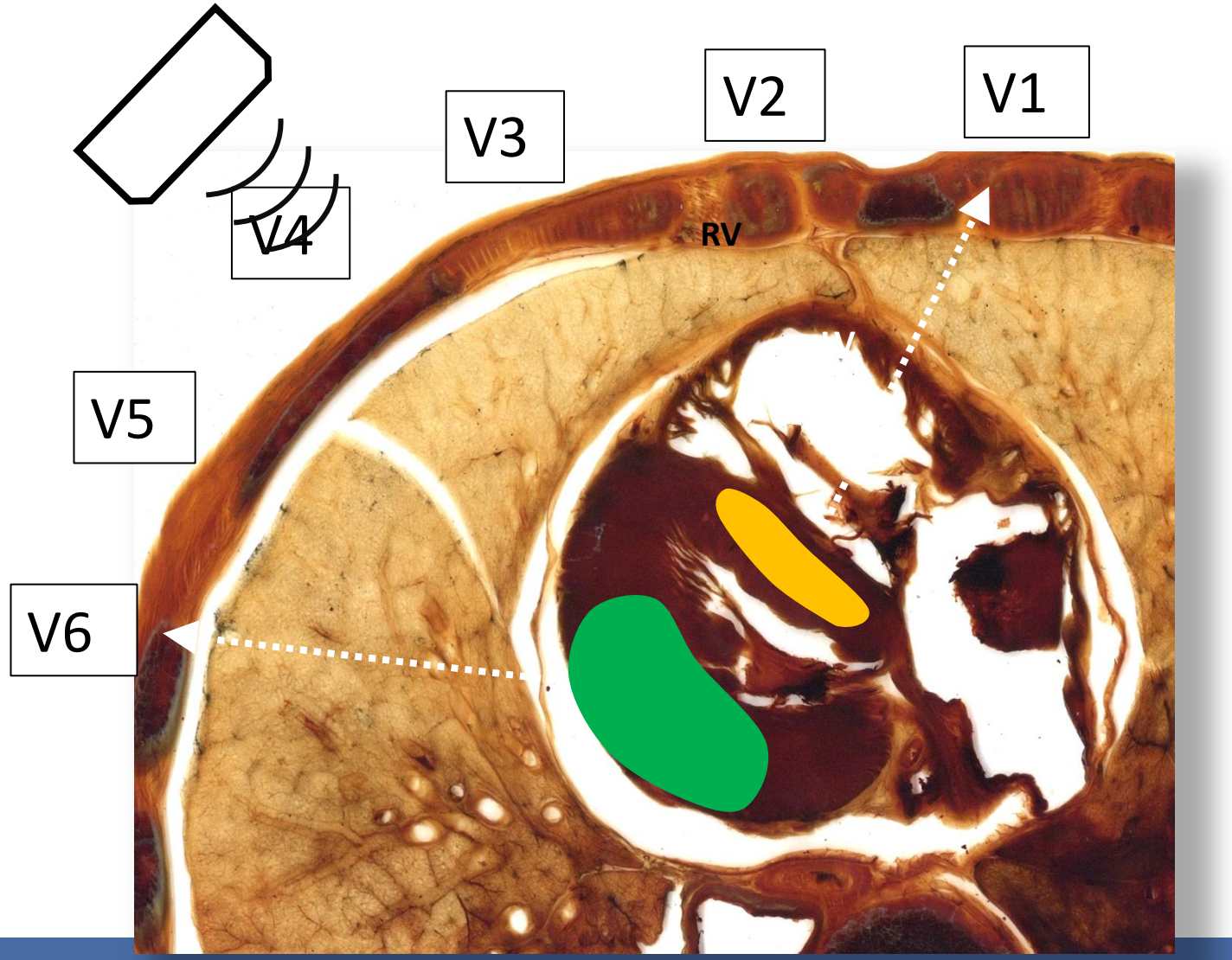
Glikson, *Europace*, 2025

Difficult cases: how to handle?

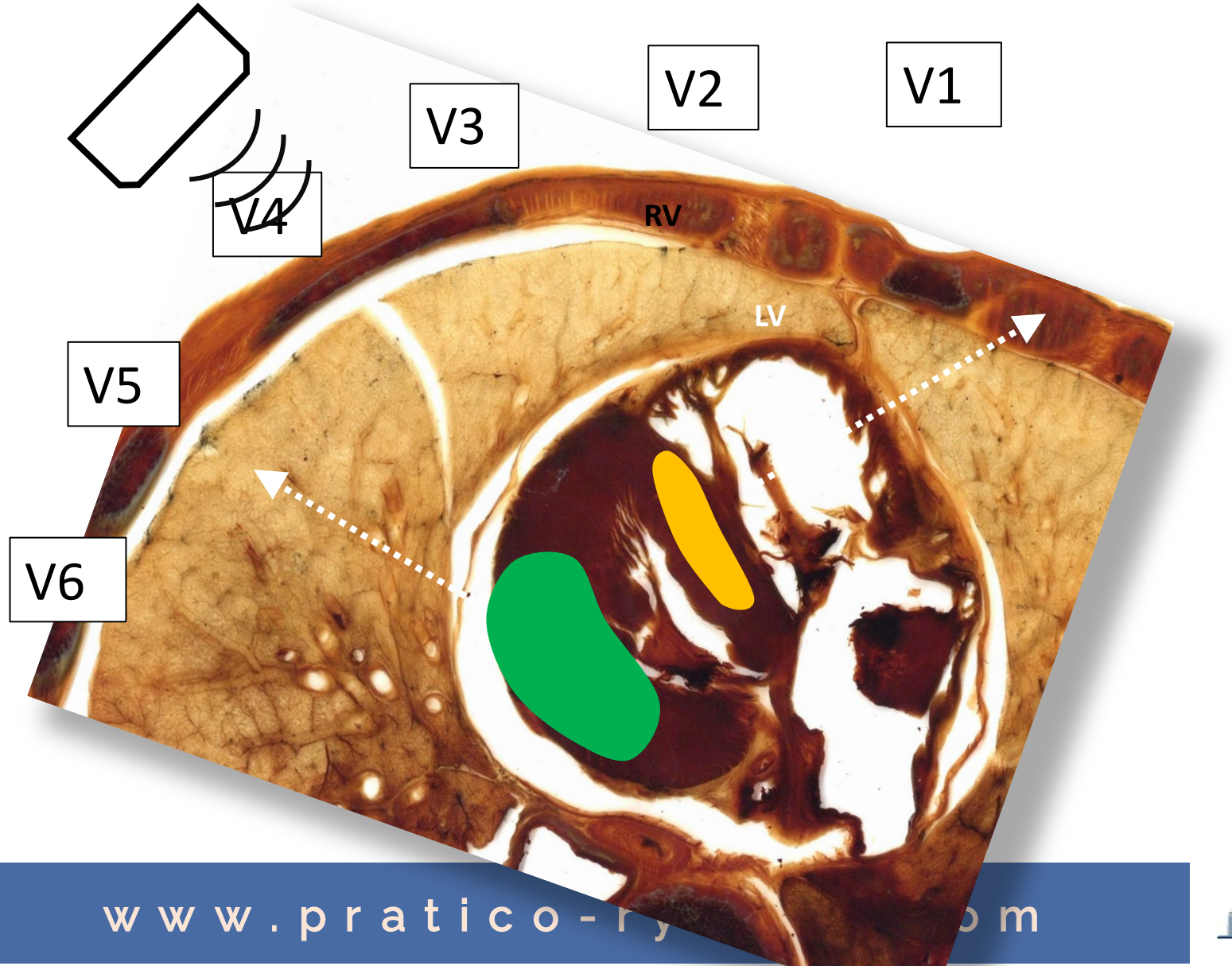
Heart rotation



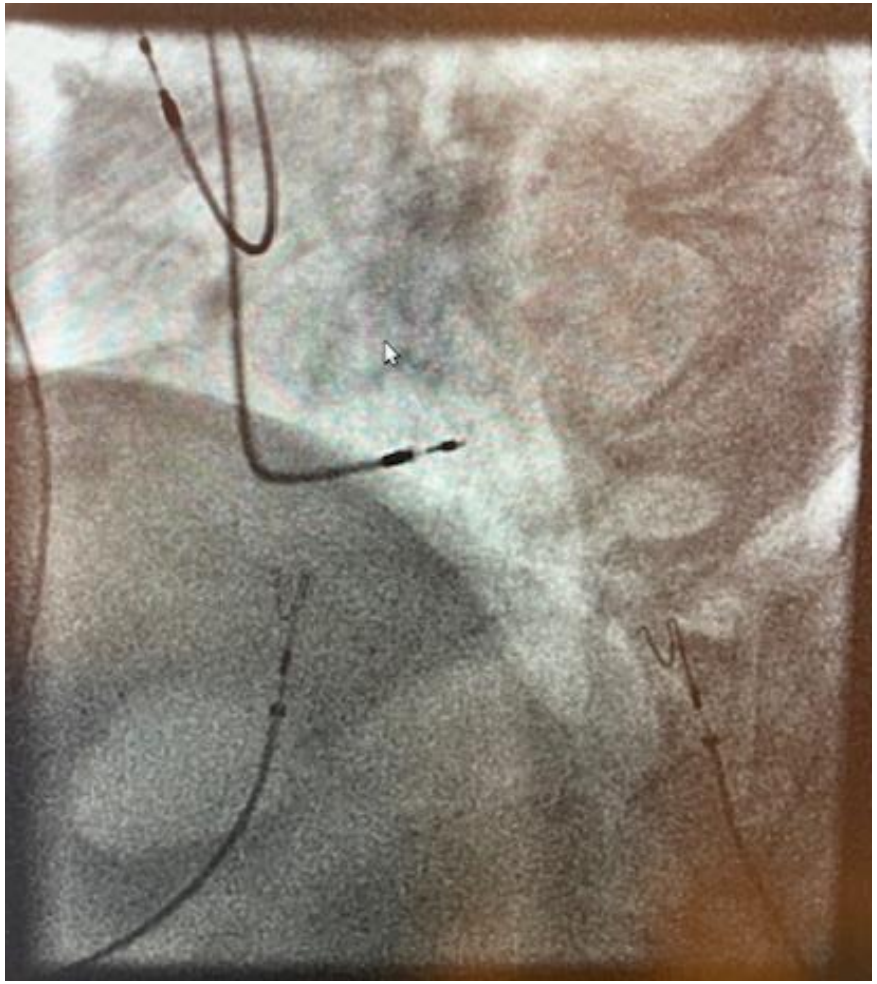
Heart in the thorax (inferior view) and precordial ECG leads

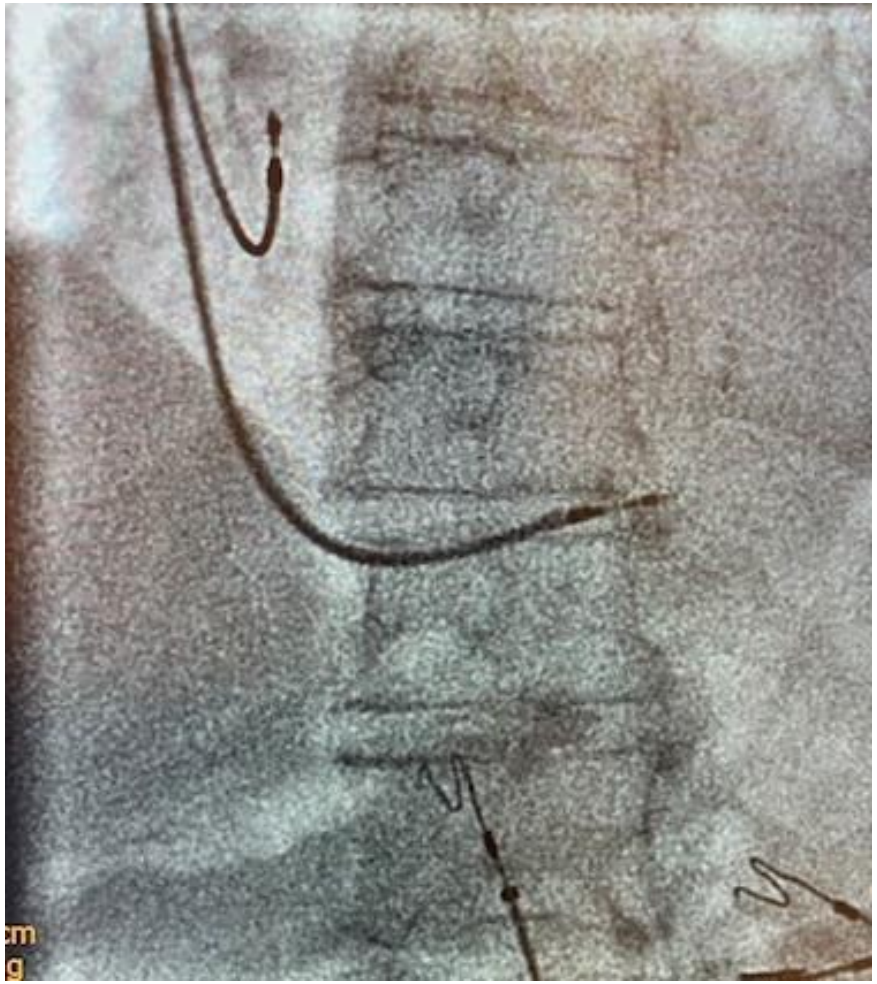


Heart in the thorax (inferior view) and precordial ECG leads



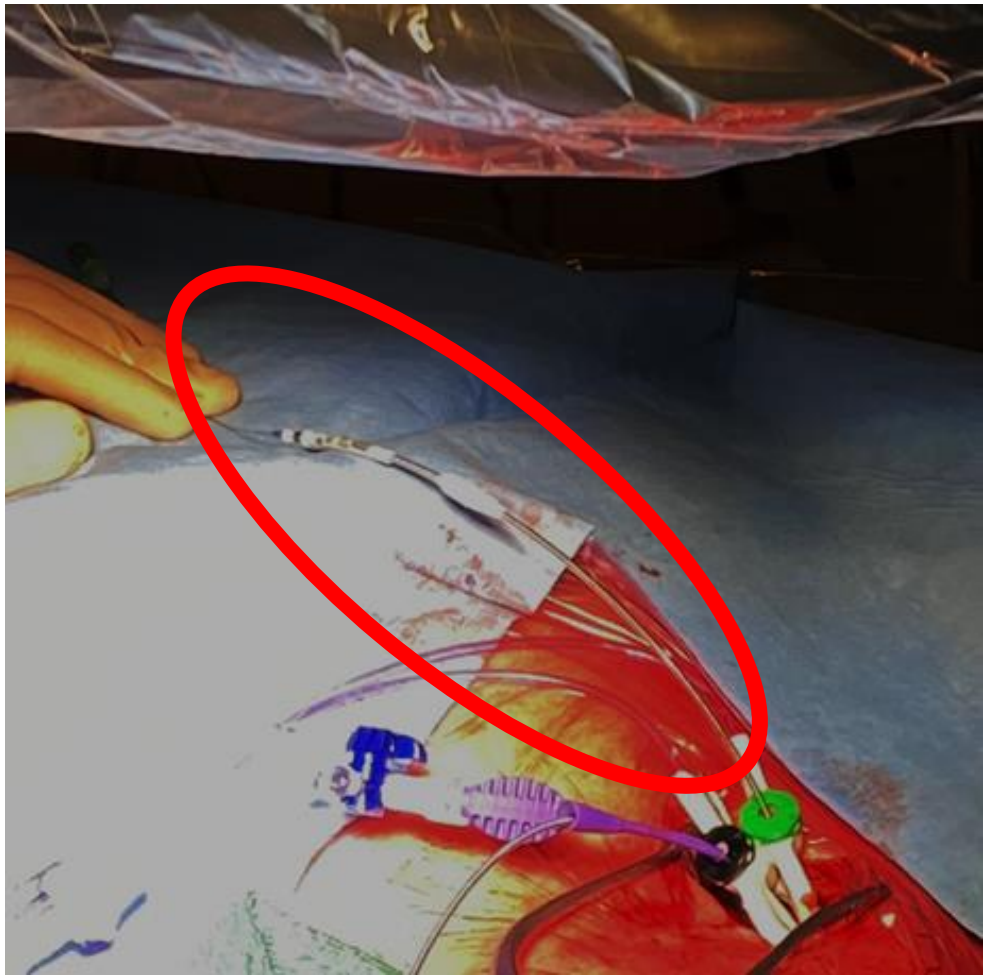
Heart rotation





Step 0: atrial lead

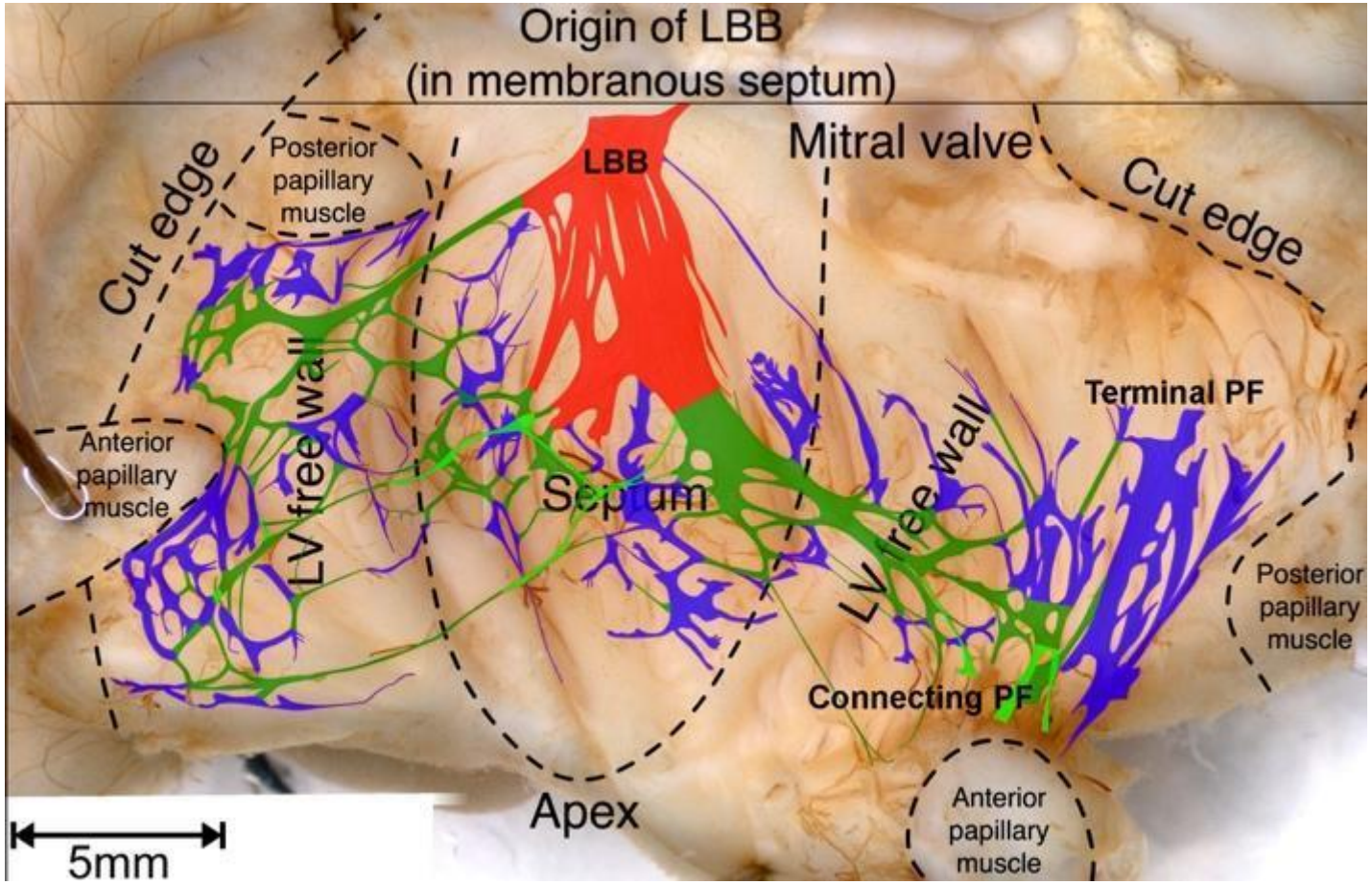
- Residual length
- Cardiac rotation



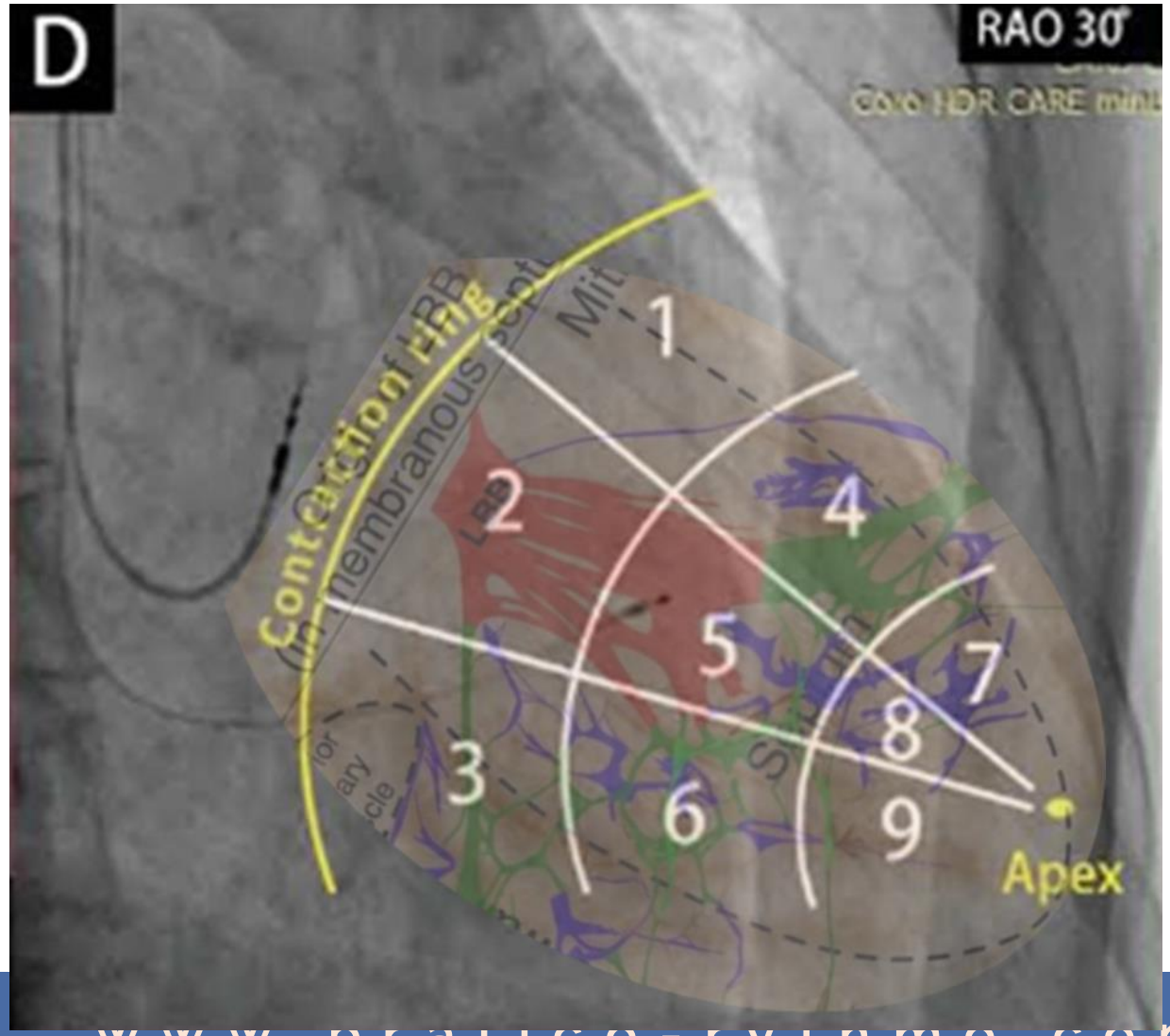
Step 1: Selection of the sheath

Selectra 3D 55 – 39: 85-90% **Chronic AF?**

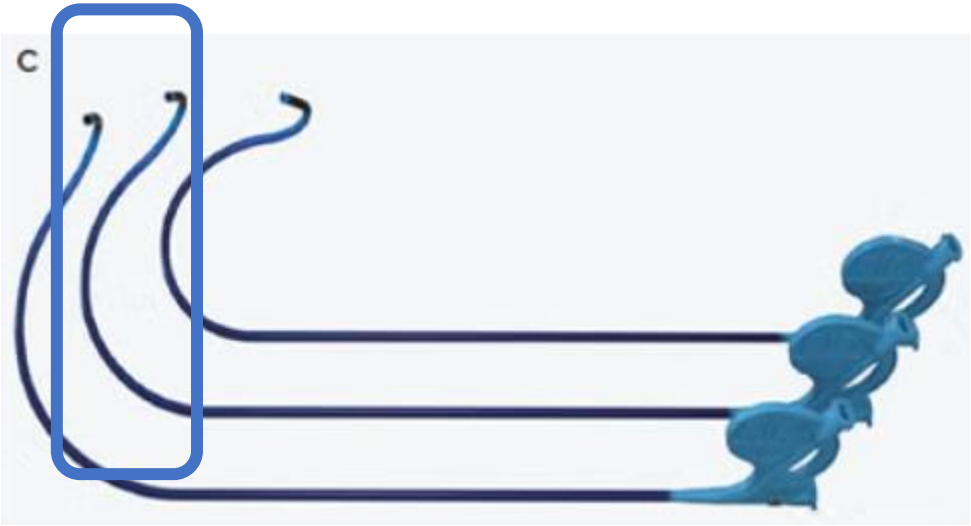
The left bundle AREA: introduction to catheters

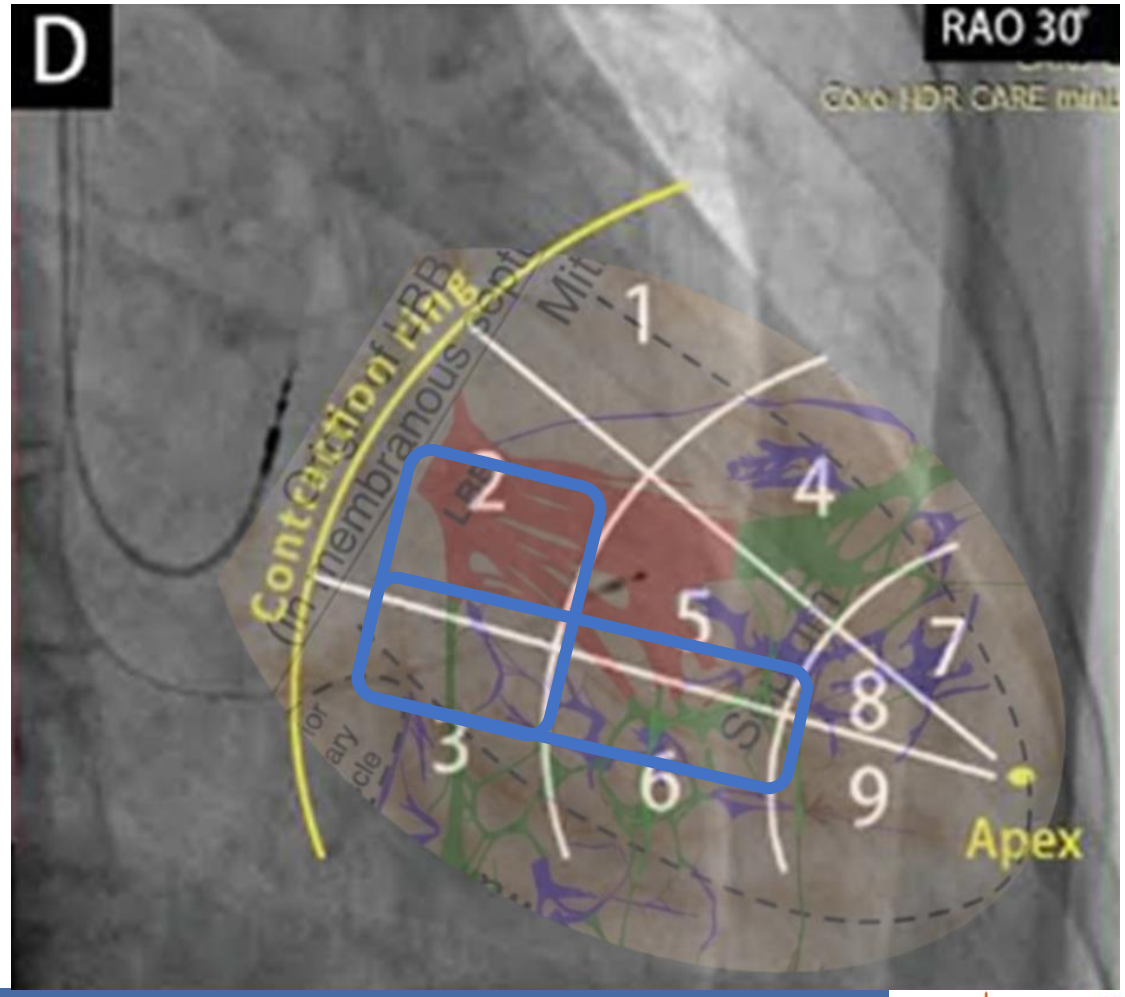


LBBAP Targetting

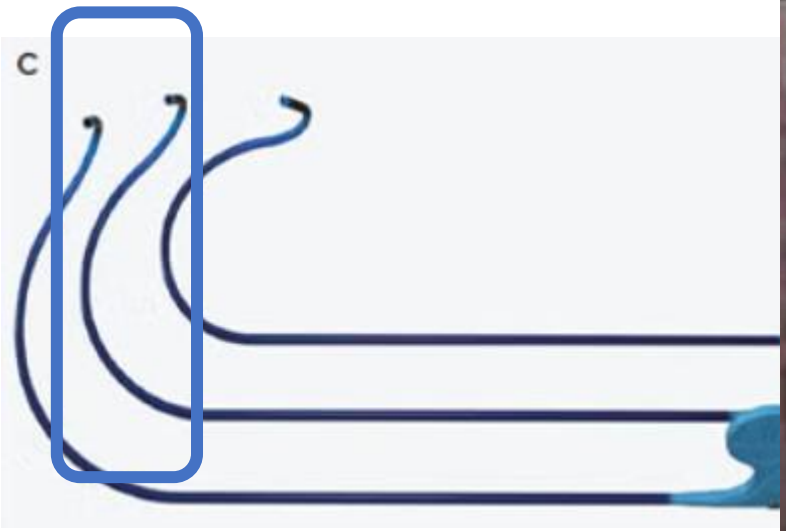


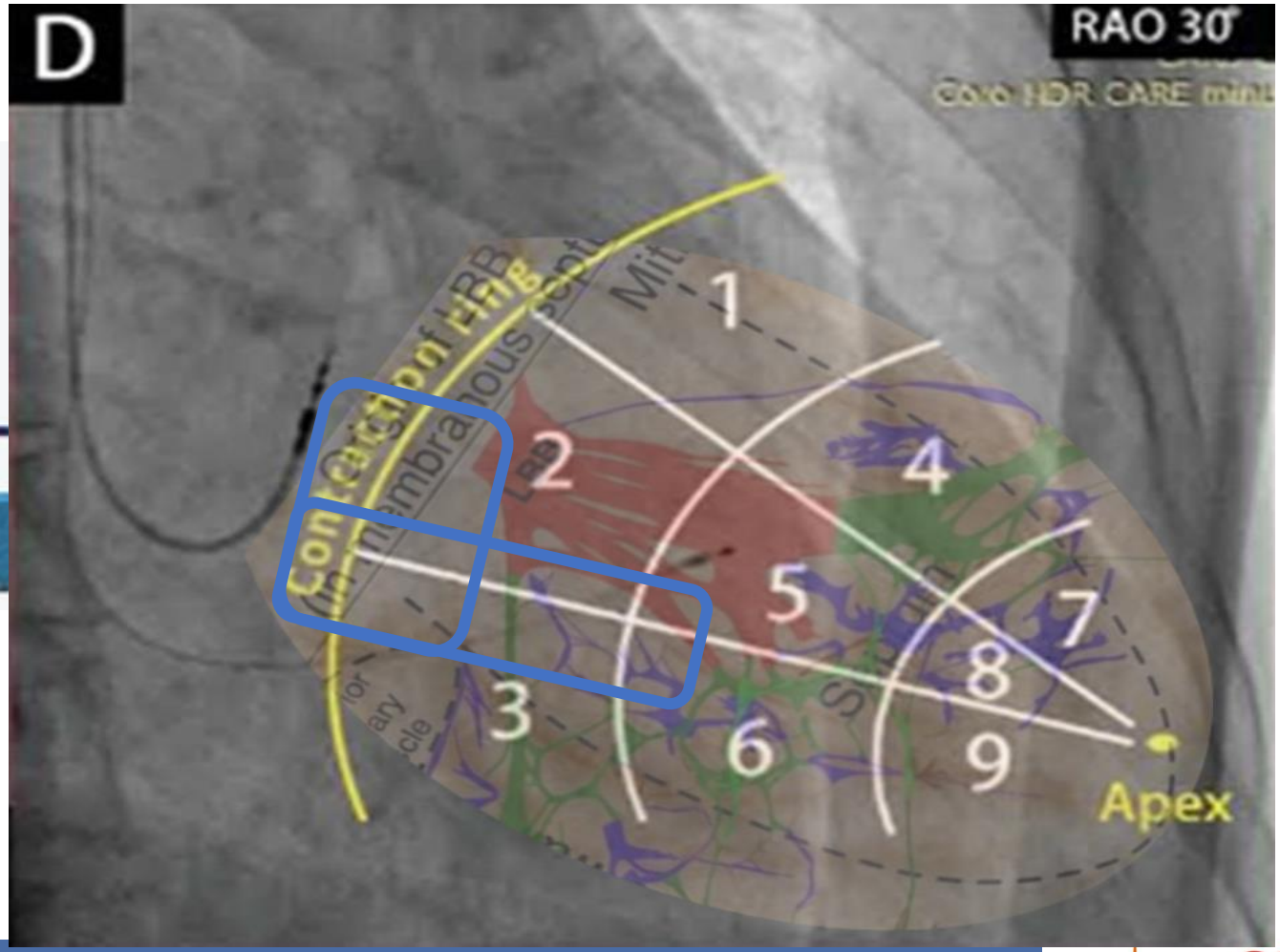
Selectra 3D 55 - 39



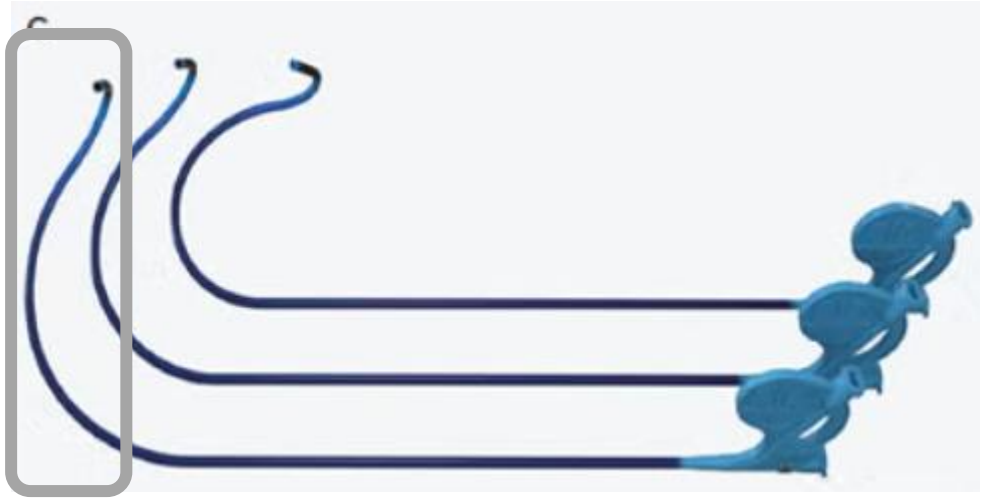


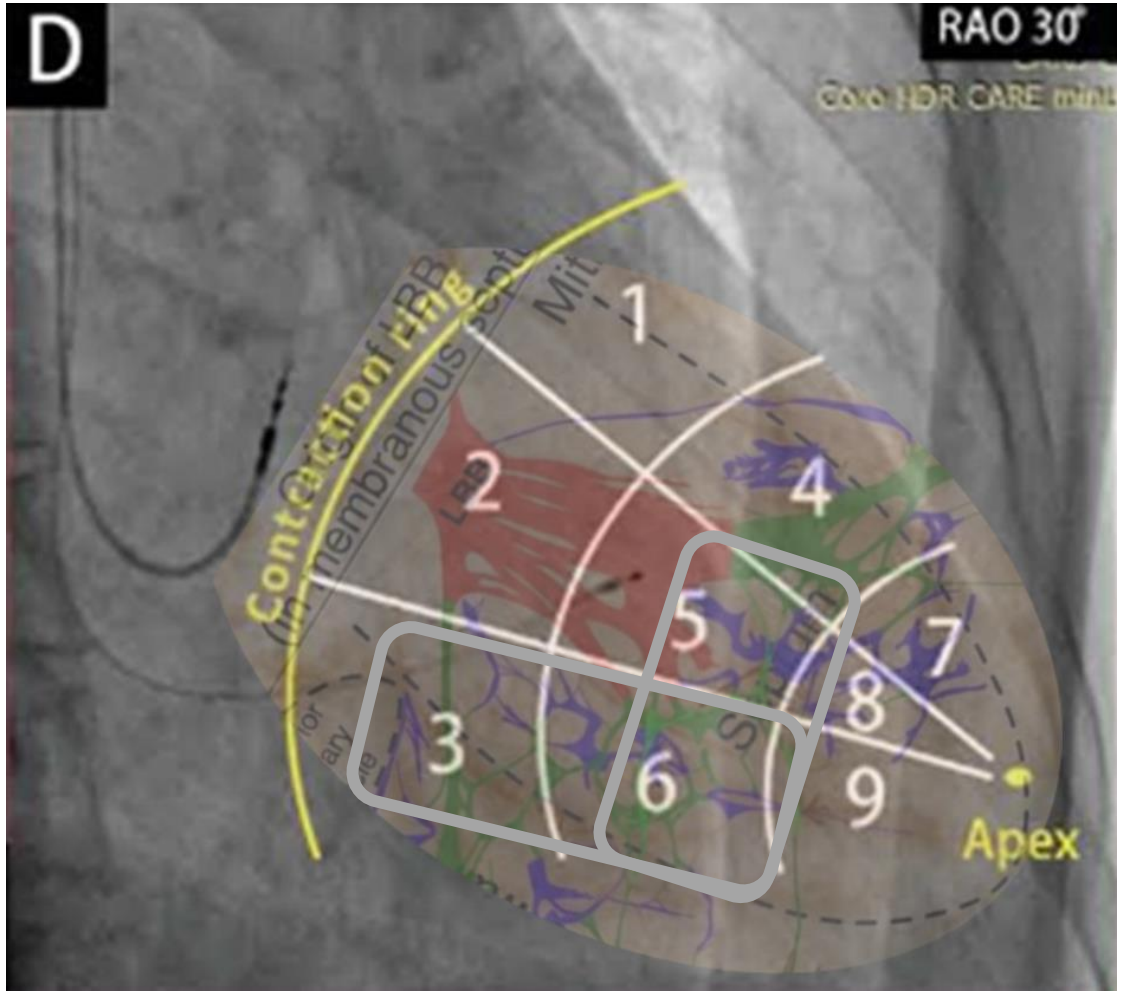
Selectra 3D 55 – 39 Bigger Heart





Selectra 3D 65 - 42



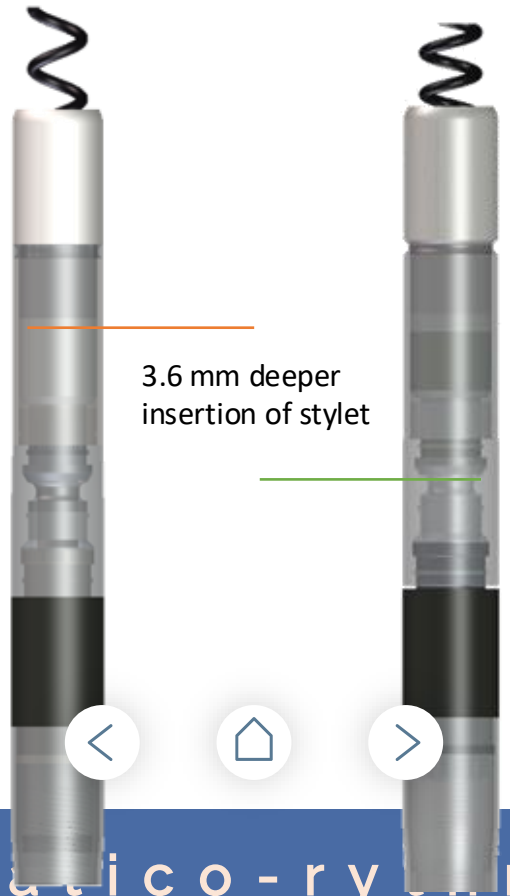


Step 2: lead preparation

New dedicated lead: Solia CSP S

Dedicated lead

	Solia CSP S
Lead body diameter	1.8 mm (5.6 F)
Length	53 cm, 60 cm
Stylet support	Yes – 2 stylet options
Screw type	Fixed screw
Screw length	2.2 mm
Screw pitch	1.3 mm
Screw cut	Optimized double cut
MR Conditional	1.5 T and 3.0 T full-body scan
Lead handling preparation	Not required
Locking tool for fixation	Not required
X-ray window	Not required



Solia S	
1.8 mm (5.6 F)	Lead body diameter
53 cm, 60 cm	Length
Yes	Stylet support
Extendable/retractable screw	Screw type
1.8 mm	Screw length
0.9 mm	Screw pitch
Double cut	Screw cut
1.5 T and 3.0 T full-body scan	MR Conditional
Yes	Lead handling preparation
Yes	Locking tool for fixation
Yes	X-ray window

Dedicated lead

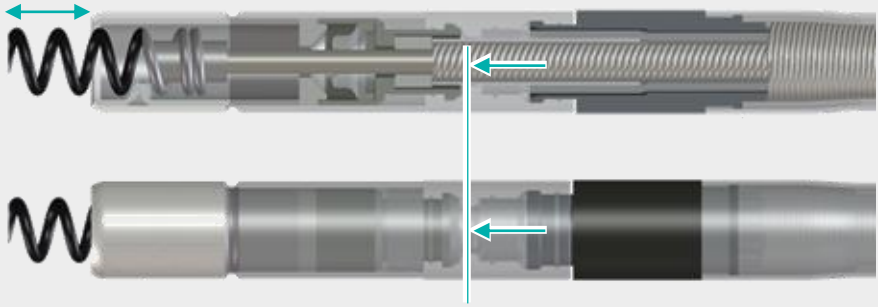
Design concept based on the well-established Solia lead design

- Lead body (available in 53 cm and 60 cm)
- Ring electrode
- Connector Solia T
- Outer/inner conductor
- Tip housing and steroid collar
- Lumen & stylet-driven lead

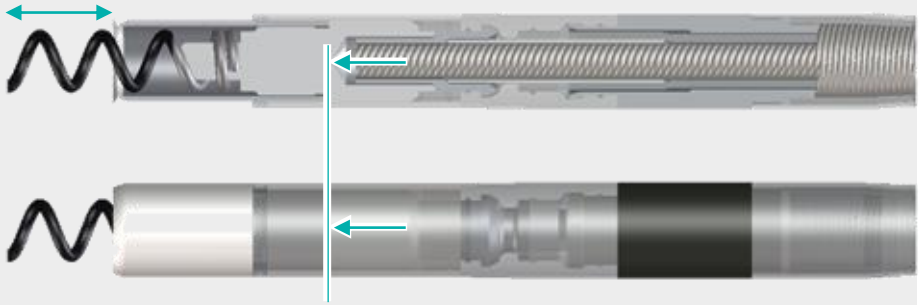
Design changes

- **Longer fixation screw 2.2 mm** vs. Solia S 1.8 mm
- Fixed-screw
- **New pitch 1.3 mm** vs. Solia S 0.9 mm
- Tip modification, fixation with two cut surfaces
- Optimized distal end for high resilience
- 3.6 mm deeper insertion of stylet

Solia S (1.8 mm 0.9 mm pitch)



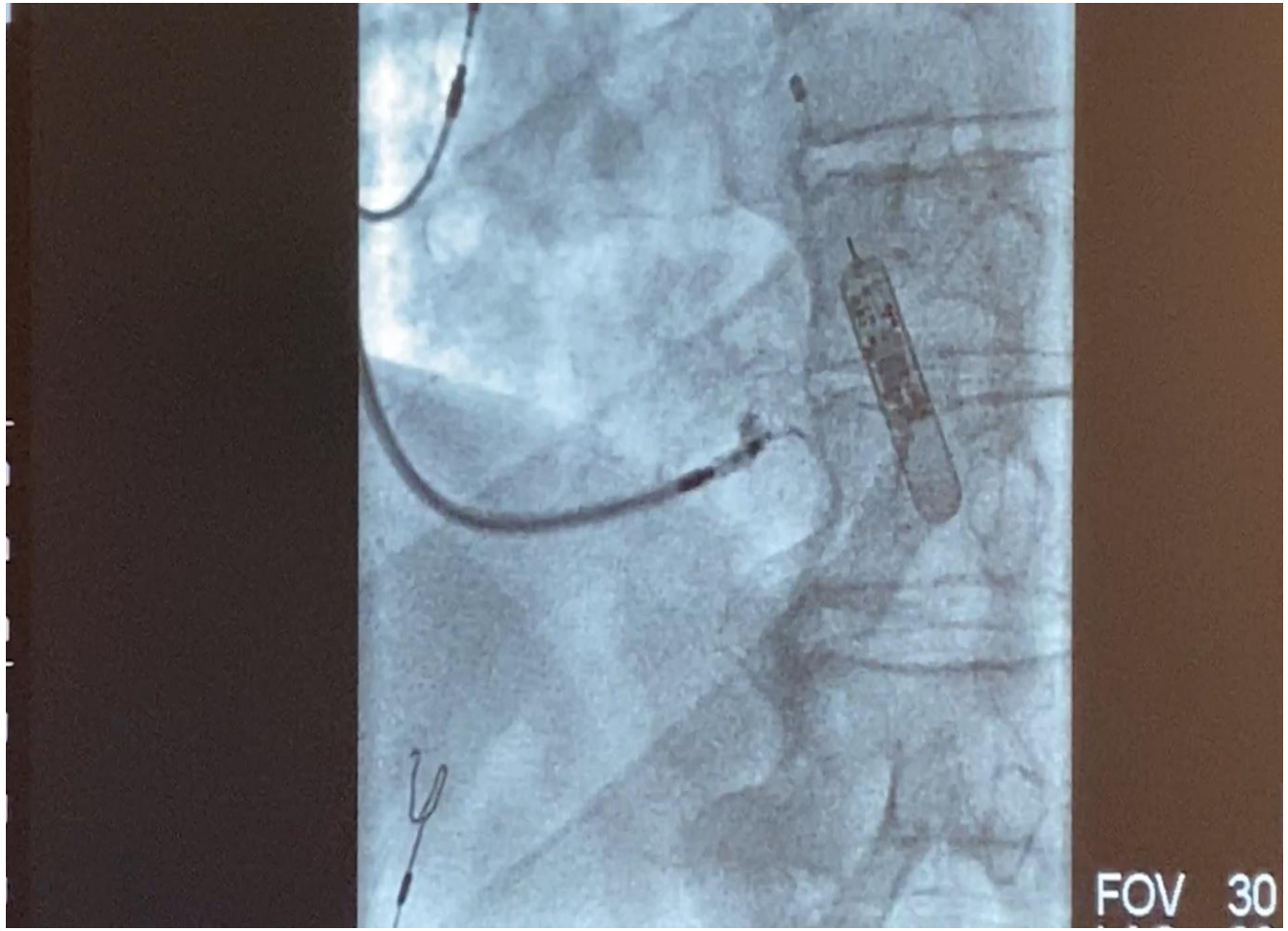
Solia CSP S (2.2 mm fixed-screw 1.3 mm pitch)



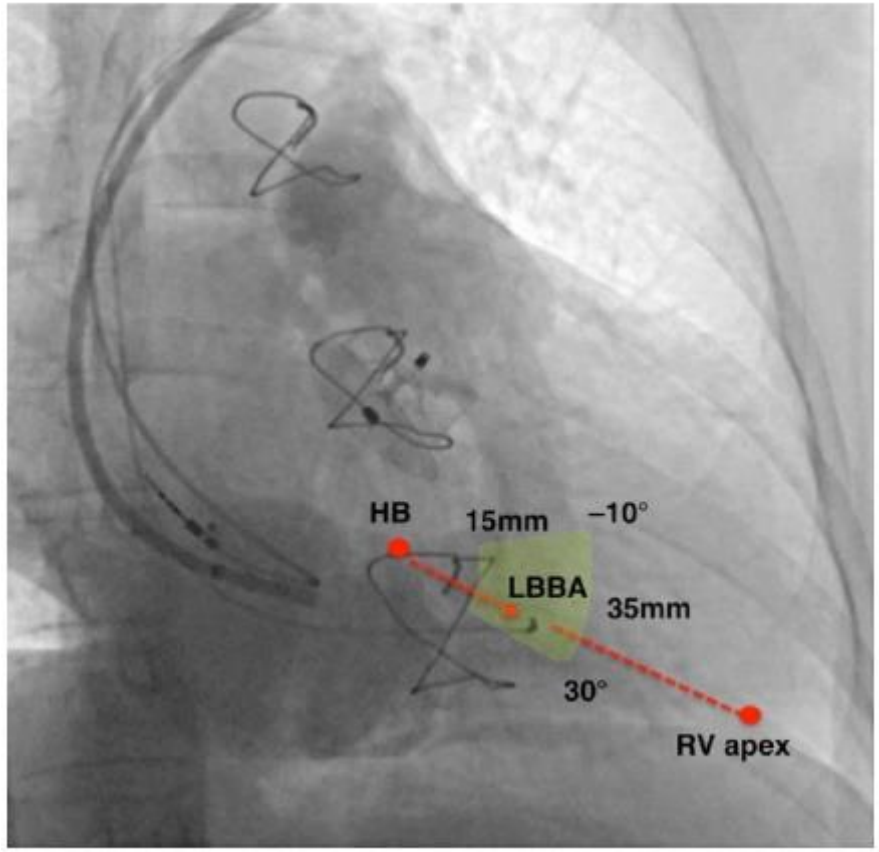
Step 3: selection of the position

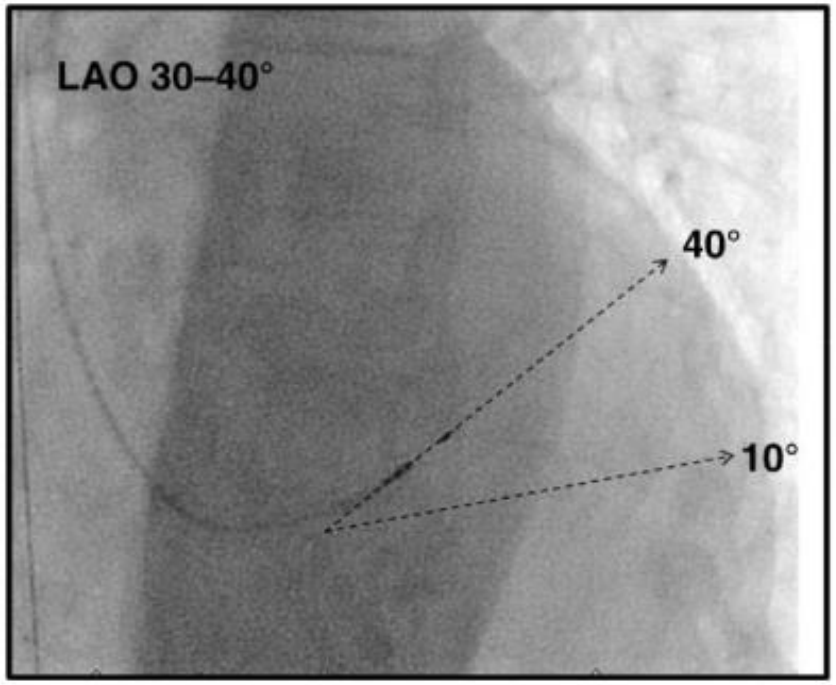
- Angulation 10-40°
- Assess position on the septum with contrast
- Pace in unipolar (high ouput)

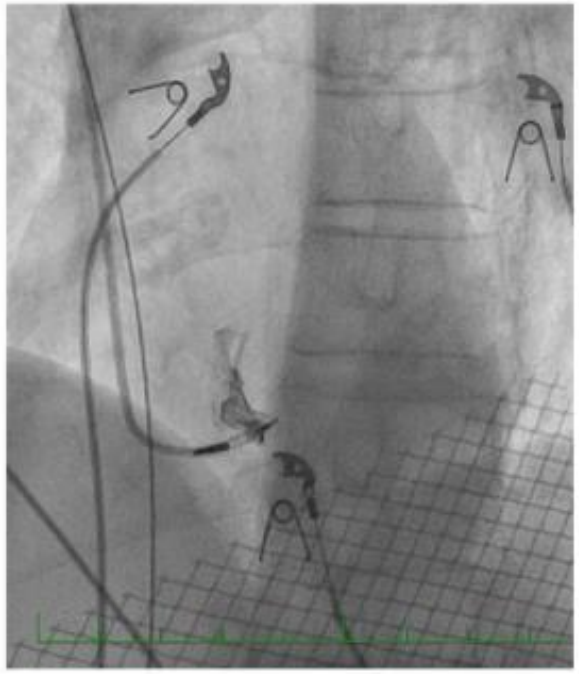
- **Retract the lead (few mm)**
- Extend the helix (+/- 15 turns)
- **Check impedance**



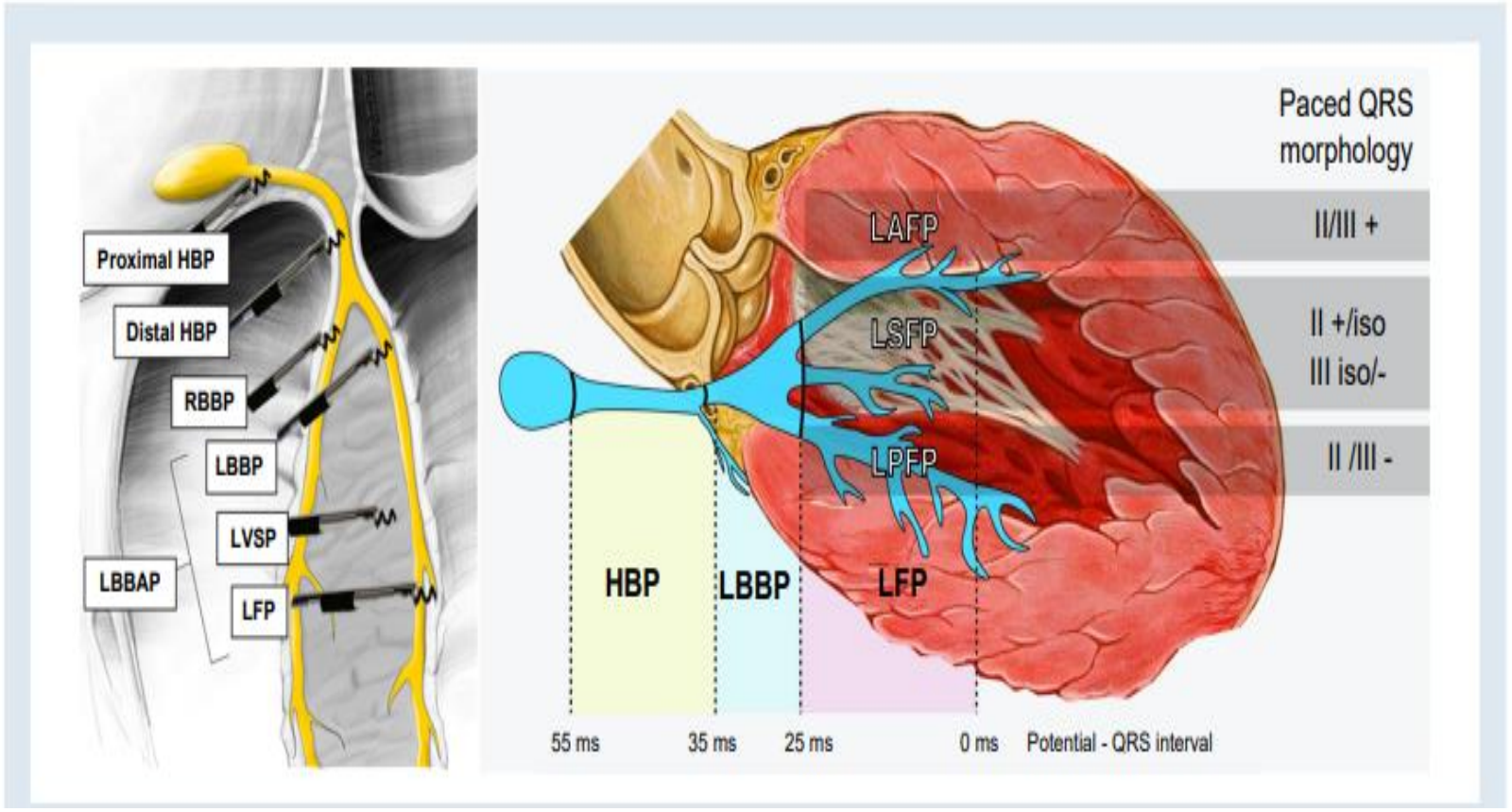
Initial position



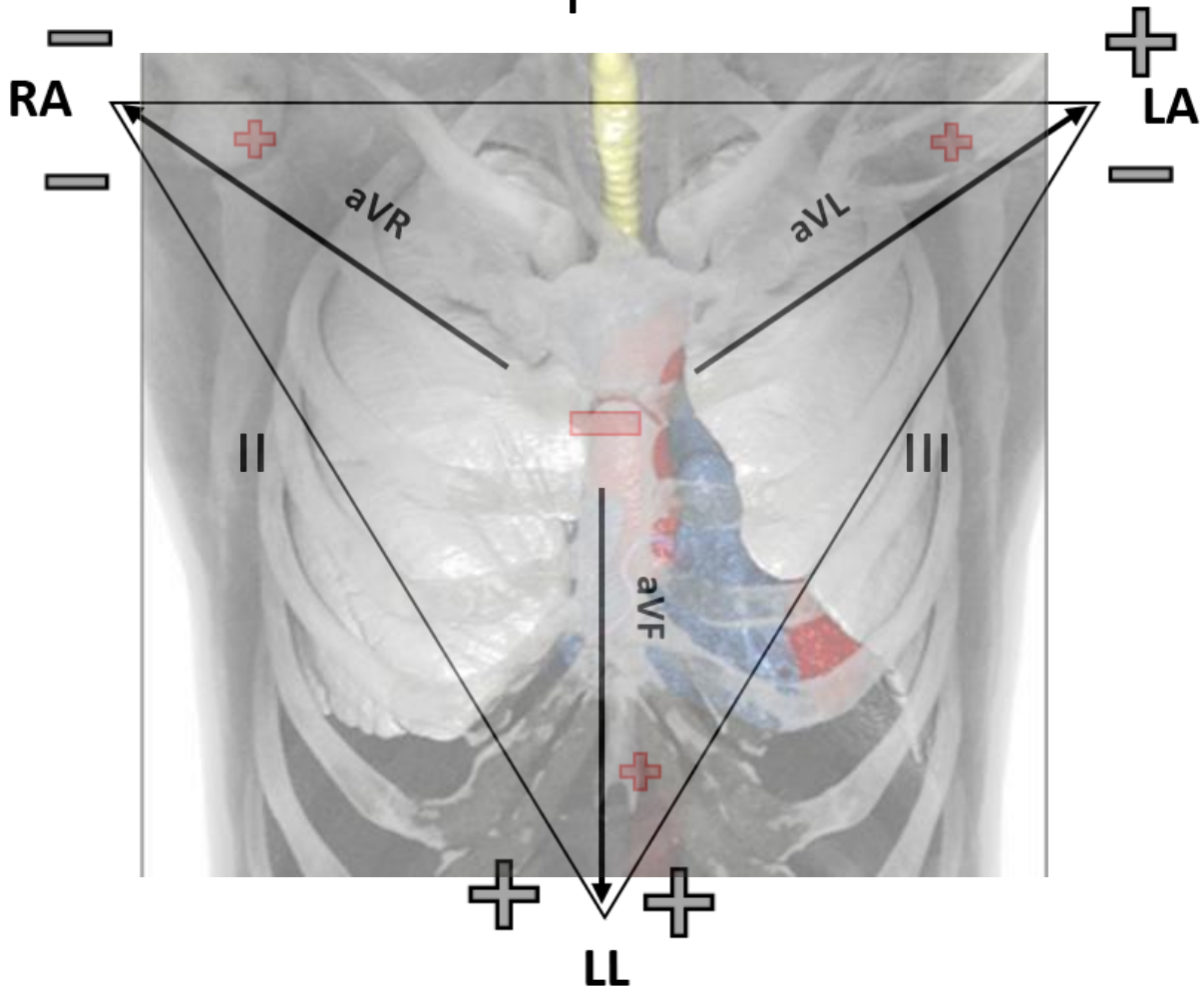


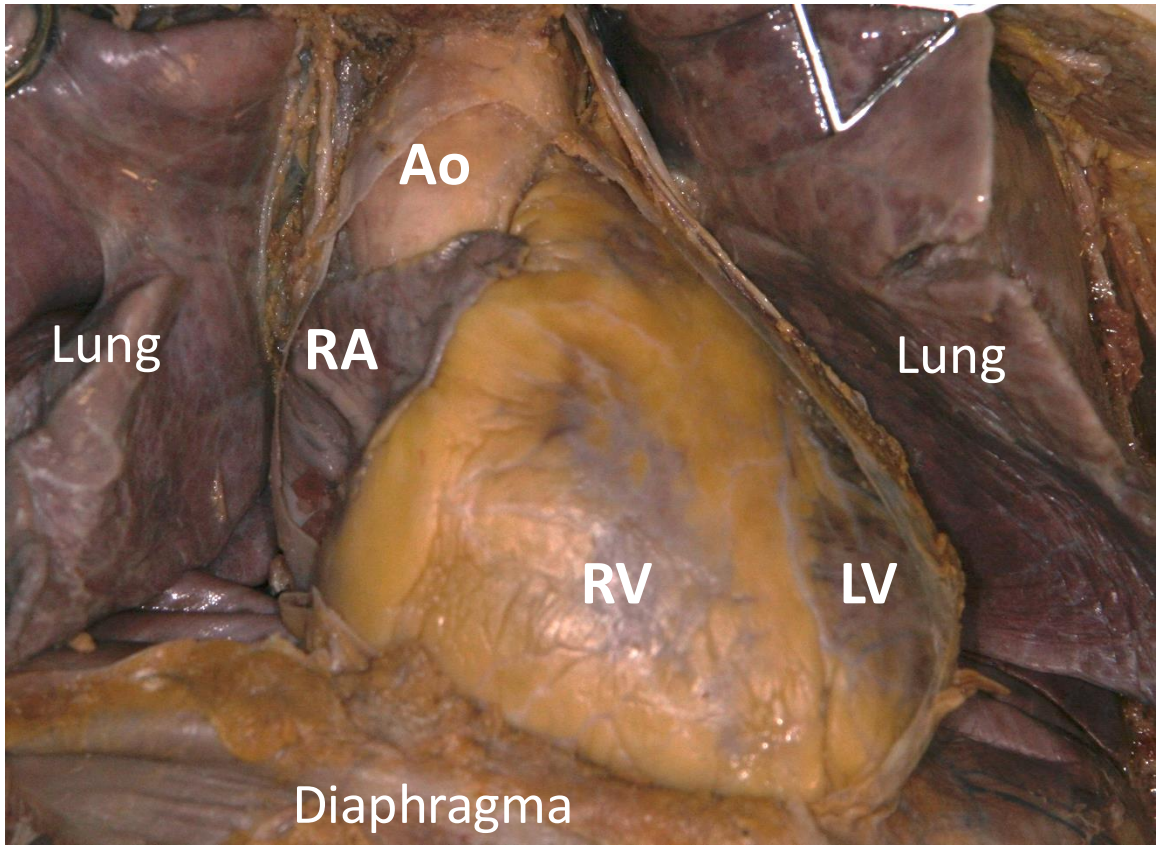


ECG considerations



Heart in the thorax and limb ECG leads

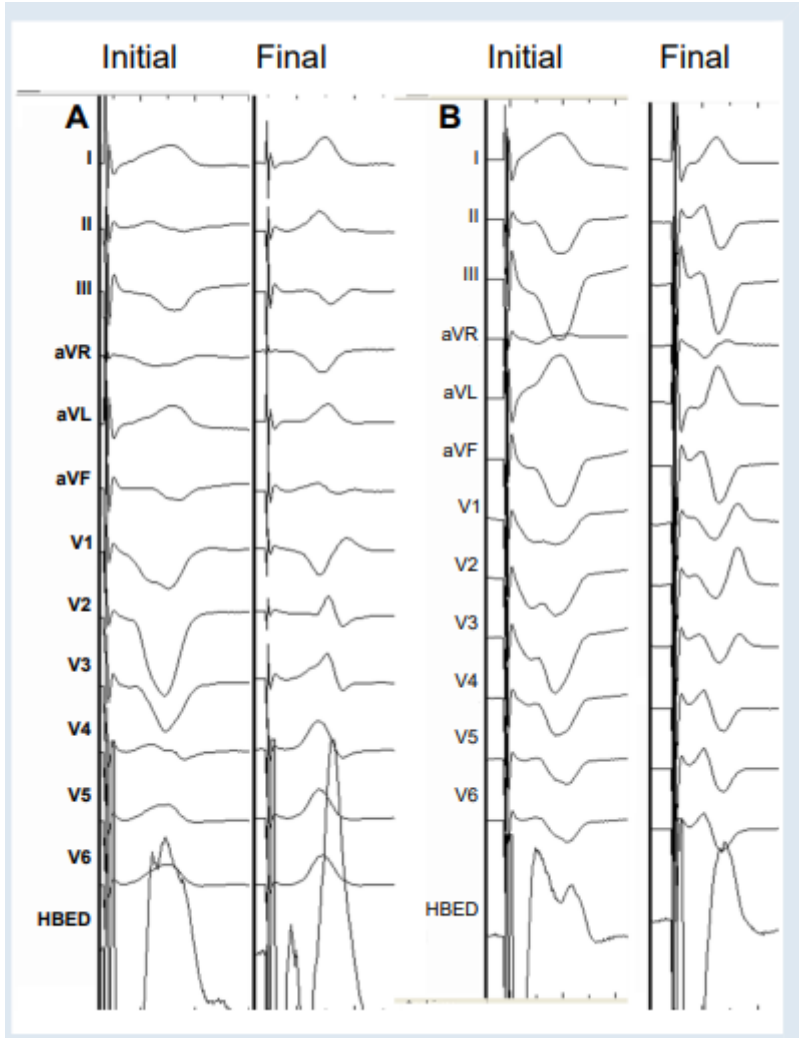




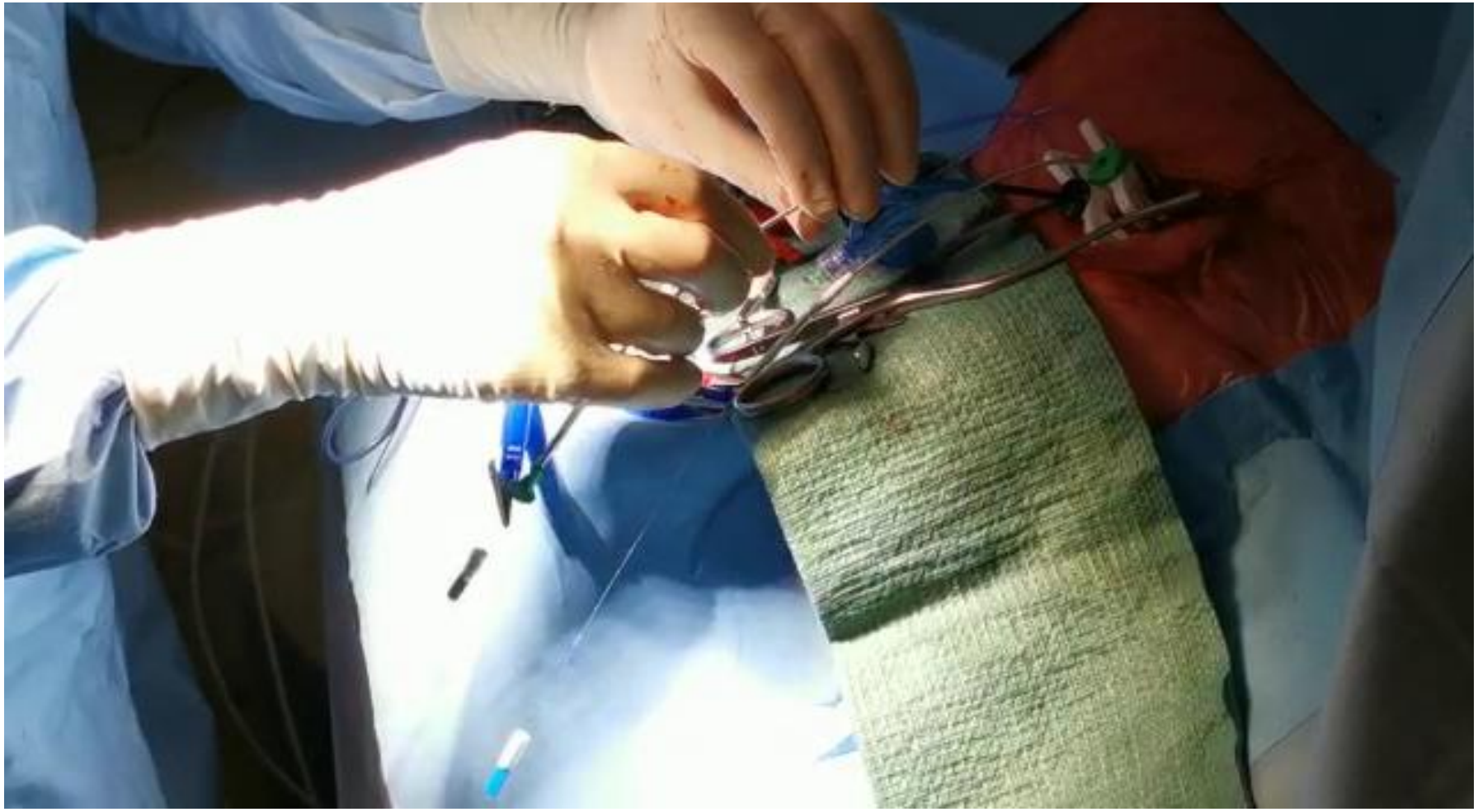
Initial position

DII

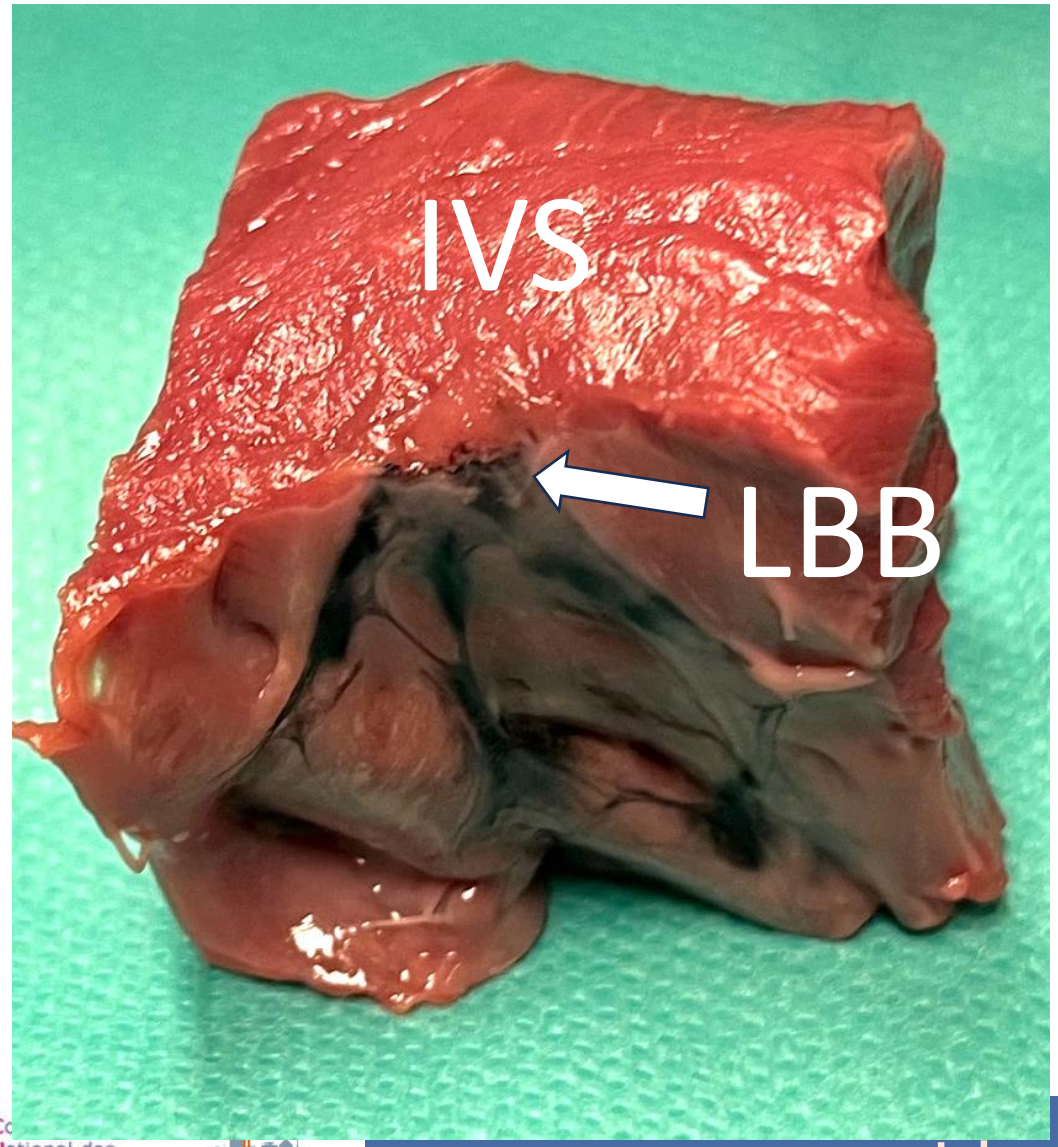
V1

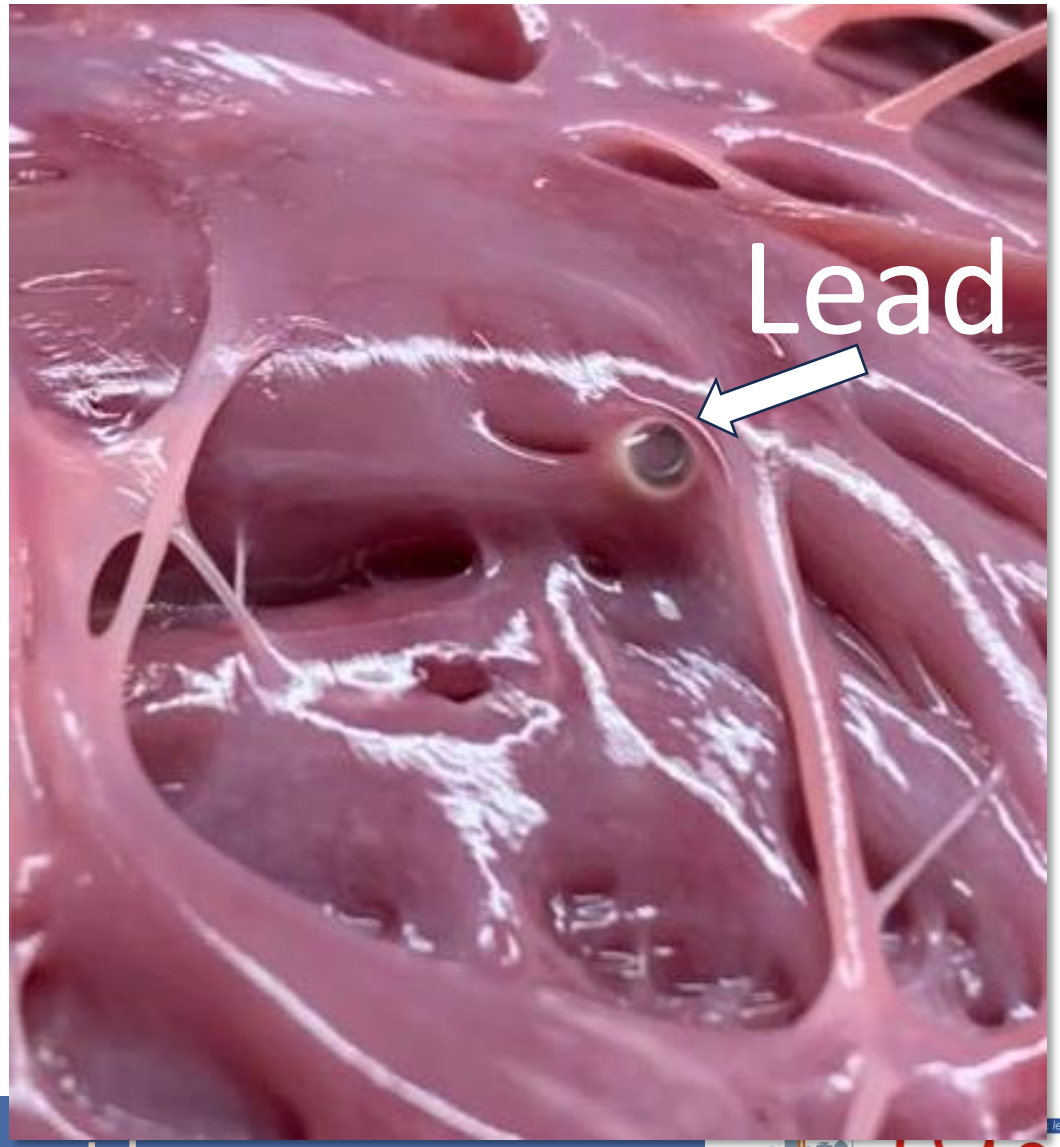


Step 4: Lead insertion

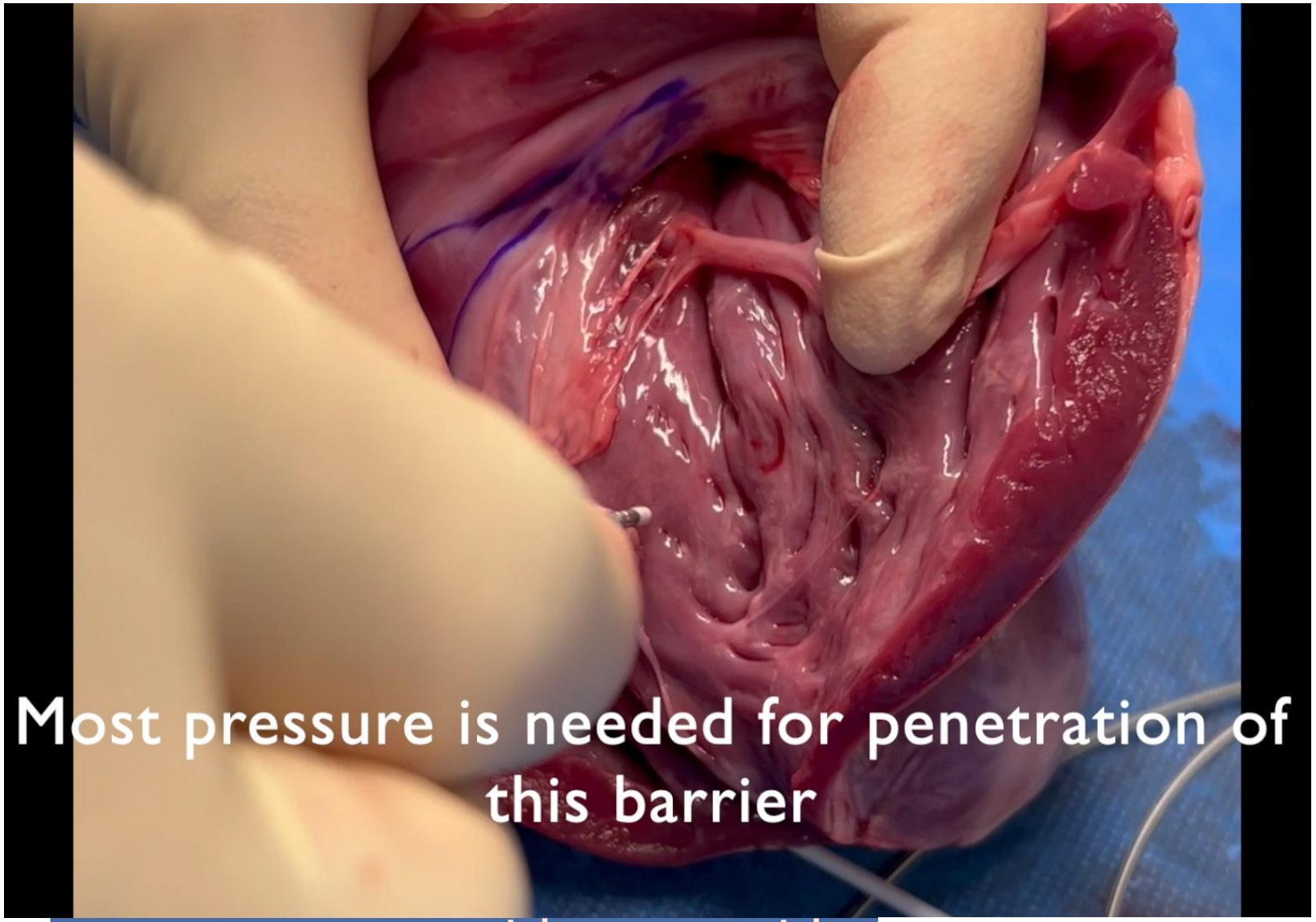


LBB anatomy and LBBAP





Screwing in technique



Entanglement

- Lead does not penetrate the septum
  - Torque in the lead

➢ Rotate anticlockwise till the lead is free in the sheath

➢ Reposition the sheath

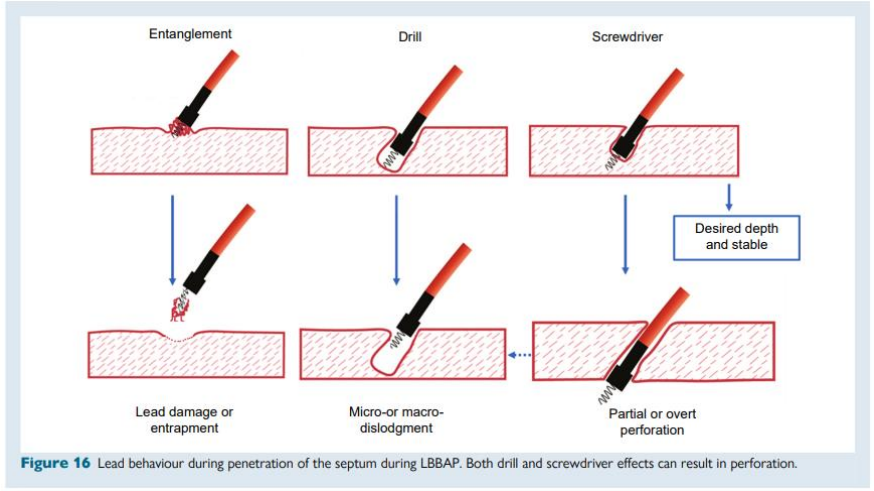
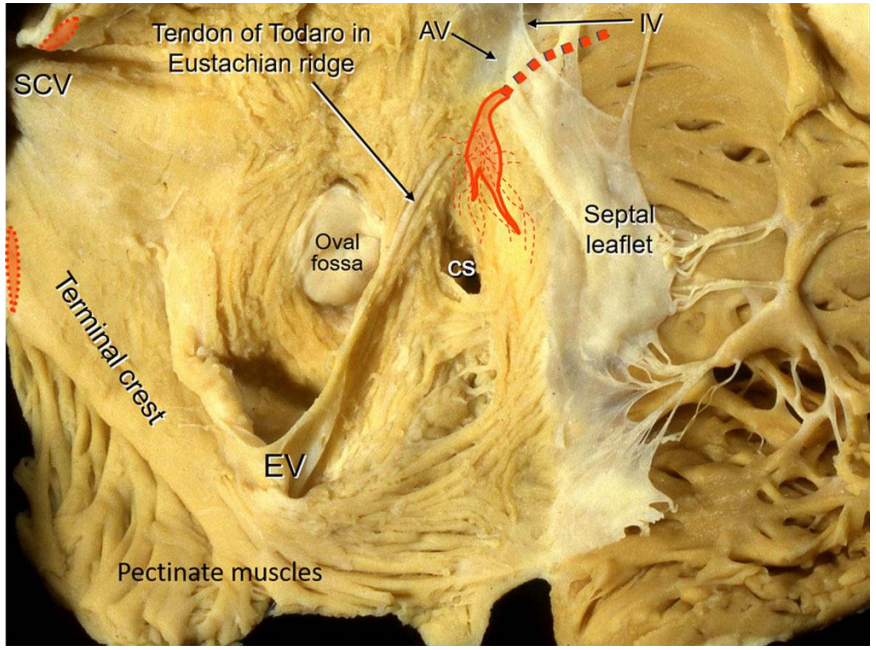


Figure 16 Lead behaviour during penetration of the septum during LBBAP. Both drill and screwdriver effects can result in perforation.



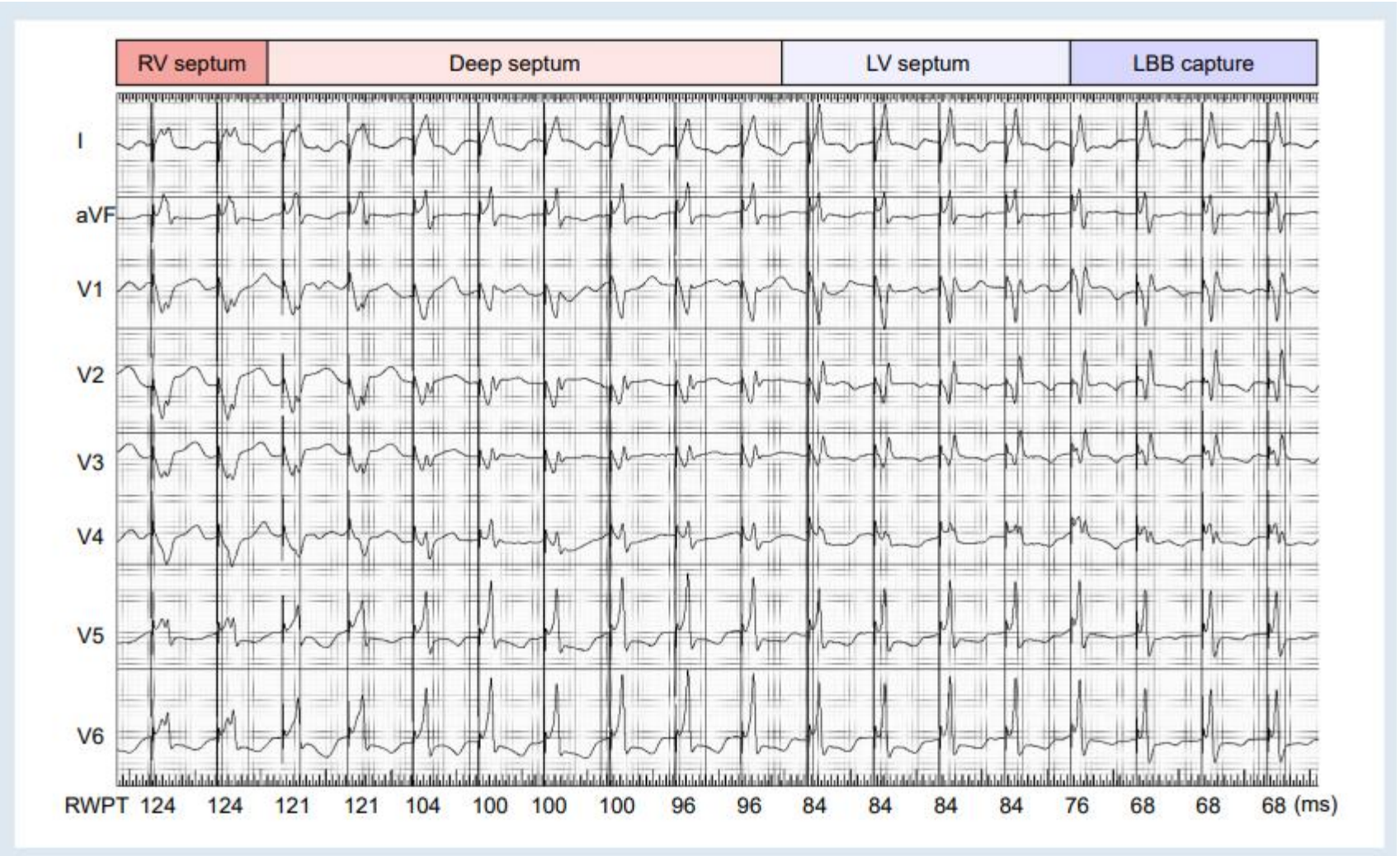
Burri et al, *Europace*, 2023

Step 4: Lead insertion

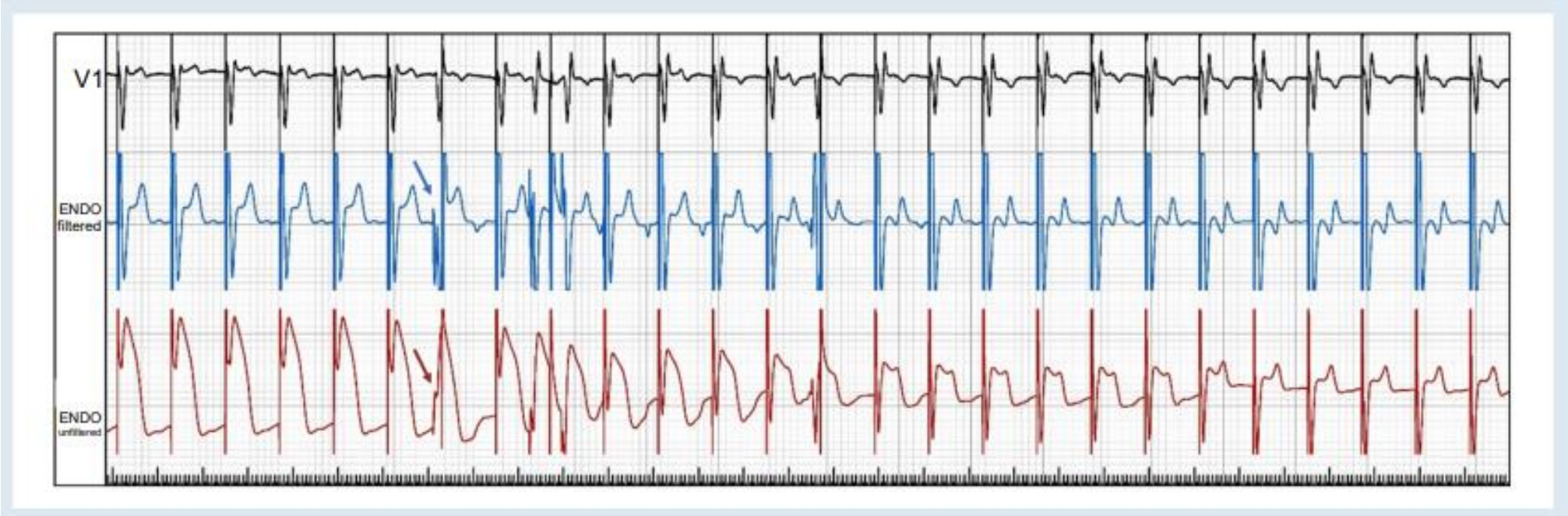
Lead insertion

- Continuous fluroscopy LAO 30-40°
- Continuous pacing : Unipolar 5V
  - ECG modification
  - Myocardial COI
  - Pacing impedance
- Fixation beats
- LBB, LF potential

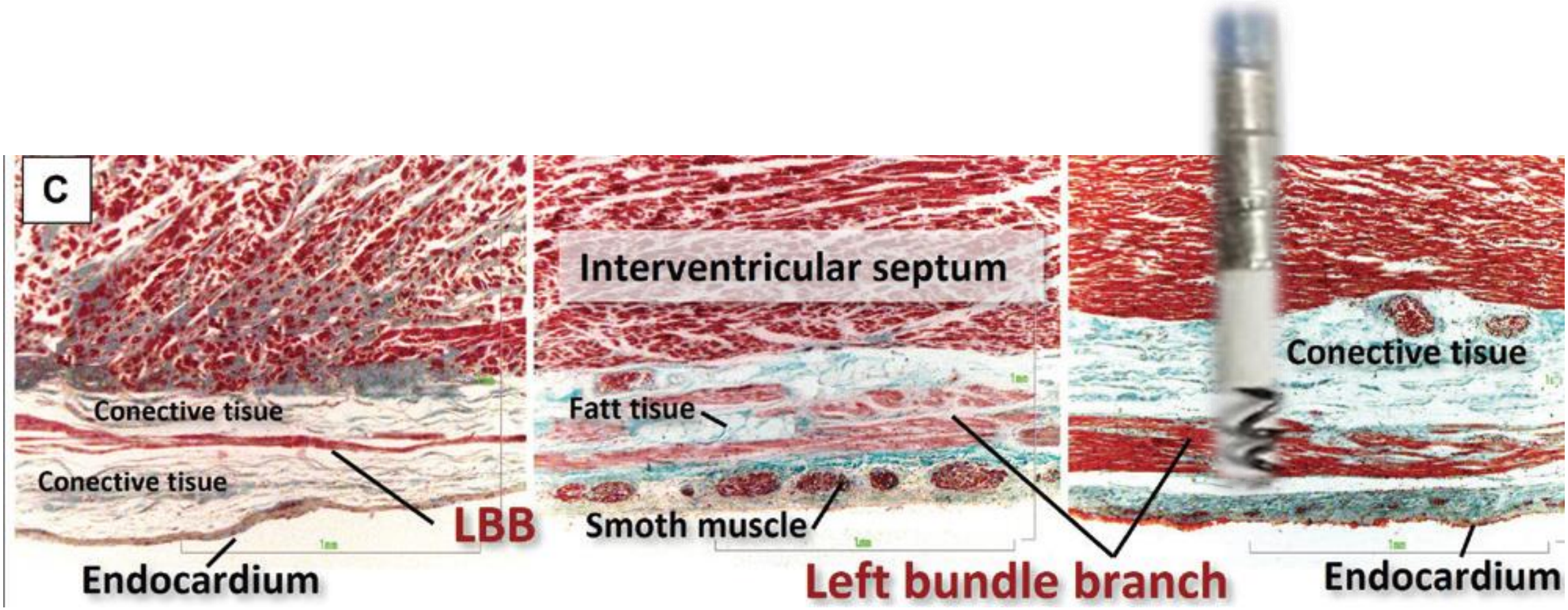
Lead progression : ECG progression



Current of injury



LBB anatomy



Cabrera JÁ et al. *Arrhythm Electrophysiol Rev*. 2021;10(3):181-189.

Complications

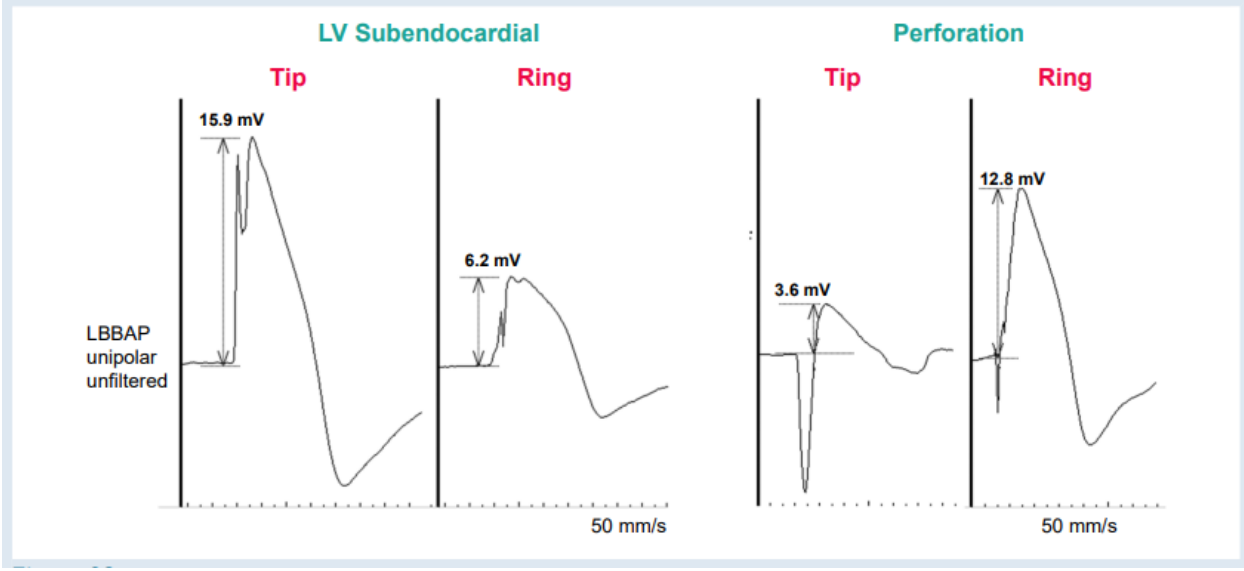
- Septum perforation (2%)
  - Impedance drop
  - Loss of capture
  - COI drop

➢ Reposition the lead

➢ Always asymptomatic (so far)

Table 4 Indicators of septal perforation with LBBAP

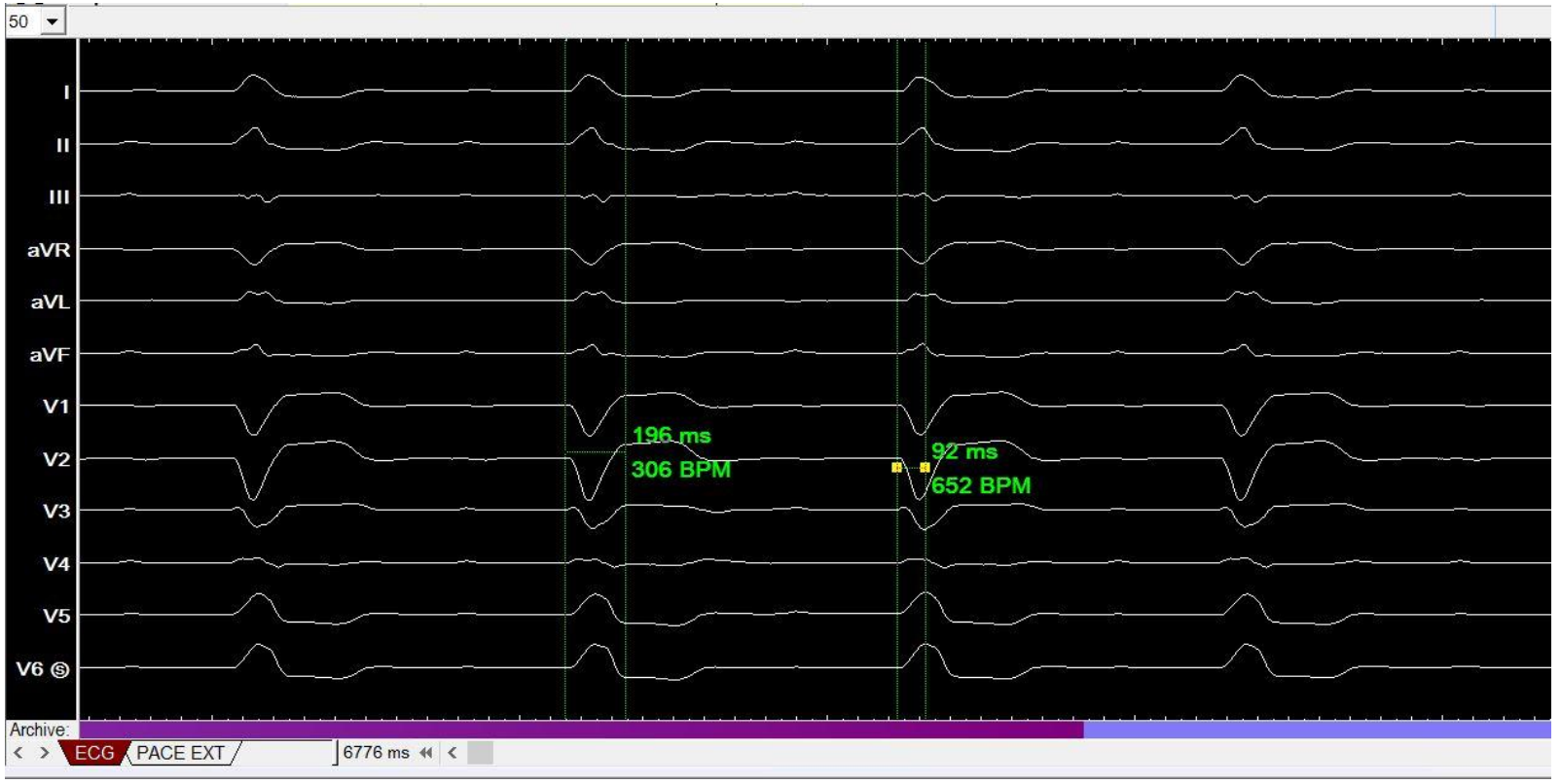
Myocardial COI amplitude
COI < 3–5 mV or absent
COI ring > tip[73]
COI < 25% of V amplitude[73]
Myocardial COI with QS or RS morphology[74]
Drop-in unipolar pacing impedance to <450 Ω[74] (or by >200 Ω)
Worsening of capture/sensing thresholds[24,73]
Loss of LBB/fascicular potential[23]
Contrast dye leakage into LV with injection via the delivery catheter[87]
Overt perforation visualized by lead position/motion on fluoroscopy



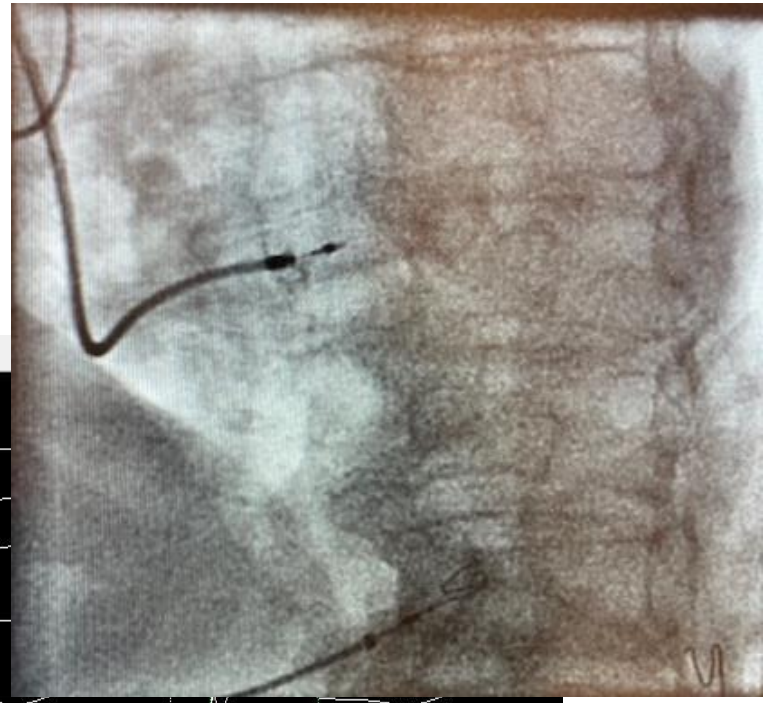
Burri et al, *Europace*, 2023

Patient with CRT indication

- NIDCM
- LVEF 32% (SBP)
- LBBB



No proof of LBB capture (DSP)



LBB capture algorithm

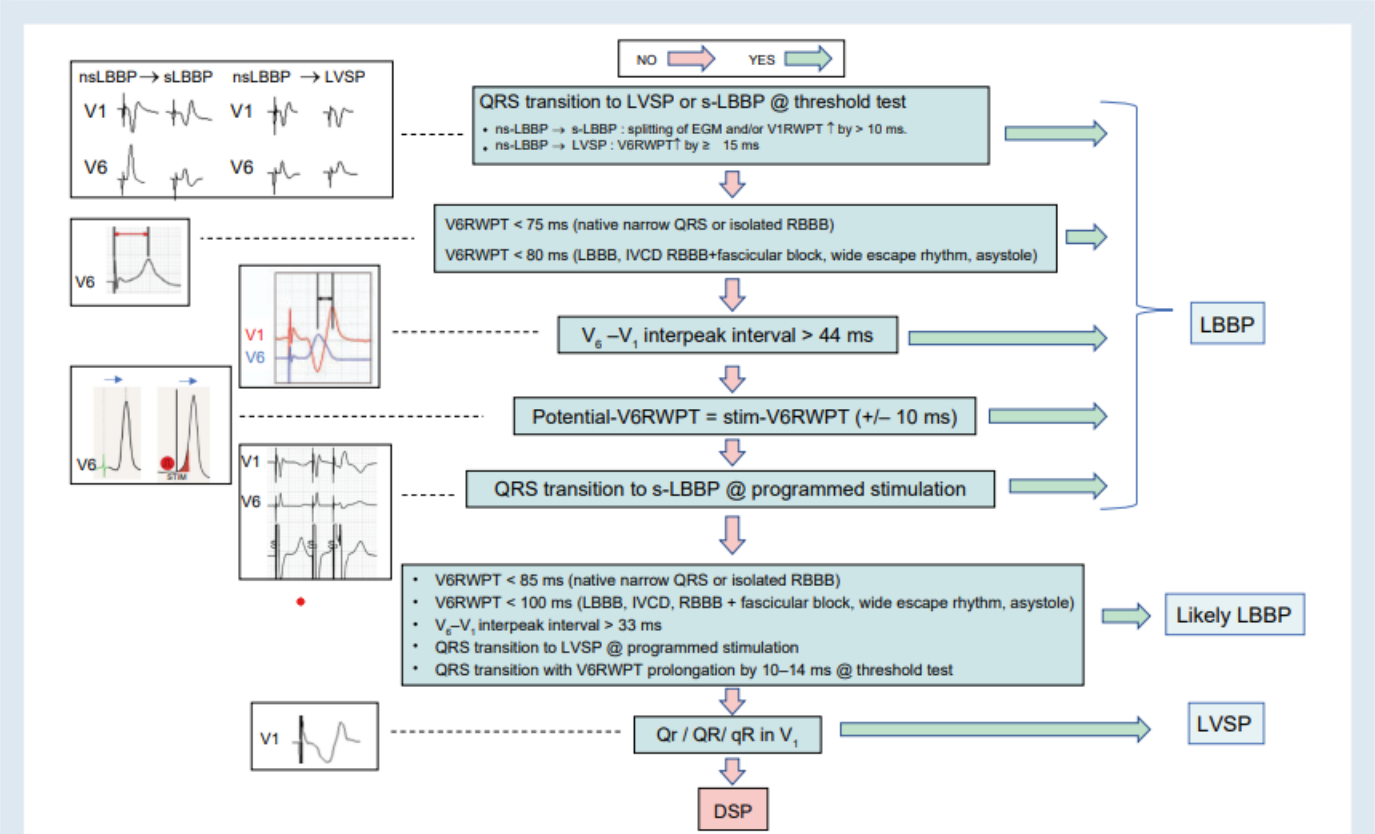
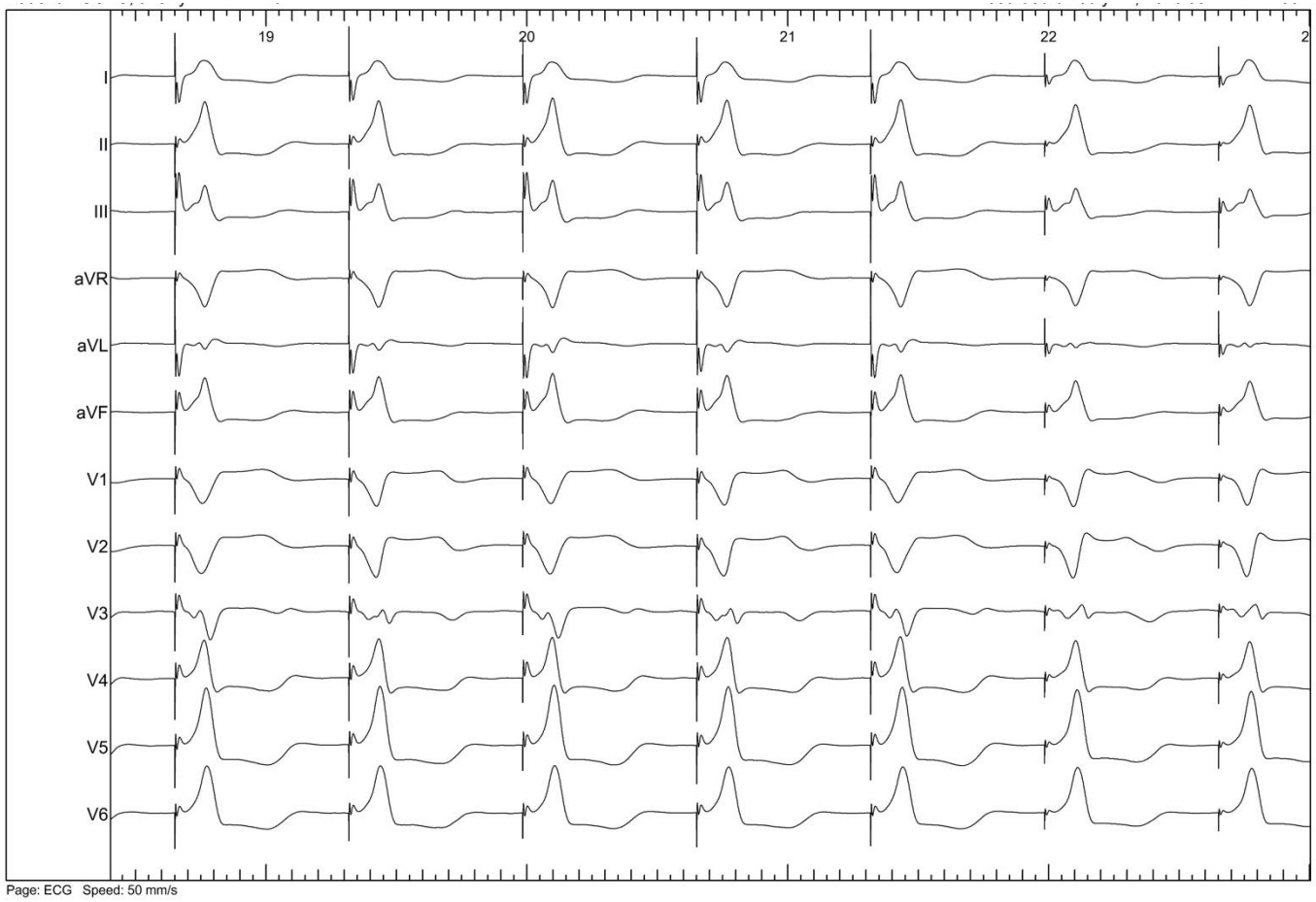
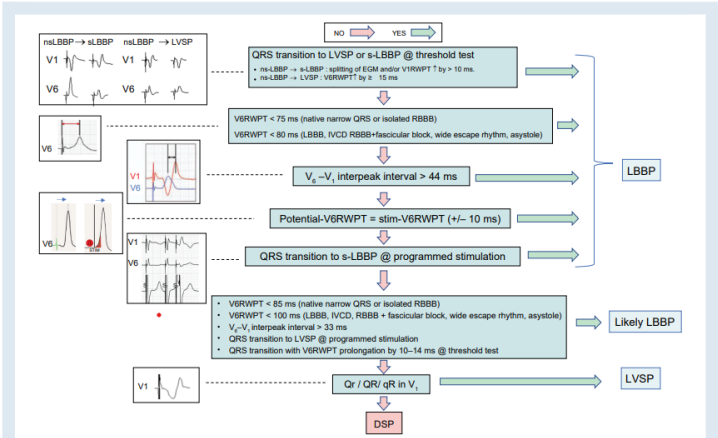


Figure 27 Algorithm for confirming conduction system capture with LBBAP. Some of the steps may be skipped according to operator preference, experience, or feasibility to perform particular measurements/manoeuvres. DSP = deep septal pacing; IVCD = intra-ventricular conduction delay; LBBAP = left bundle branch area pacing; LBBB = left bundle branch block; ns-LBBP = non-selective left bundle branch pacing; RBBB = right bundle branch block; RBBP = right bundle branch pacing; RVVPT = R-wave peak time; s-LBBP = selective left bundle branch pacing.

Burri et al, *Europace*, 2023

QRS transition





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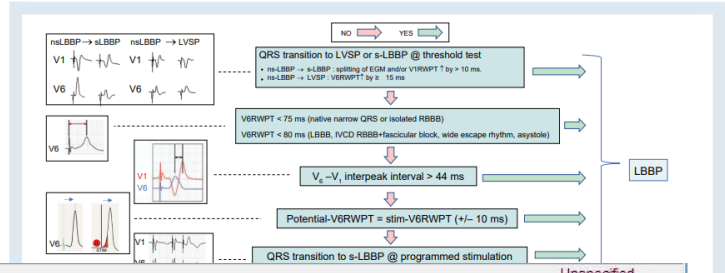
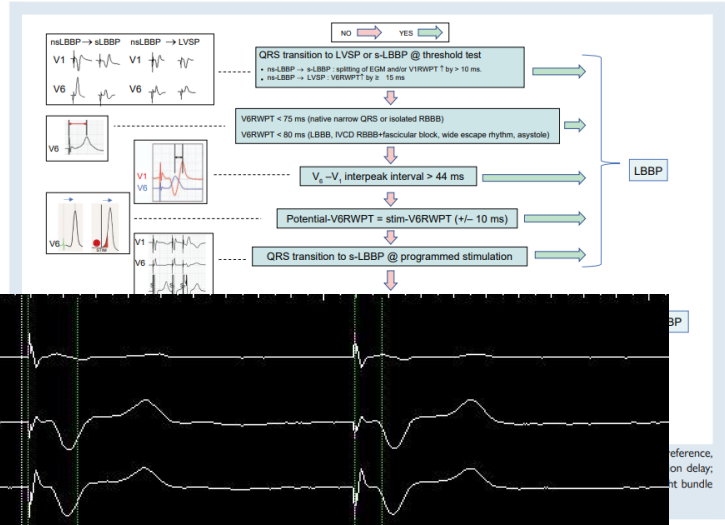
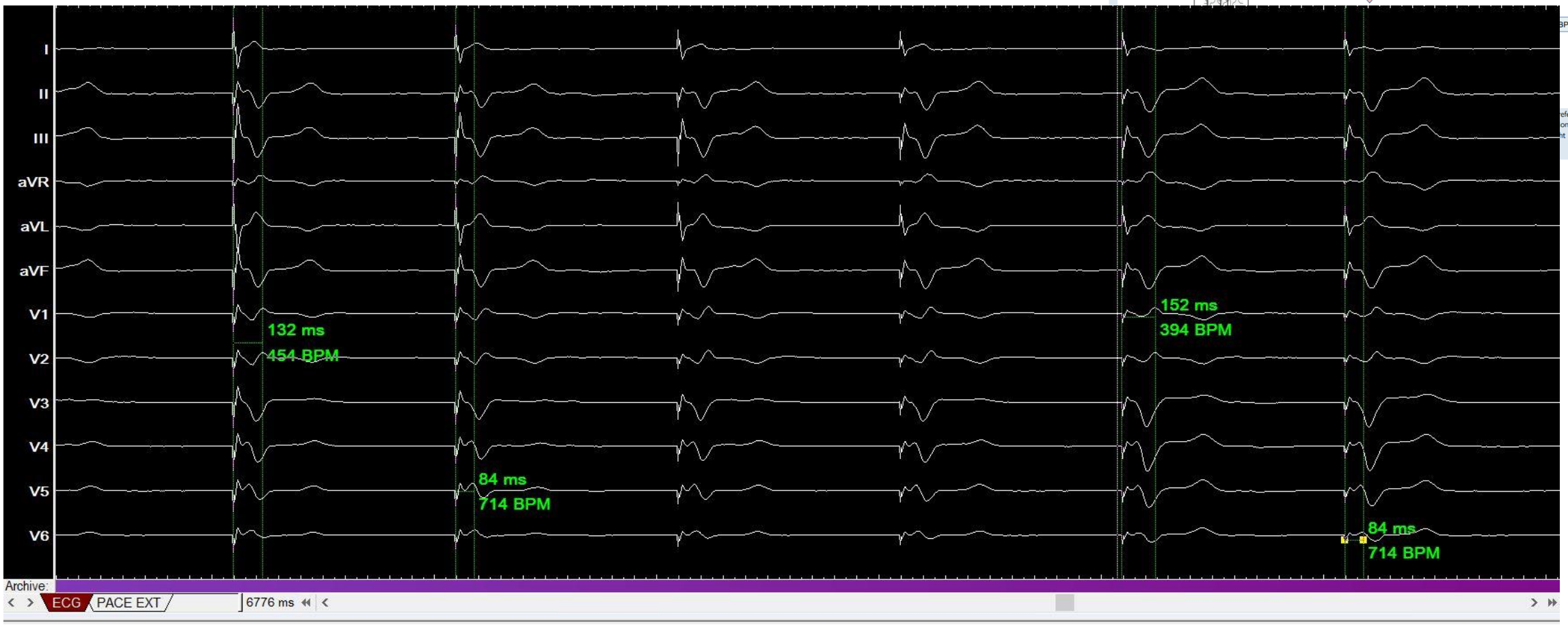
QRS transition

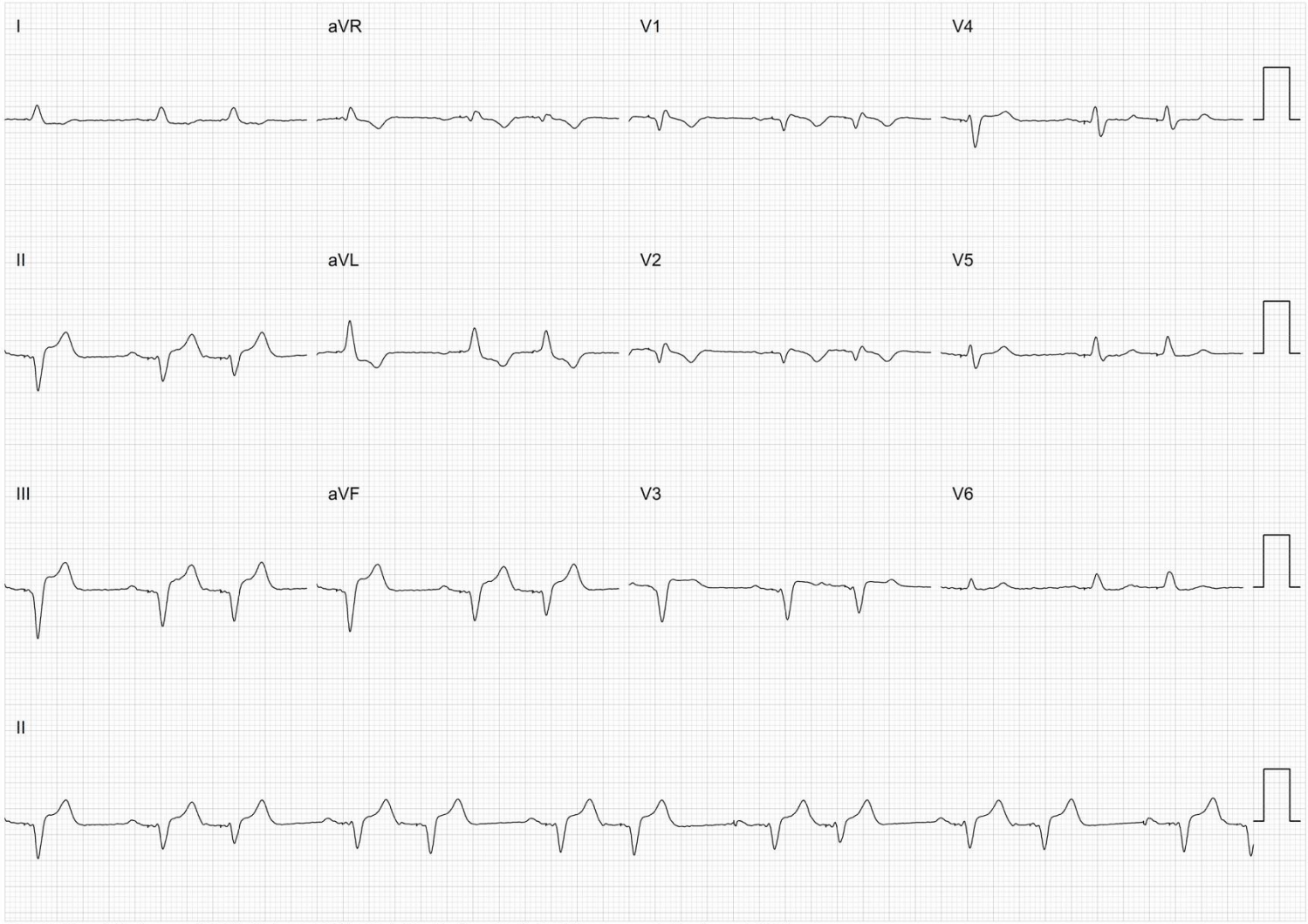


QRS transition





QRS transition



V6 RWPT


I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
LBB lead
80 ms
80 ms
92 ms
NATIVE CONDUCTION
ns-LBBP
LV-septal

V6-V1 interpeak interval

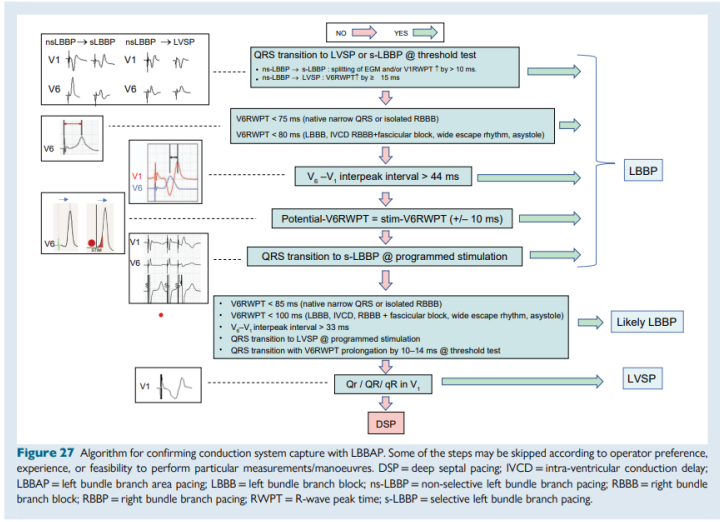


Figure 27 Algorithm for confirming conduction system capture with LBBAP. Some of the steps may be skipped according to operator preference, experience, or feasibility to perform particular measurements/manoeuvres. DSP = deep septal pacing; IVCD = intra-ventricular conduction delay; LBBAP = left bundle branch area pacing; LBBB = left bundle branch block; ns-LBBP = non-selective left bundle branch pacing; RBBB = right bundle branch block; RBBP = right bundle branch pacing; RWPT = R-wave peak time; s-LBBP = selective left bundle branch pacing.

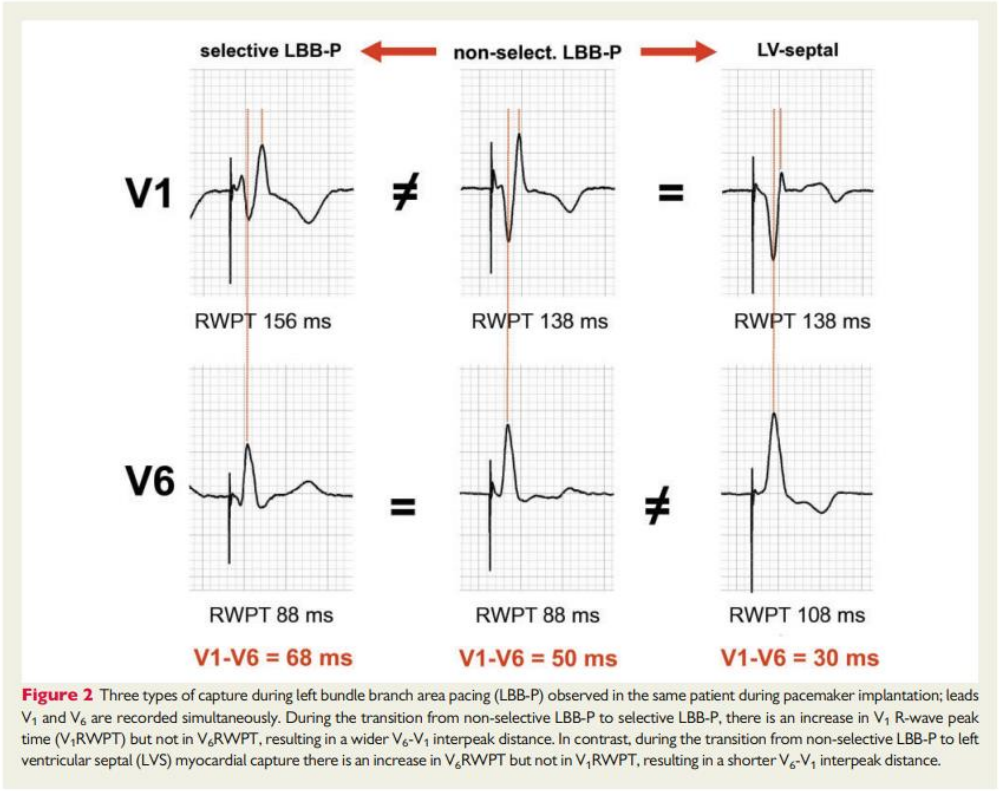
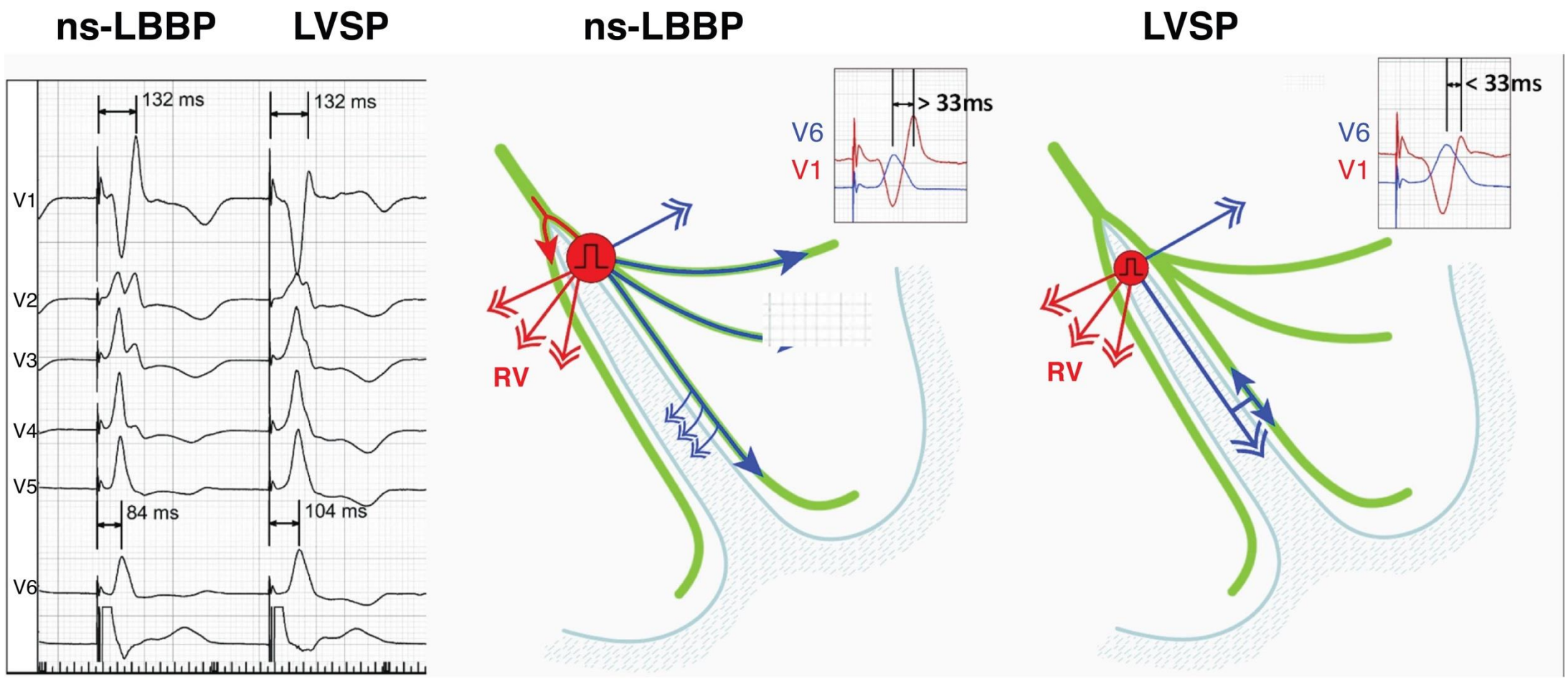


Figure 2 Three types of capture during left bundle branch area pacing (LBB-P) observed in the same patient during pacemaker implantation; leads V_1 and V_6 are recorded simultaneously. During the transition from non-selective LBB-P to selective LBB-P, there is an increase in V_1 R-wave peak time (V_1RWPT) but not in V_6RWPT, resulting in a wider V_6-V_1 interpeak distance. In contrast, during the transition from non-selective LBB-P to left ventricular septal (LVS) myocardial capture there is an increase in V_6RWPT but not in V_1RWPT, resulting in a shorter V_6-V_1 interpeak distance.

V6-V1 interval > 44ms

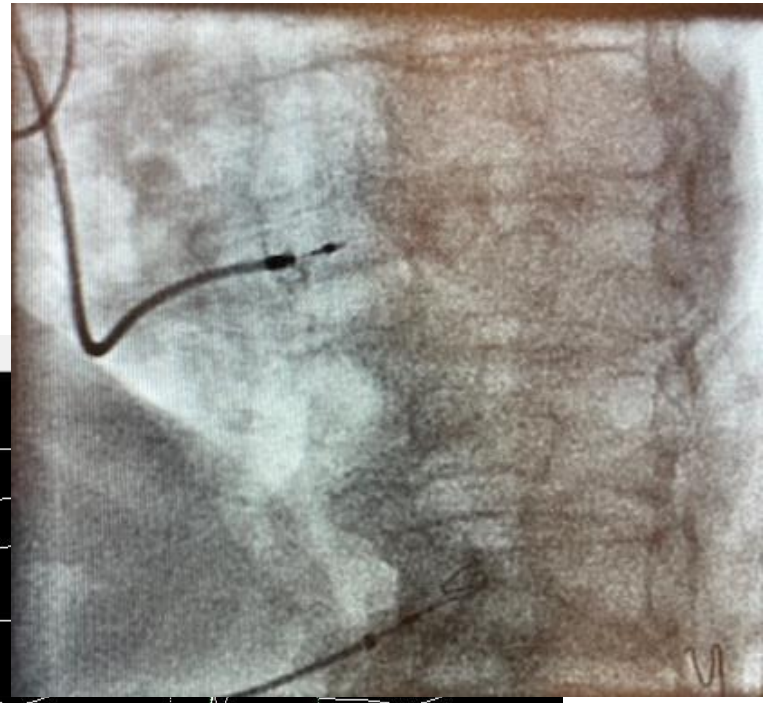
Jastrzebski et al, *Europace*, 2022

V6–V1 Criterion to confirm LBB capture

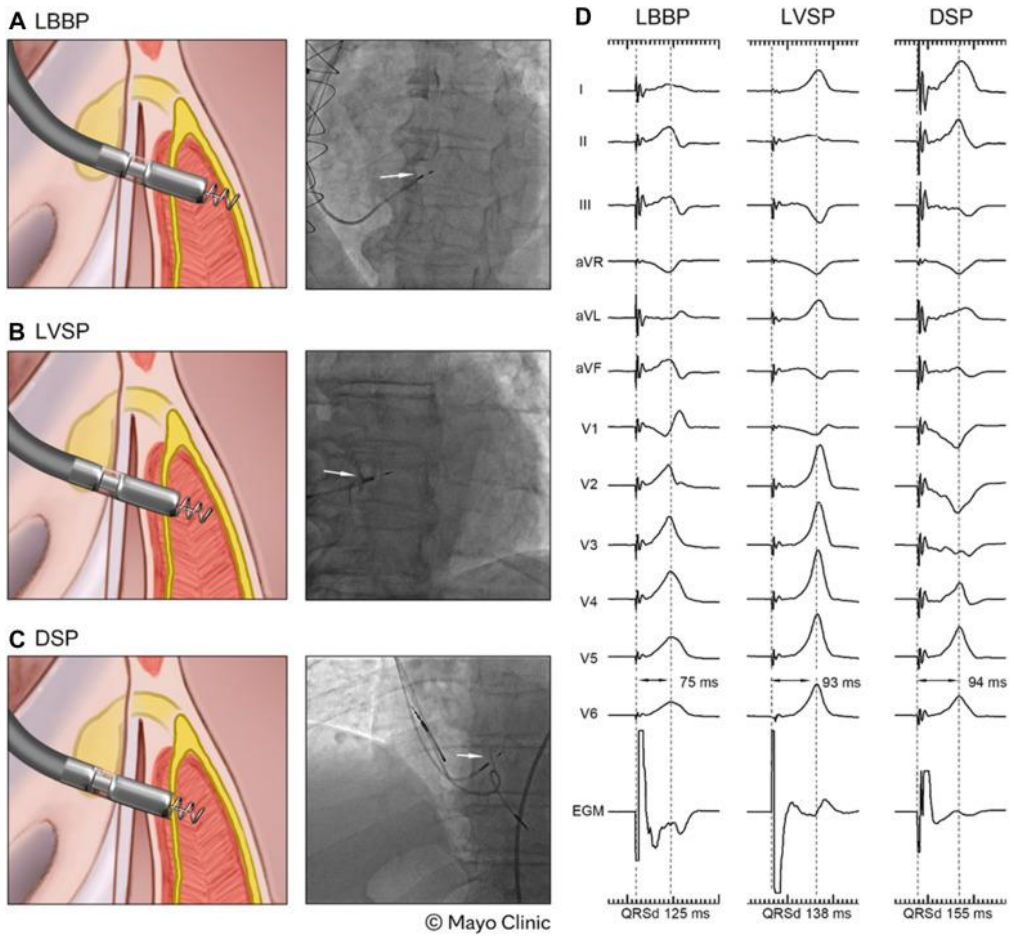


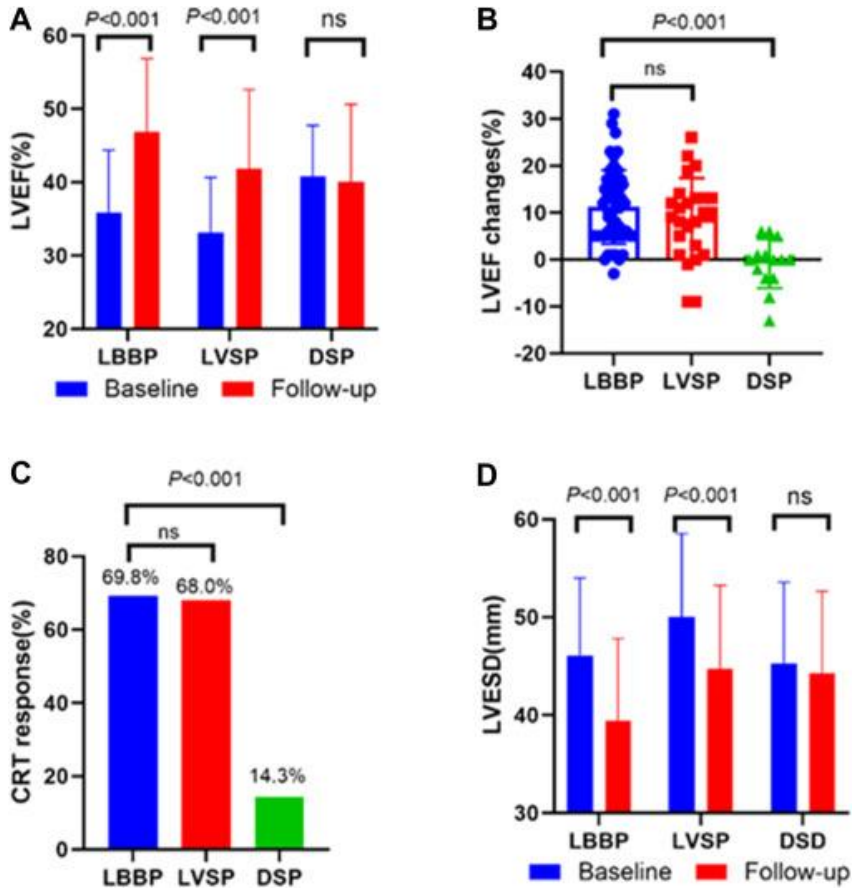
Jastrzebski et al. EUROPACE (2022) 24, 40-47

No proof of LBB capture (DSP)



Deep septal pacing

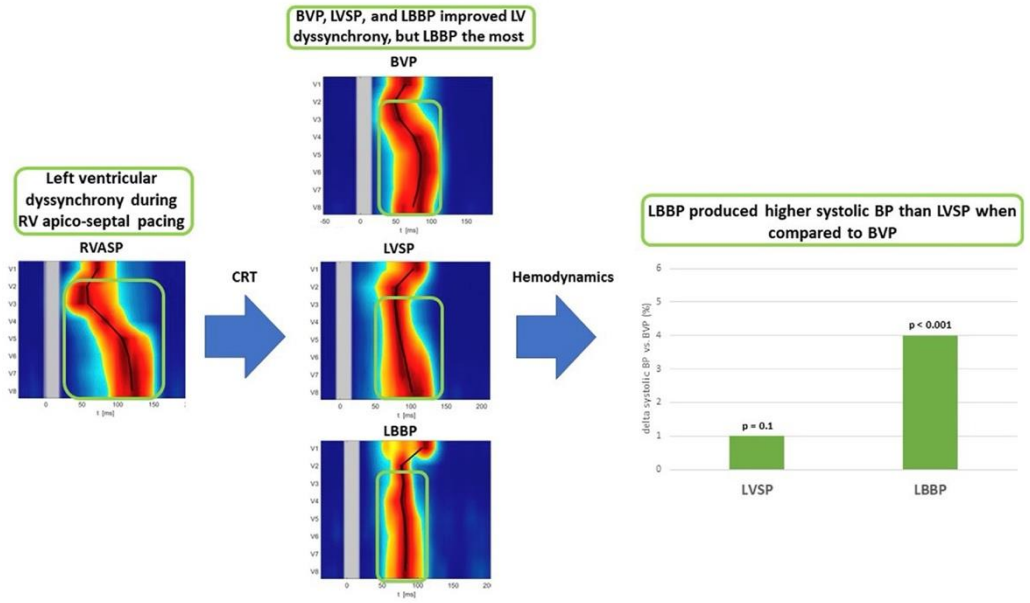




Chen et al, *Heart Rhythm O2*, 2024

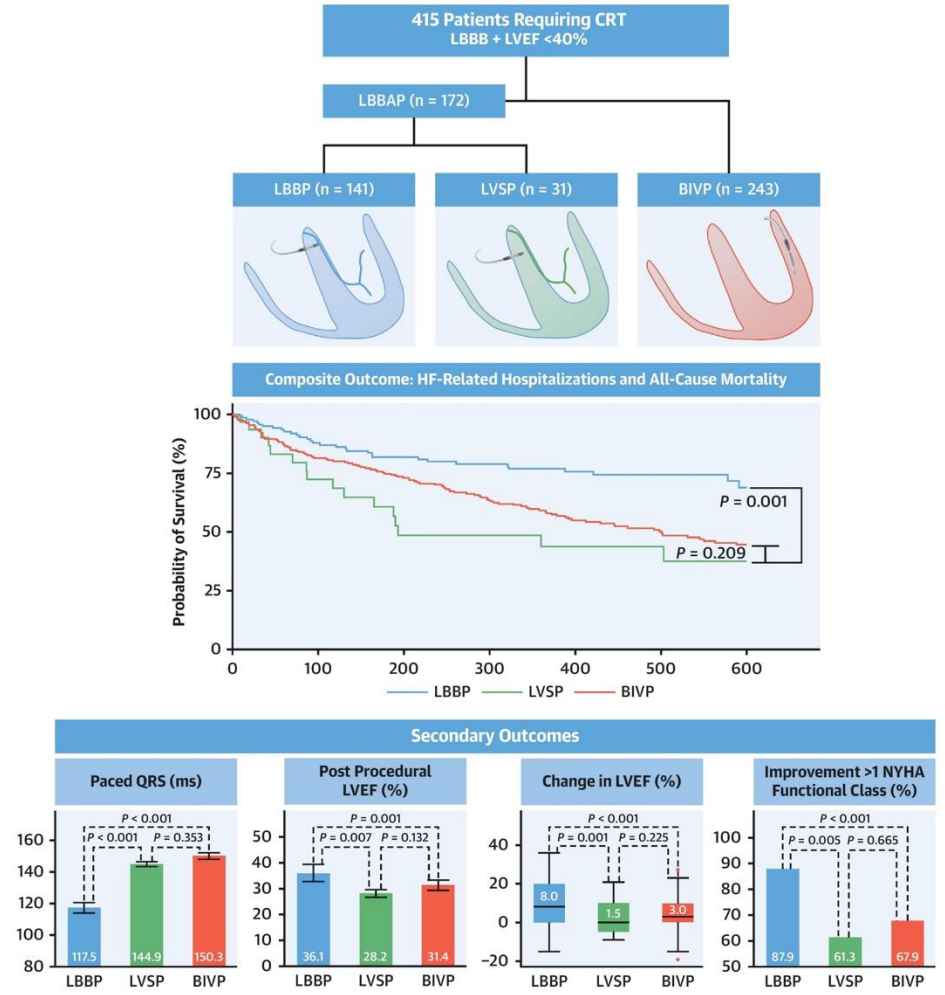
LBBP vs LVSP vs BiVP

CENTRAL ILLUSTRATION: BVP, LVSP, and LBBP Lead to LV Resynchronization Compared With RVASP. Better LV Synchrony During LBBP Translates to Higher Systolic Blood Pressure Increase Than During LVSP Compared With BVP



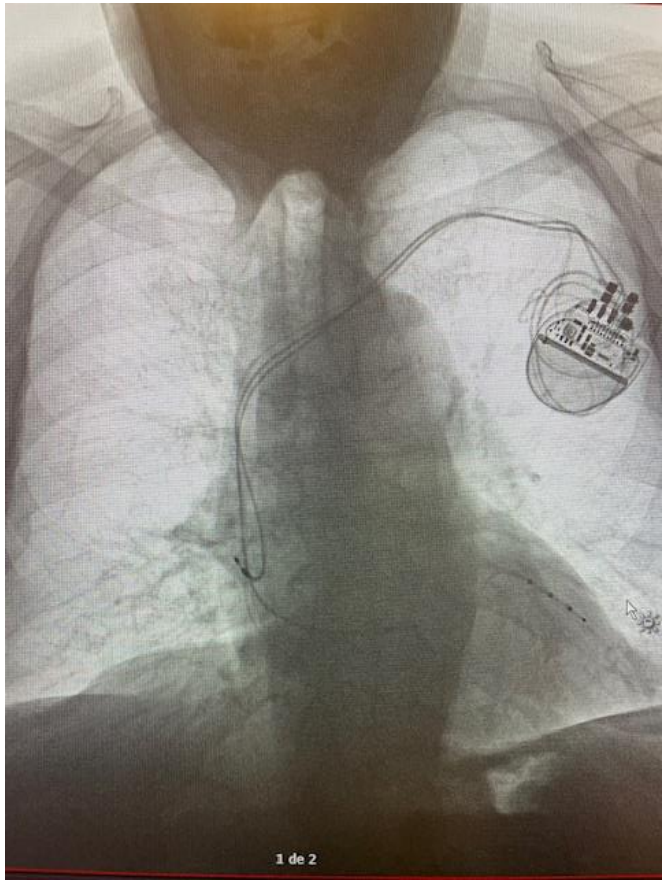
Curila K, et al. J Am Coll Cardiol EP. 2024;10(7):1722-1732.

CENTRAL ILLUSTRATION: LBBP vs LVSP vs BIVP for Cardiac Resynchronization Therapy



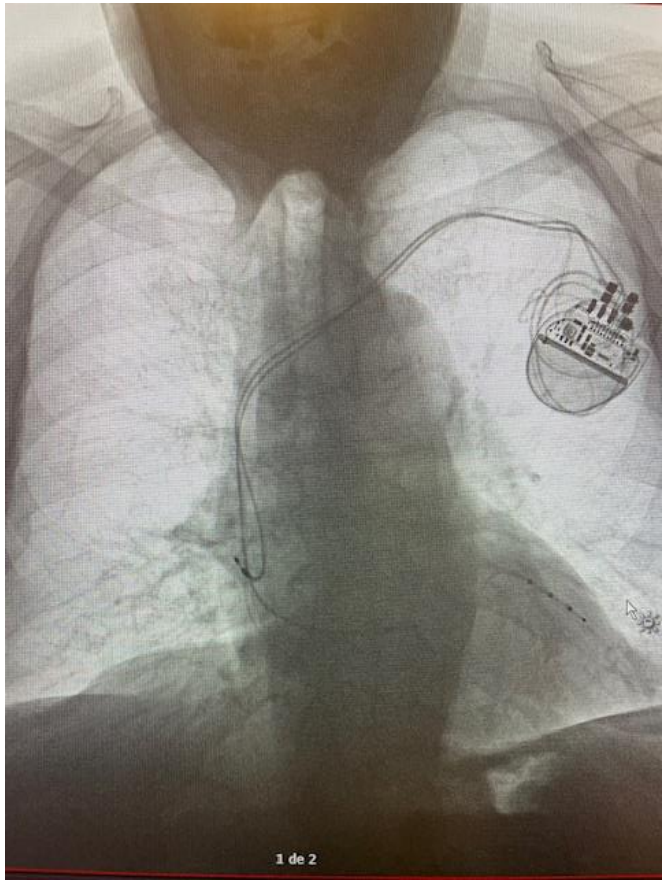
Diaz JC, et al. J Am Coll Cardiol EP. 2024;10(2):295-305.

Back to our patient: upgrade to BiV pacing

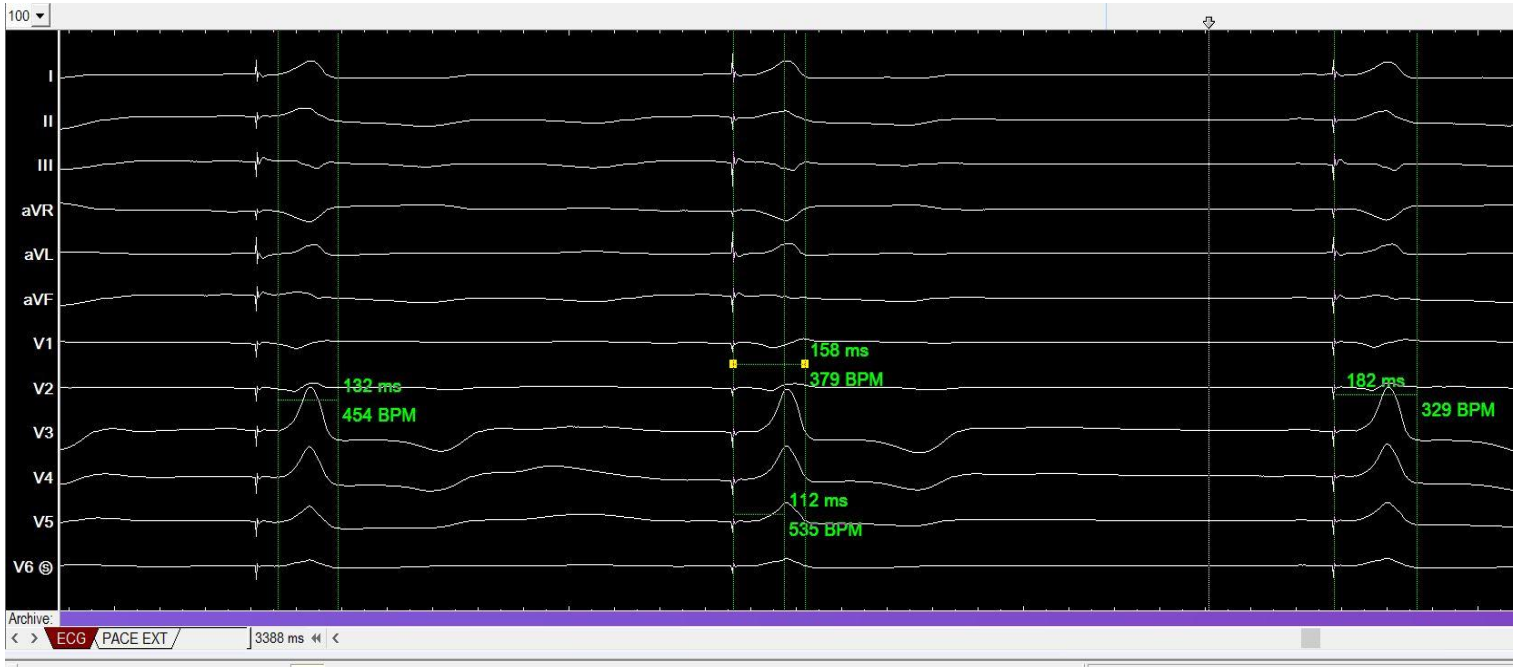


LV only

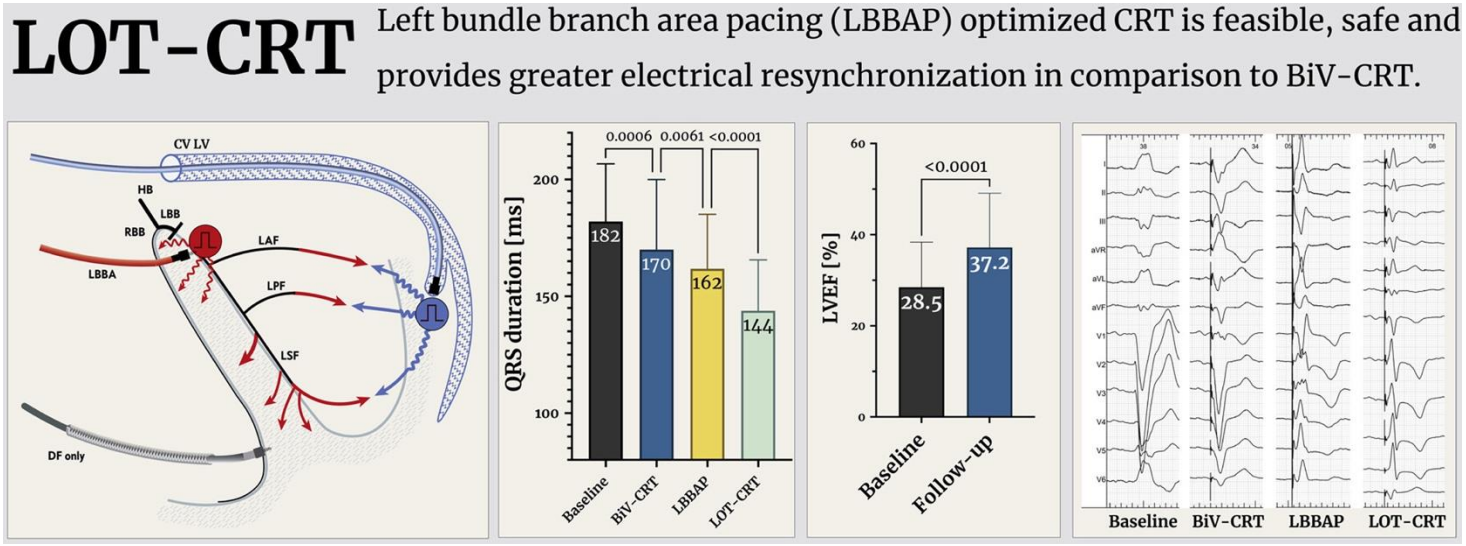
Back to our patient: upgrade to BiV pacing



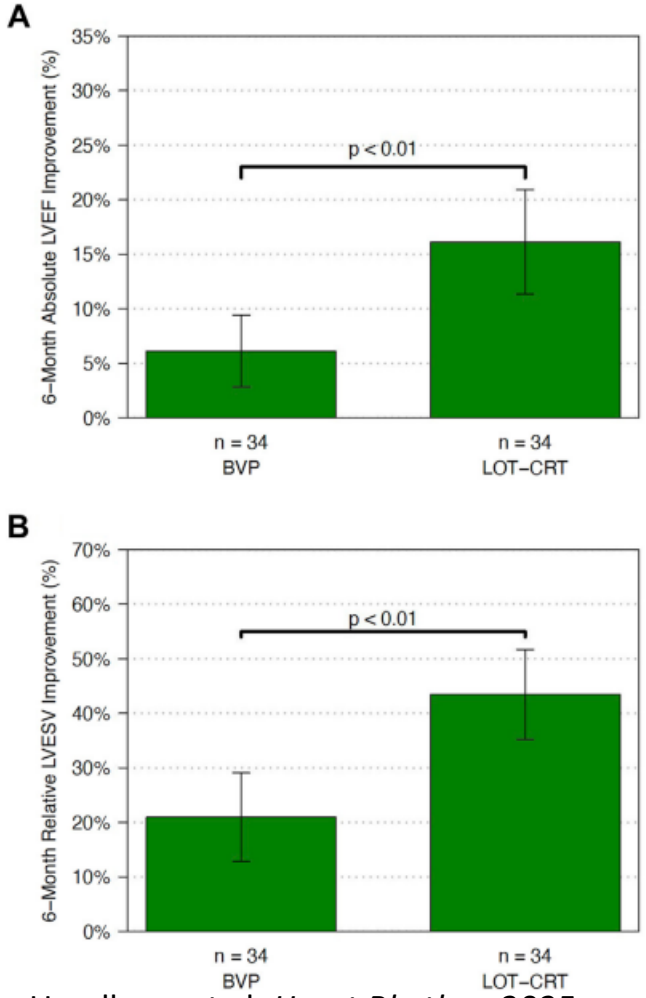
BiV pacing



LOT CRT



Jastrzebski et al, *Heart Rhythm*, 2022



Upadhyay et al, *Heart Rhythm*, 2025

CSP in 2025

- Will become the gold standard for ventricular pacing
- Probably as good as BiV pacing for CRT
- Dedicated lead
- Dedicated tools
- Various range of sheaths
- Scientific background and consensus paper

Able to address most of the cases but not all…