Identifying the Origin of VT ：
ECG Correlation and Entrainment

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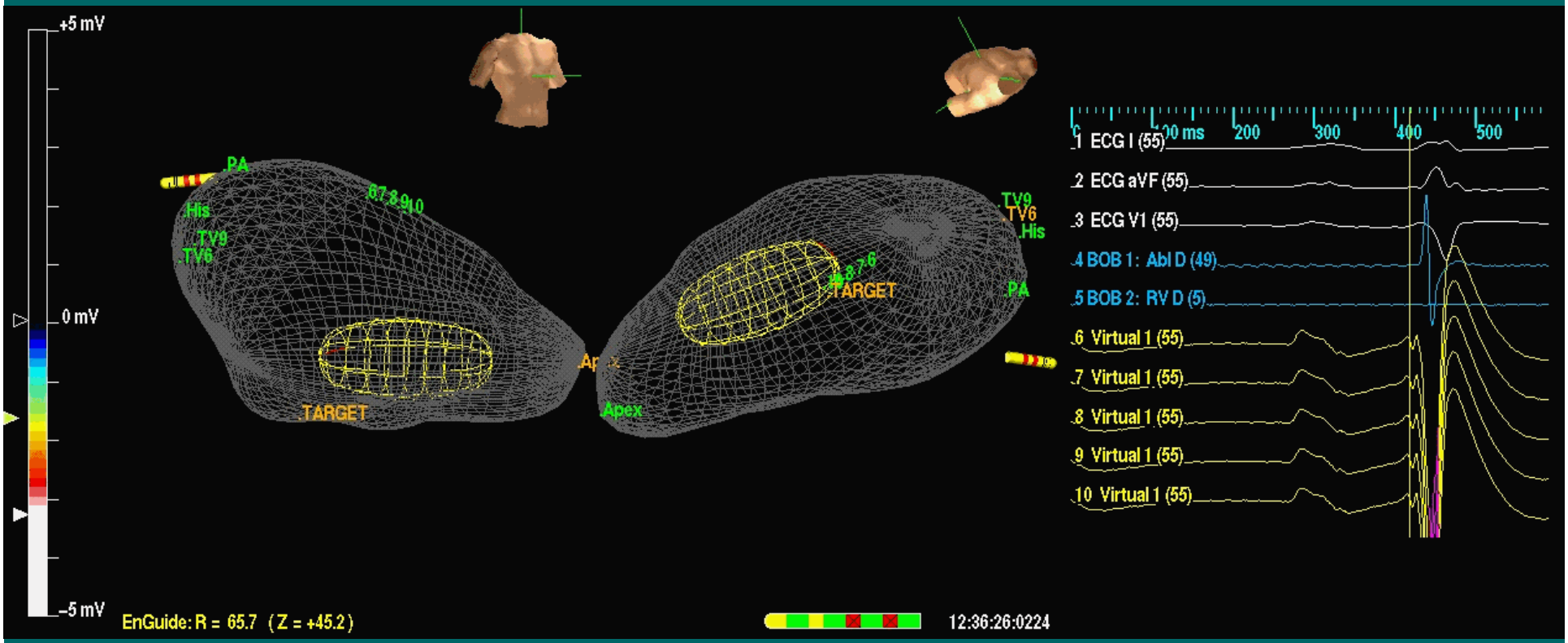
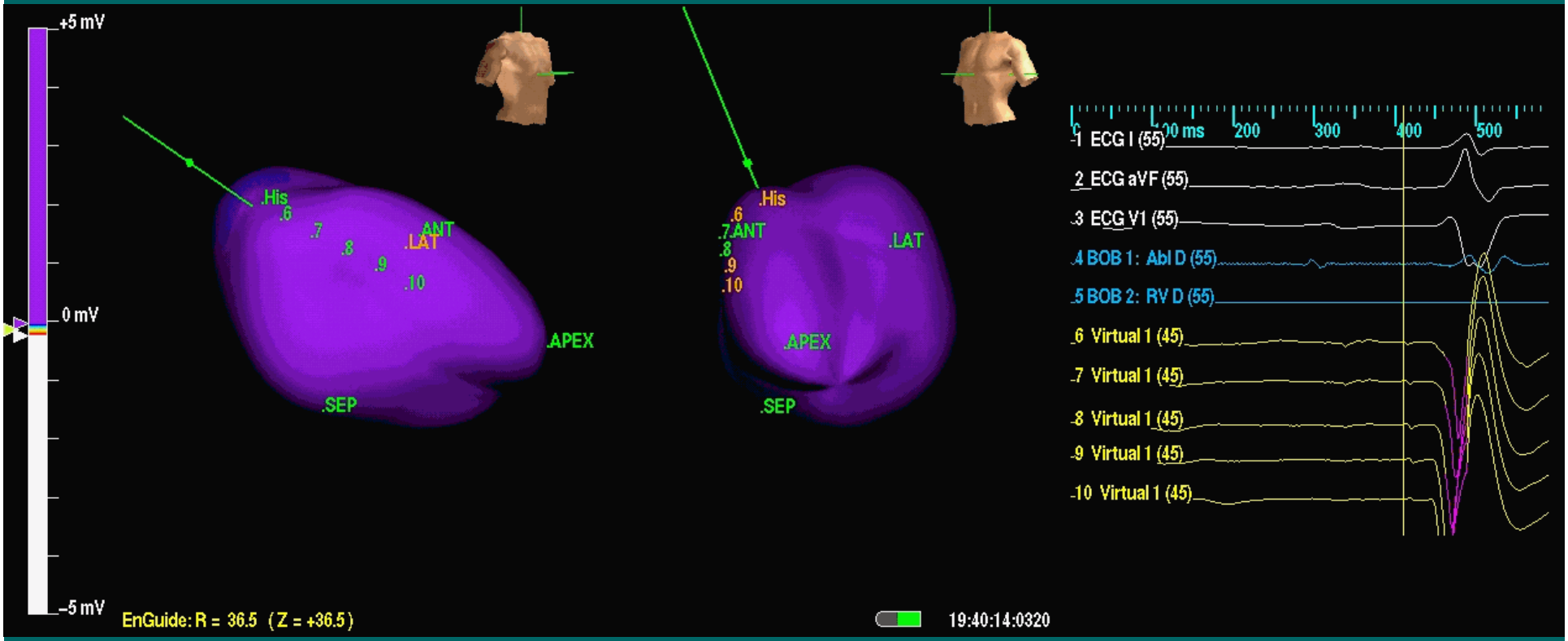
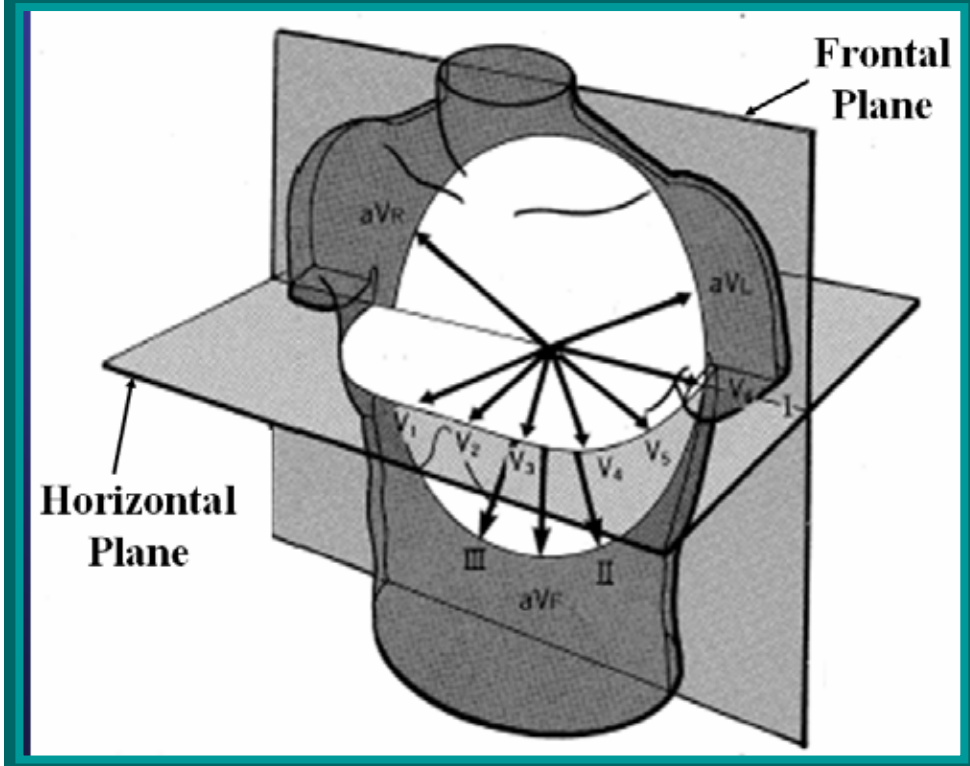
Activation of Right Ventricle (RV) during Sinus Rhythm

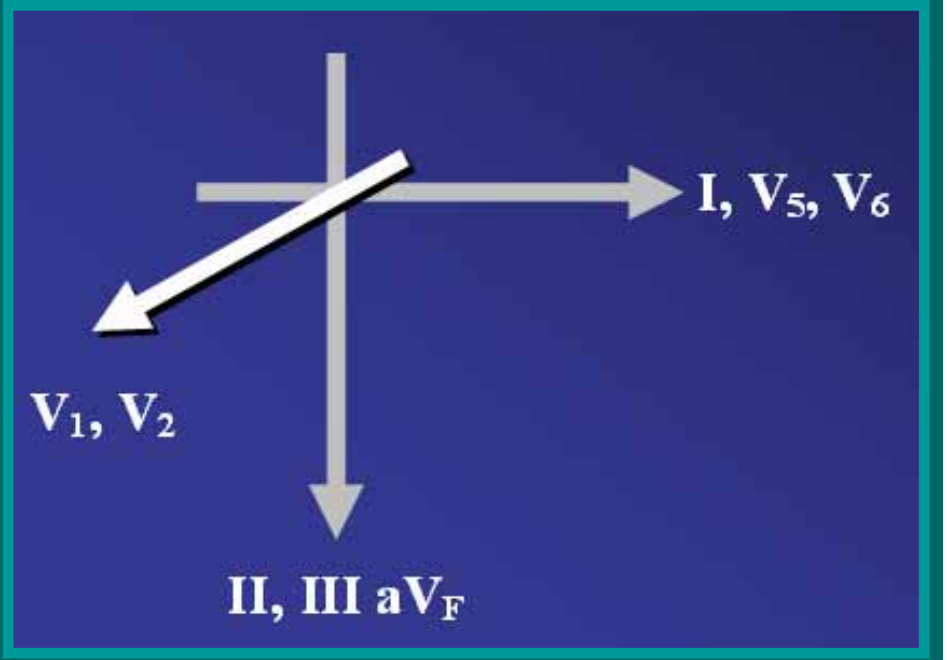


Activation of Left Ventricle (LV) during Sinus Rhythm

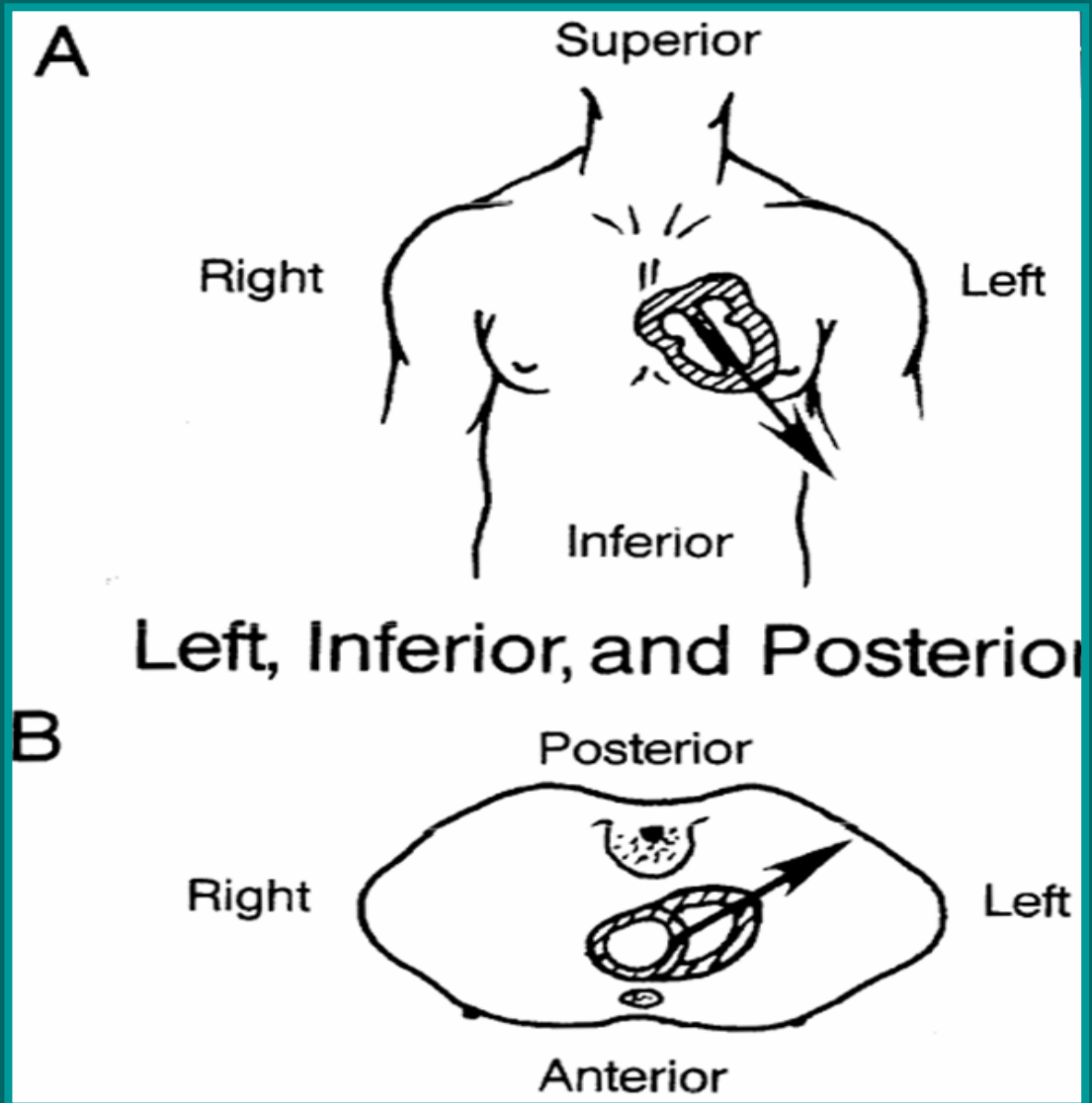


Frontal versus Horizontal Planes



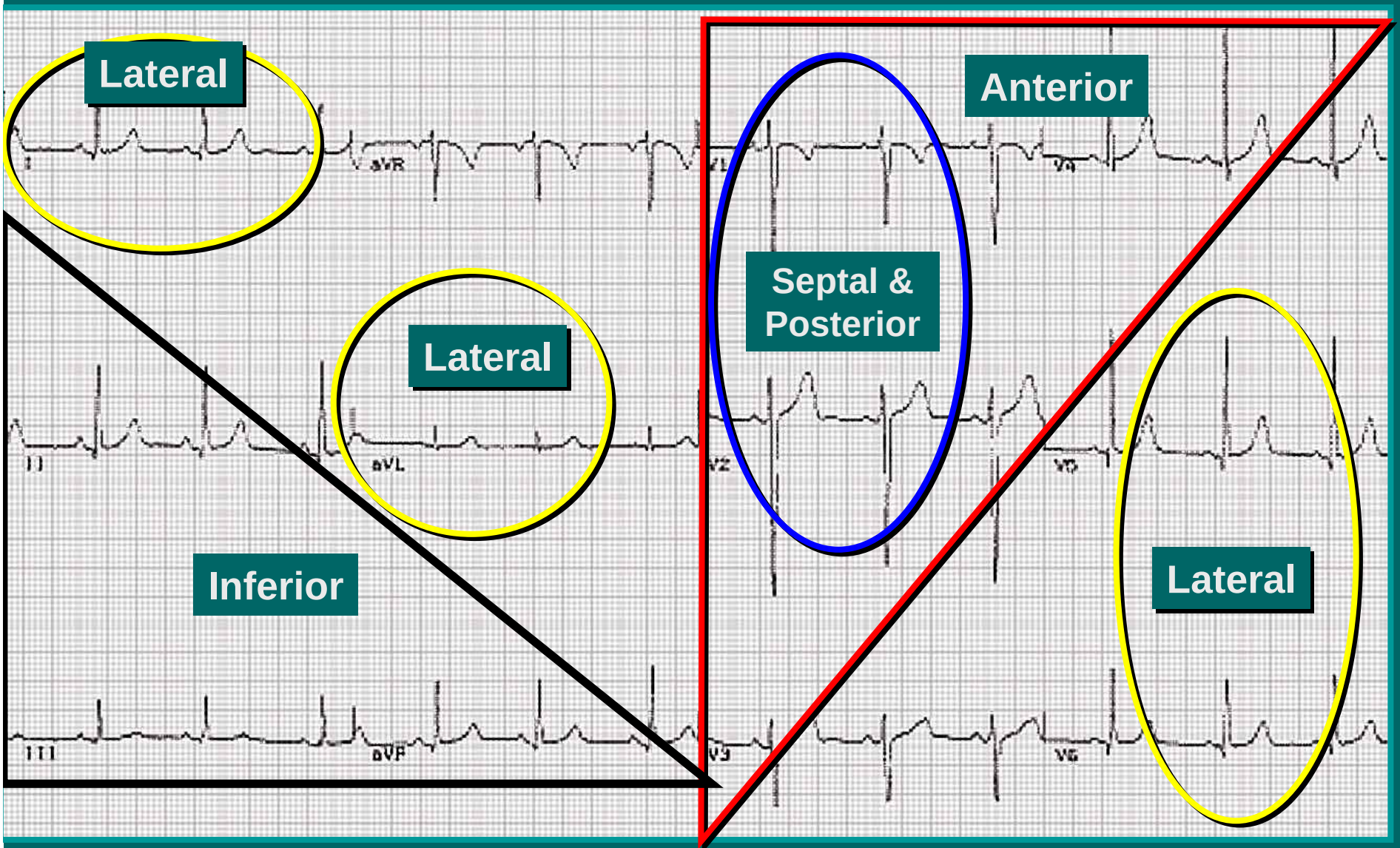


Normal QRS Vector in Three Dimensions



Emanuel Stein

Lead Grouping According to the Region They Covered

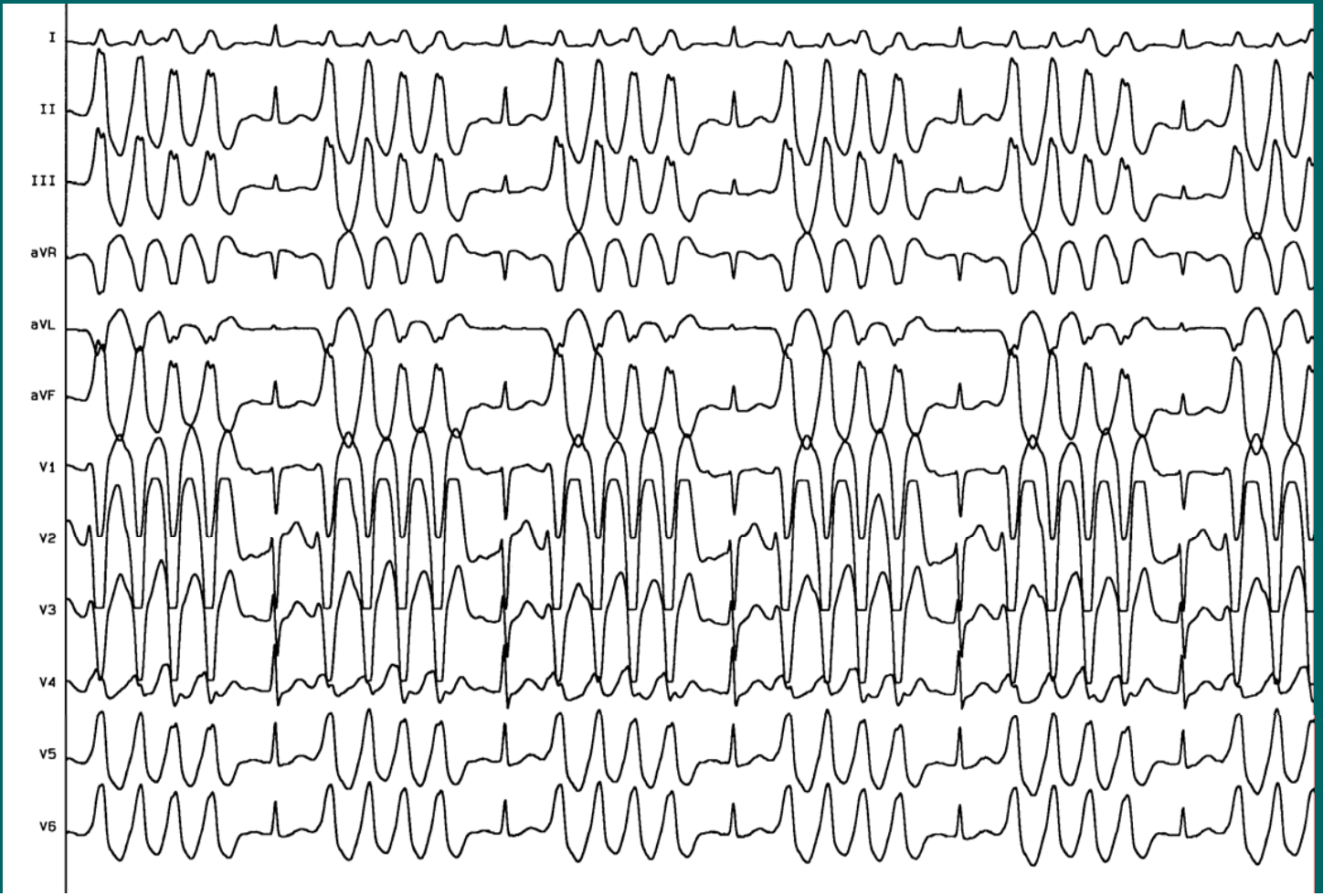


The Most Common Clinical VT Types

- Idiopathic VT:
  - Ventricular Outflow Tract (VOT) VT:
    - ***RVOT VT;***
    - ***LVOT VT;***
  - Idiopathic Left VT:
    - ***Fascicular LVT;***
    - ***Basal LVT;***
- Structural VT:
  - Ischemic VT;
  - ARVC VT;
  - Bundle Branch Reentrant (BBR) VT;
  - Others (DCM, HCM, Chaga, et al.);

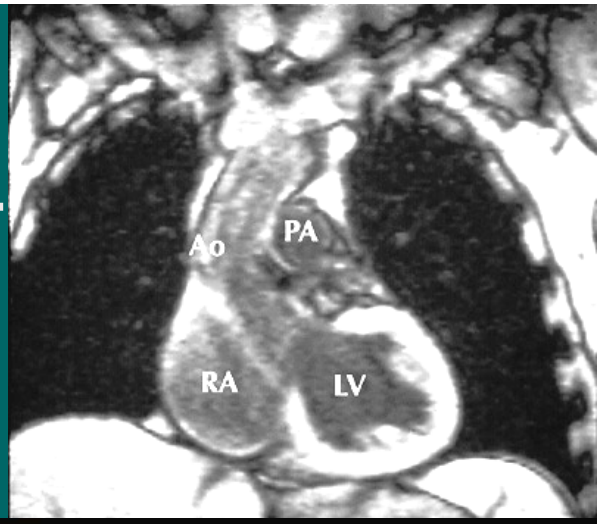
1, RVOT VT

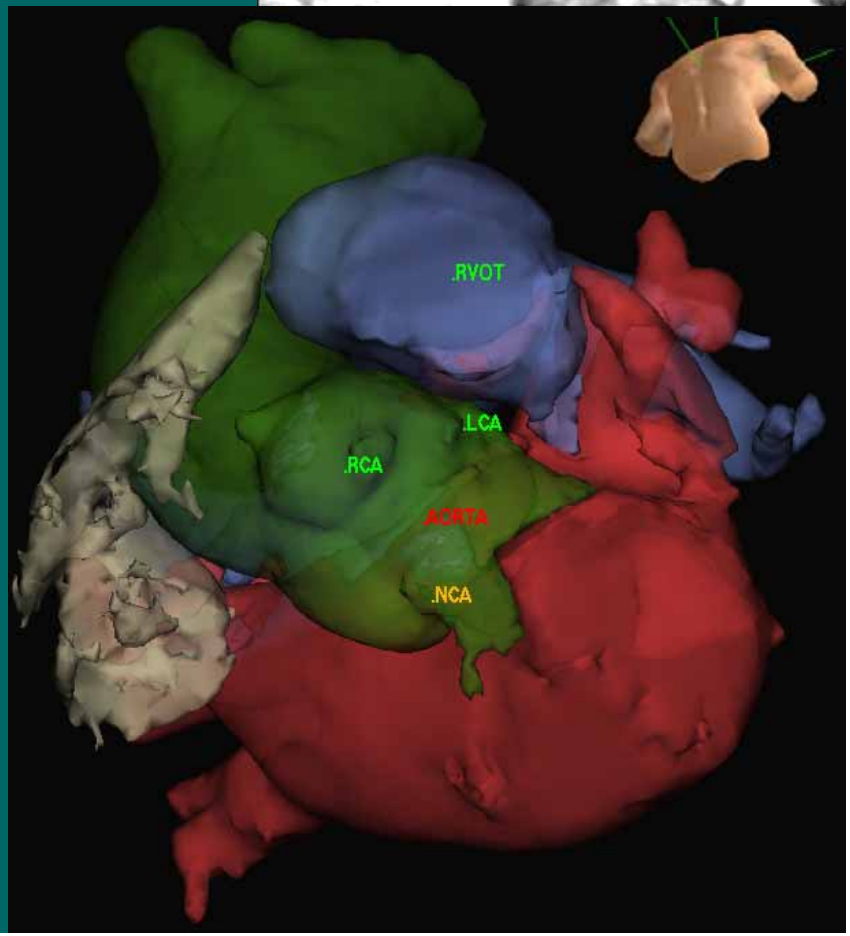
- The most common VT type;
- ECG features: LBBB + Inferior QRS axis;



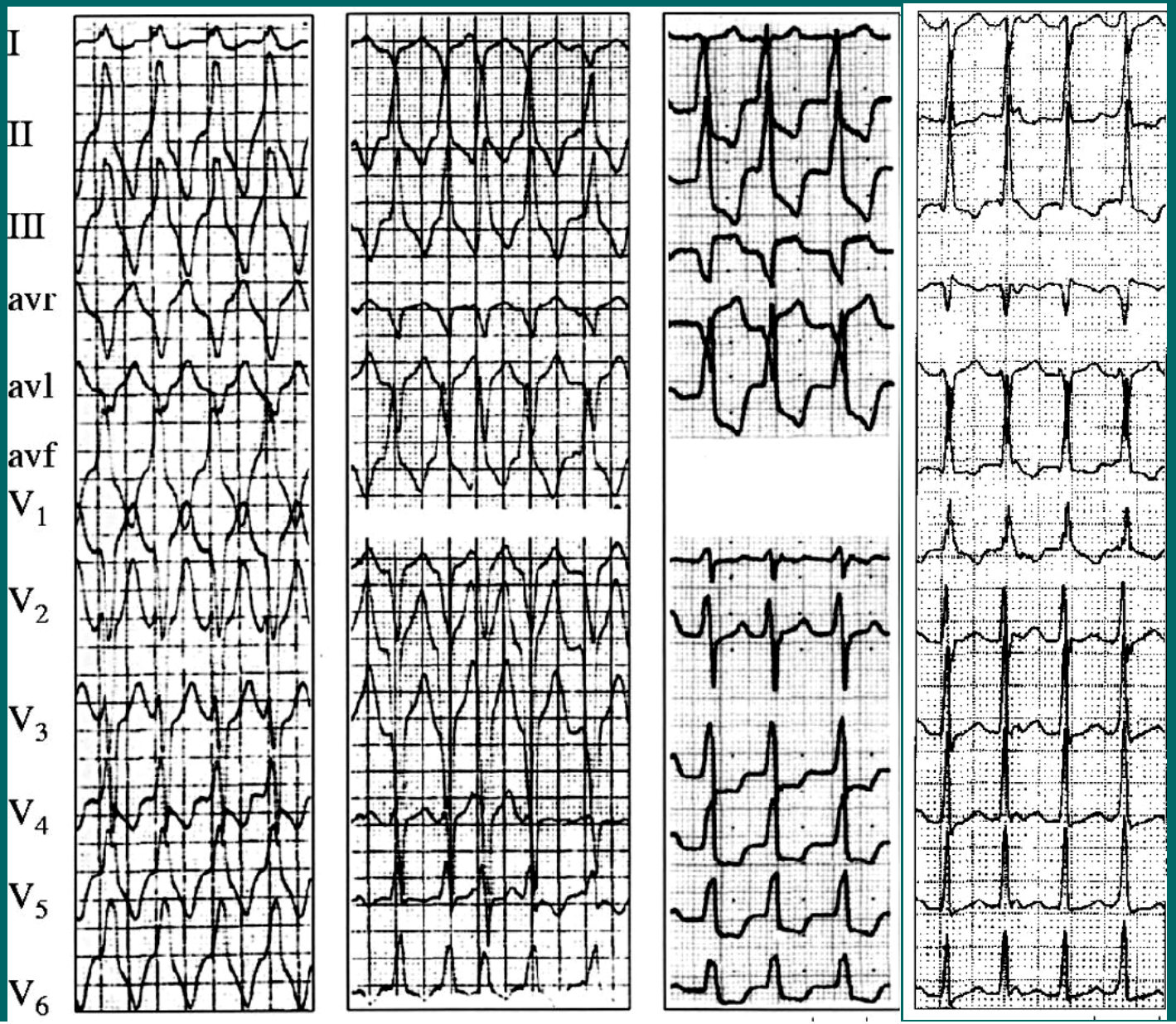
Anatomic Considerations

PA is superior, anterior and leftward of Aorta.
RVOT is adjacent to Aortic cusp.

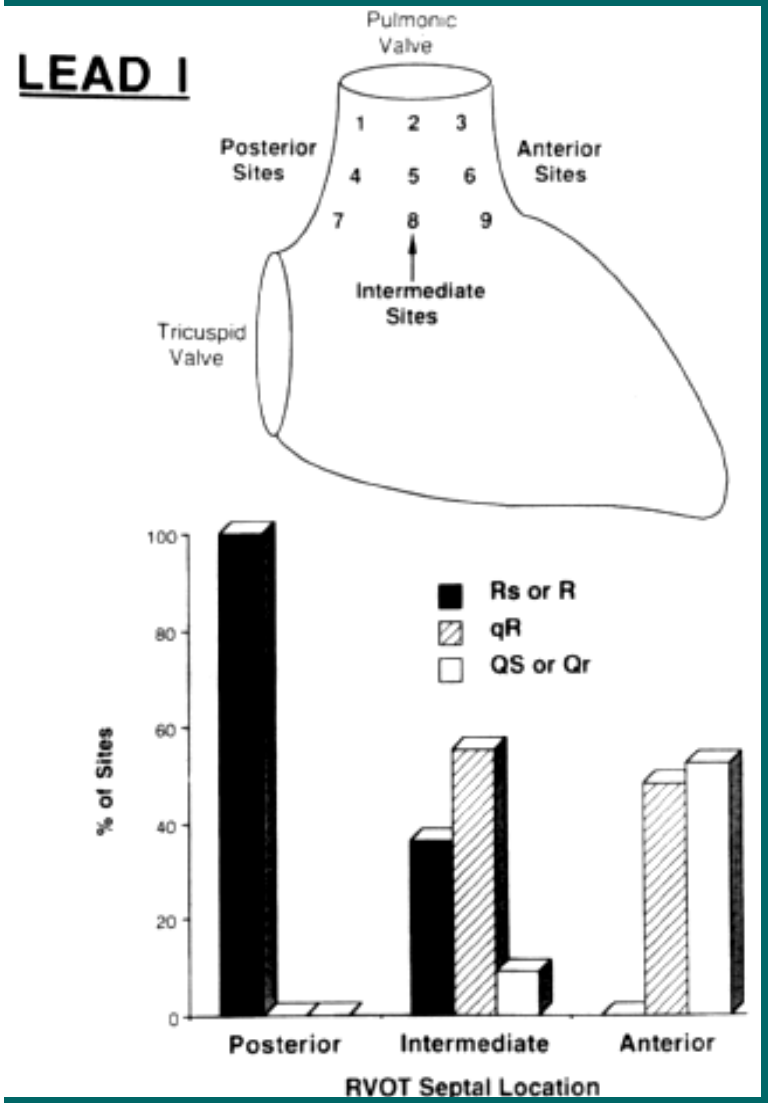


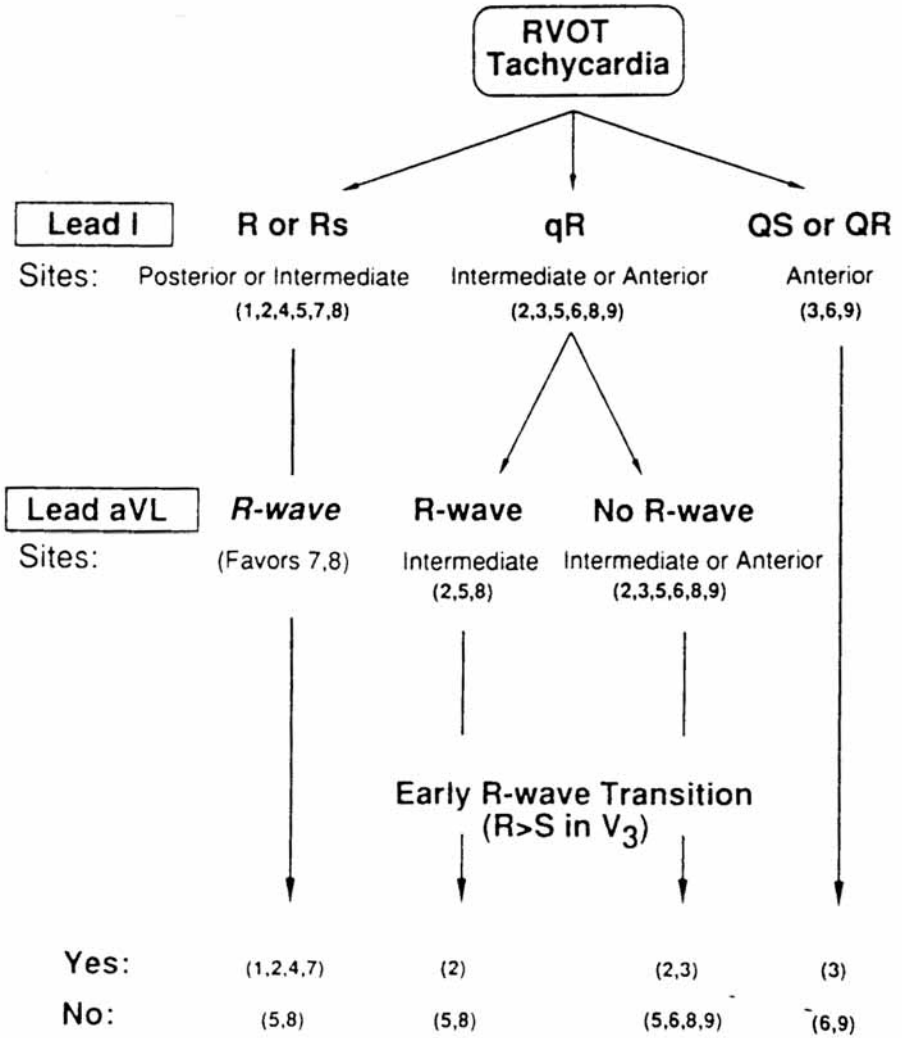


Common Patterns of Outflow Tract VTs



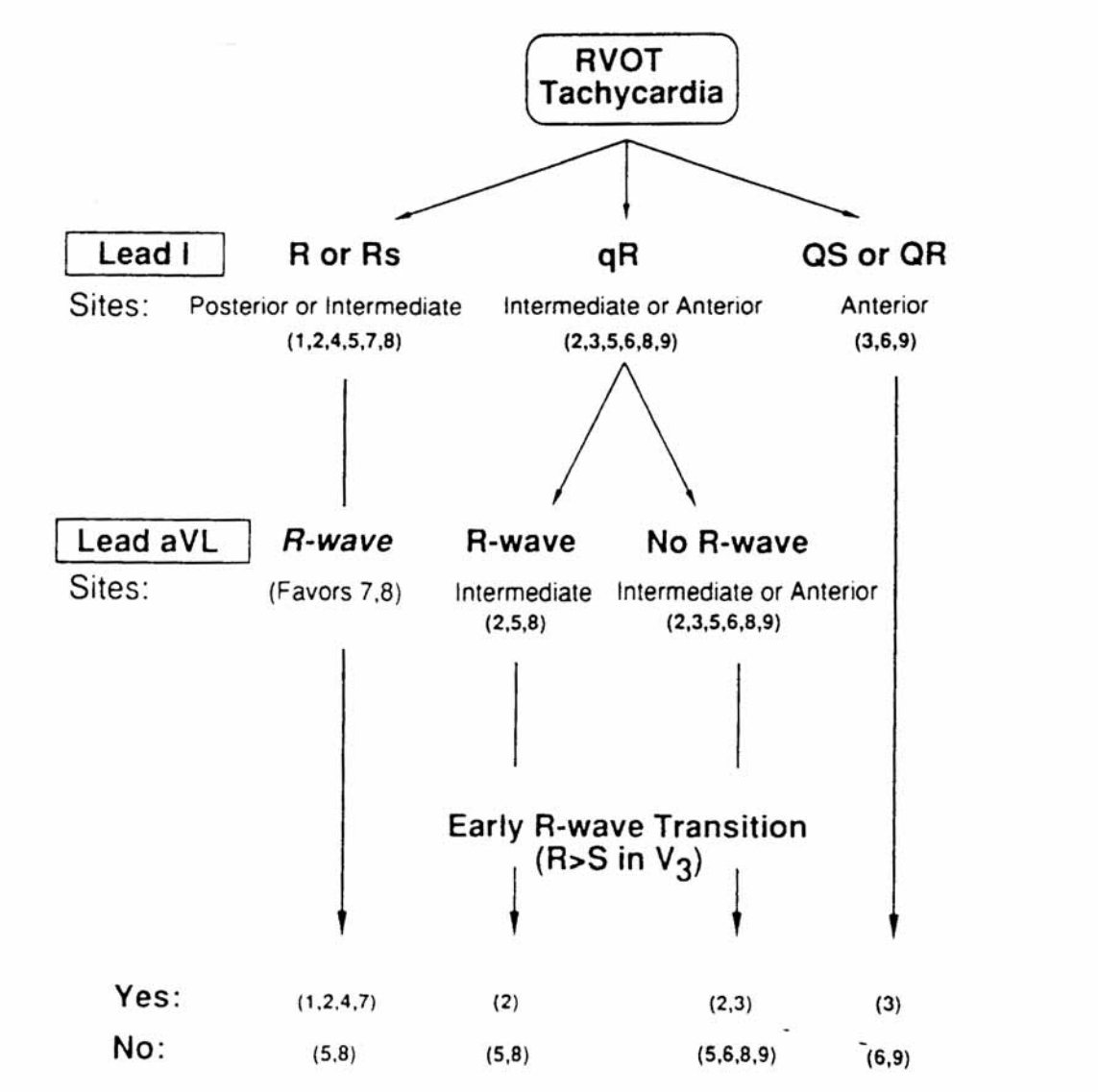
ECG in Localizing RVOT VT



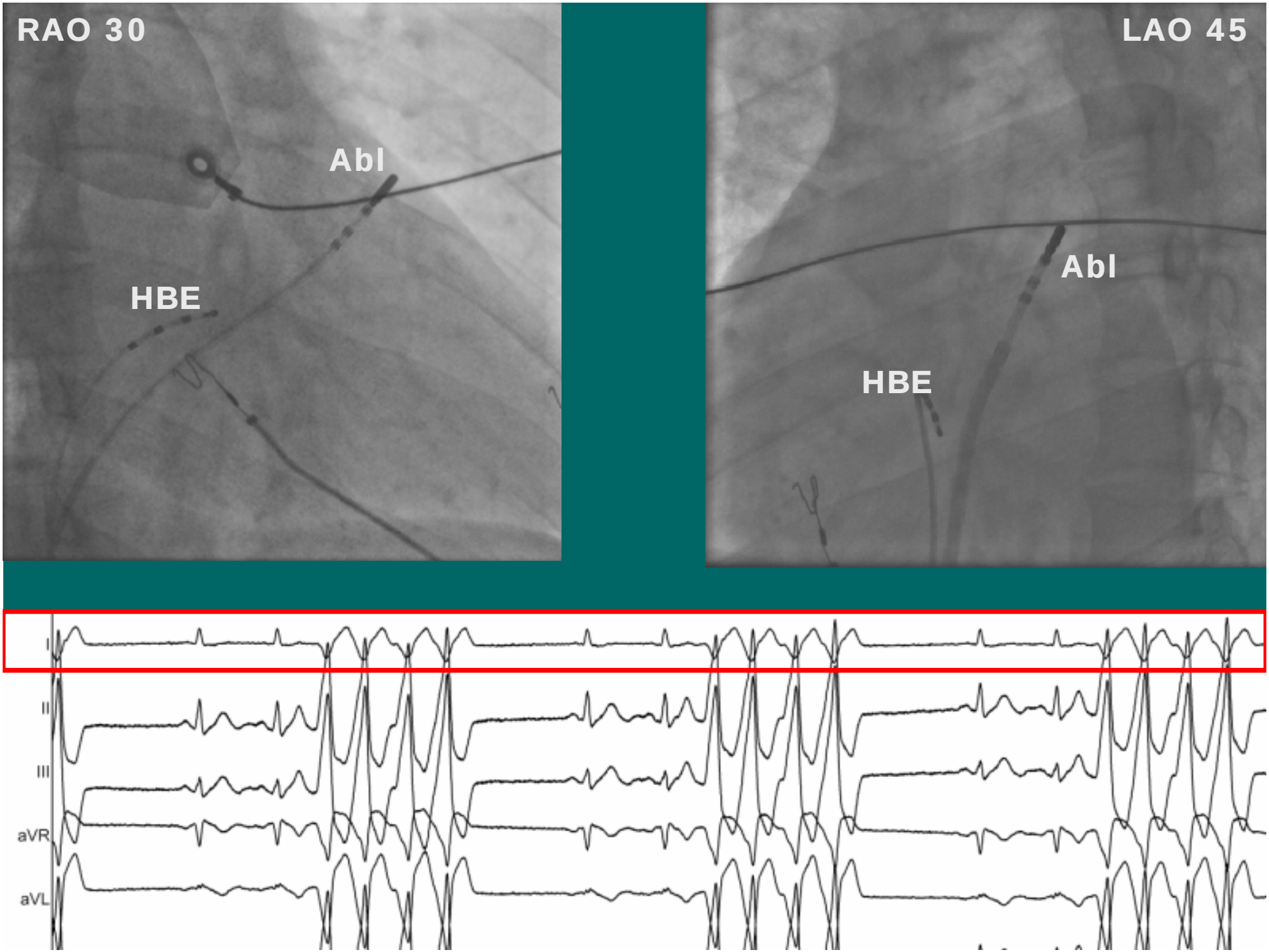


Jadonath: Am Heart J 1995;130:1107

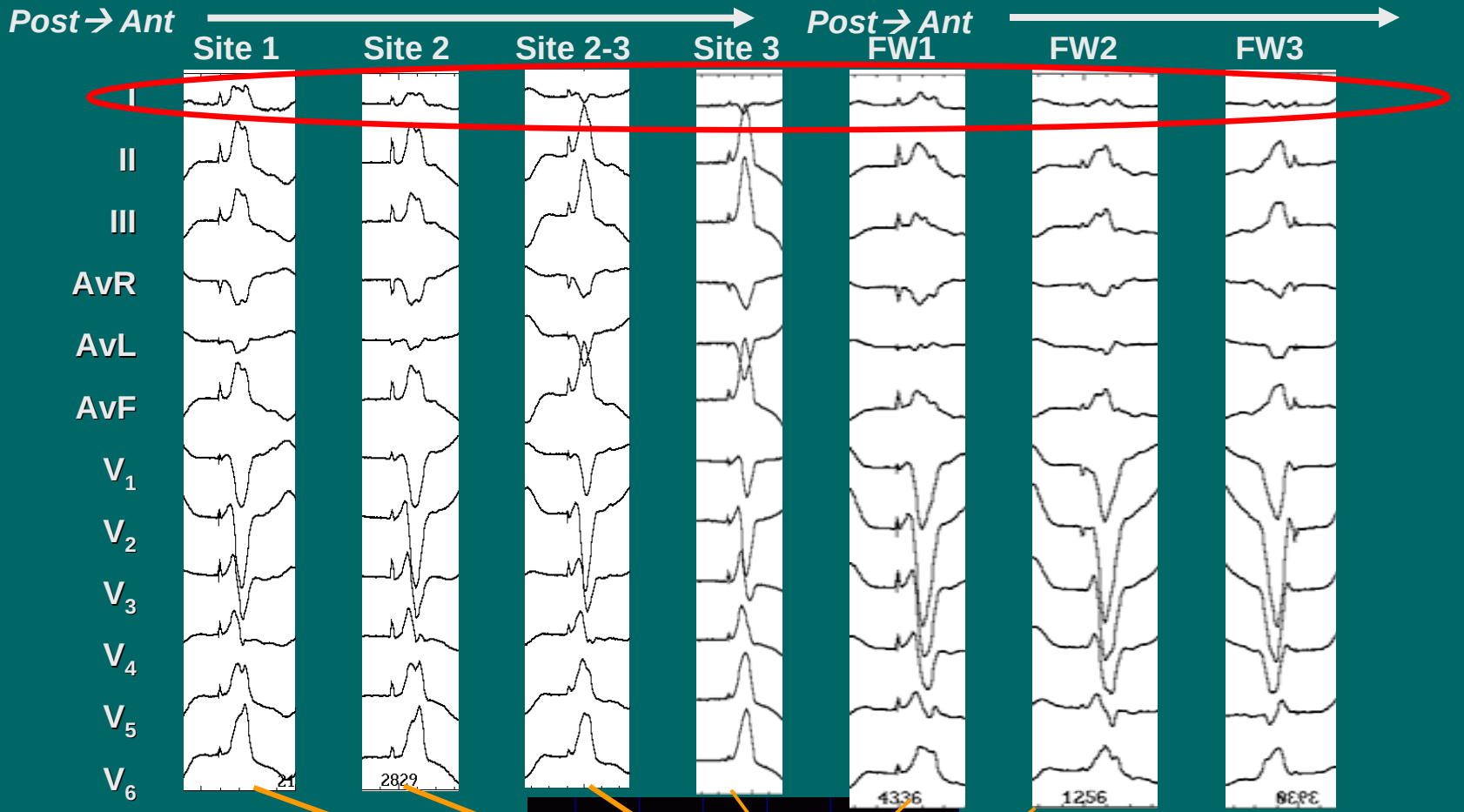
Utility of ECG in Localizing RVOT VT

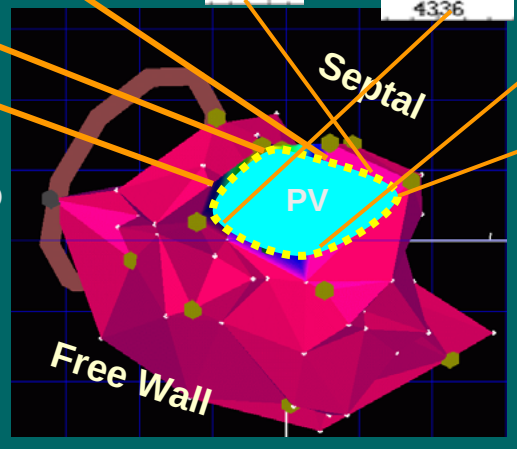


Jadonath: Am Heart J 1995;130:1107


RAO 30
Abl
HBE
LAO 45
Abl
HBE
I
II
III
aVR
aVL

RVOT VT ECG Patterns





RV Coronal View

Septal Origin:

Post (1) → Ant (3)

lead I: positive to negative for both FW and septum

Free Wall Origin:

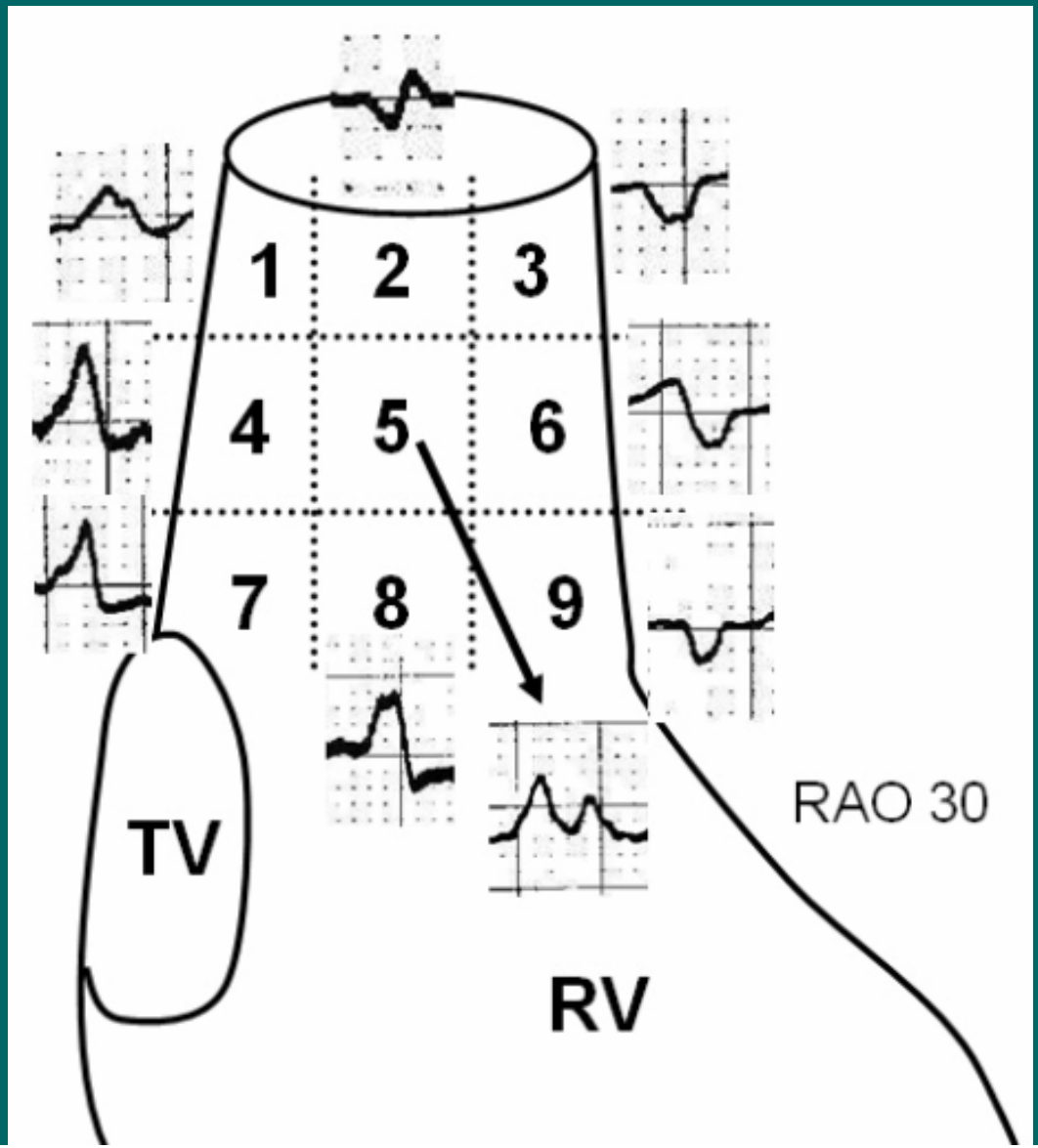
-later precordial transition

- QRS duration ↑

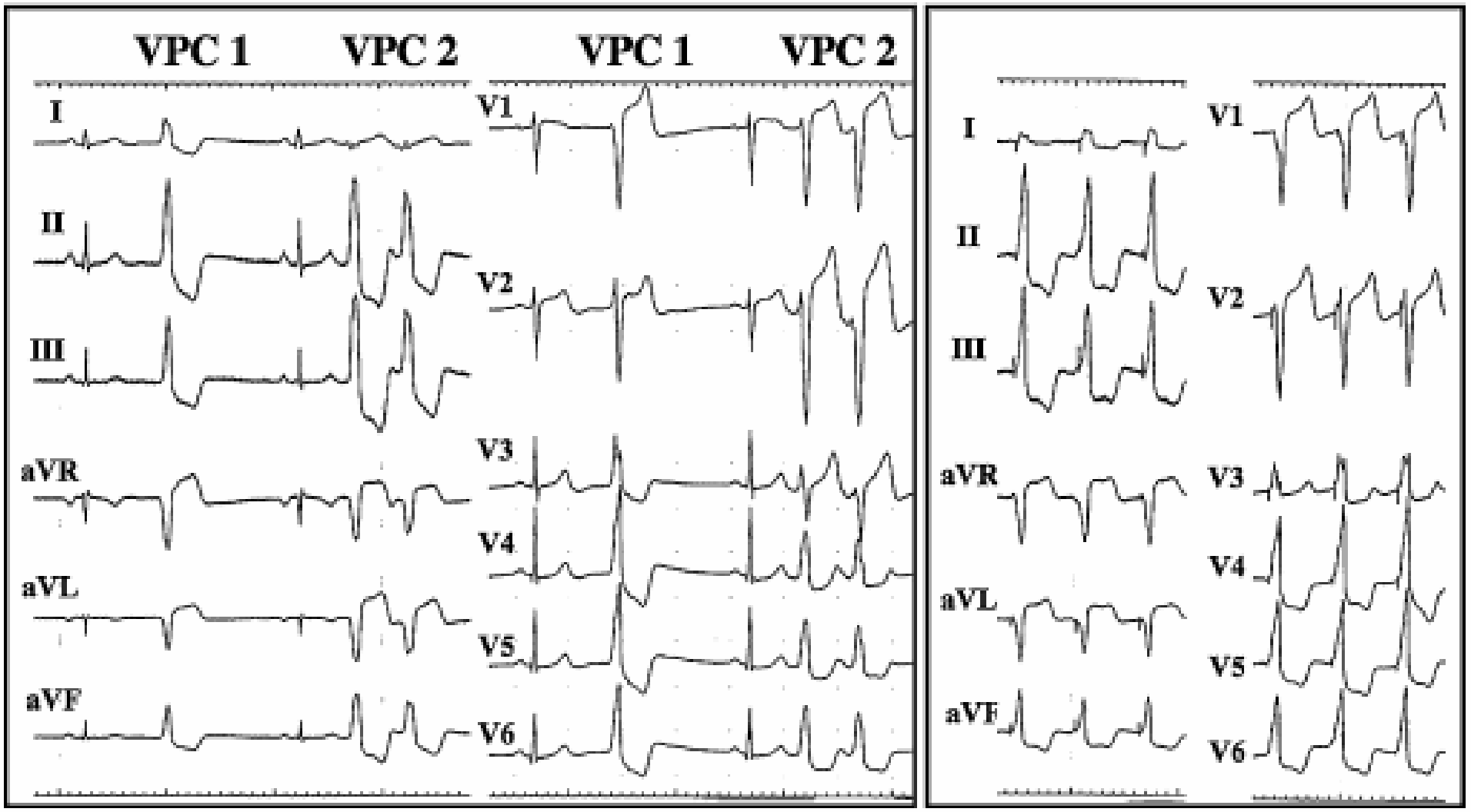
-notching in II, III, avF

-lower amplitude in II, III, avF

The Value of Lead I in Localizing RVOT VT Origin

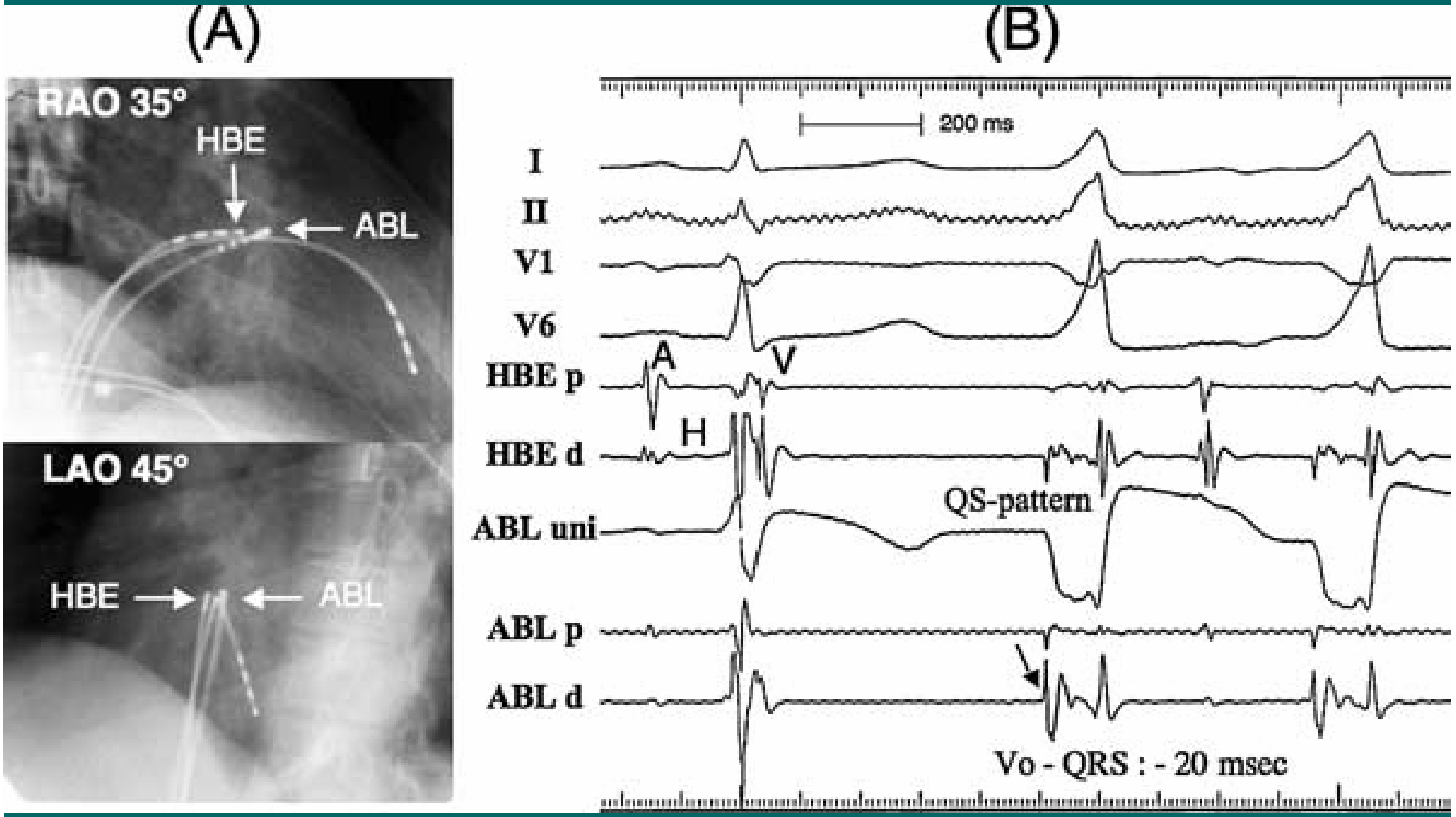


Para-Hisian RVOT VT



Yamauchi Y. J Cardiovasc Electrophysiol, 2005; 16:1041

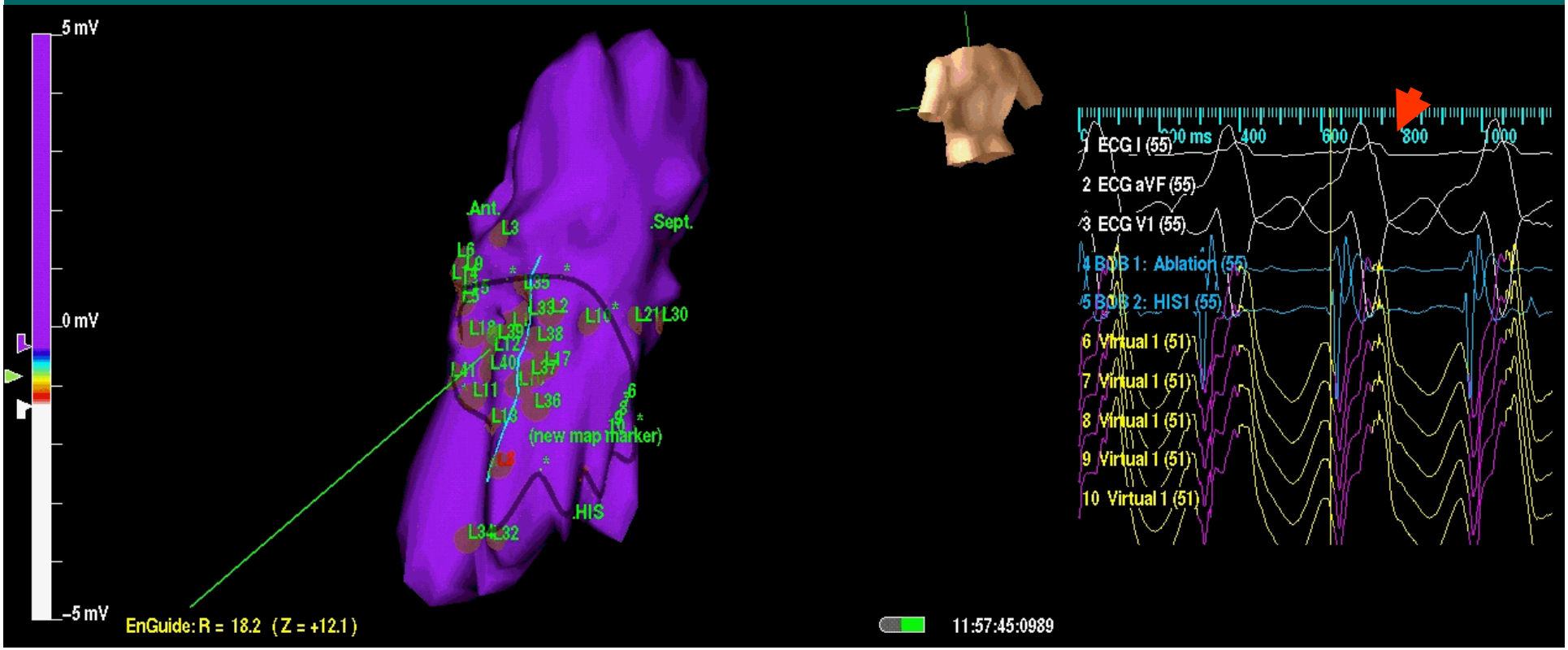
Para-Hisian RVOT VT



Yamauchi Y. J Cardiovasc Electrophysiol, 2005; 16:1041

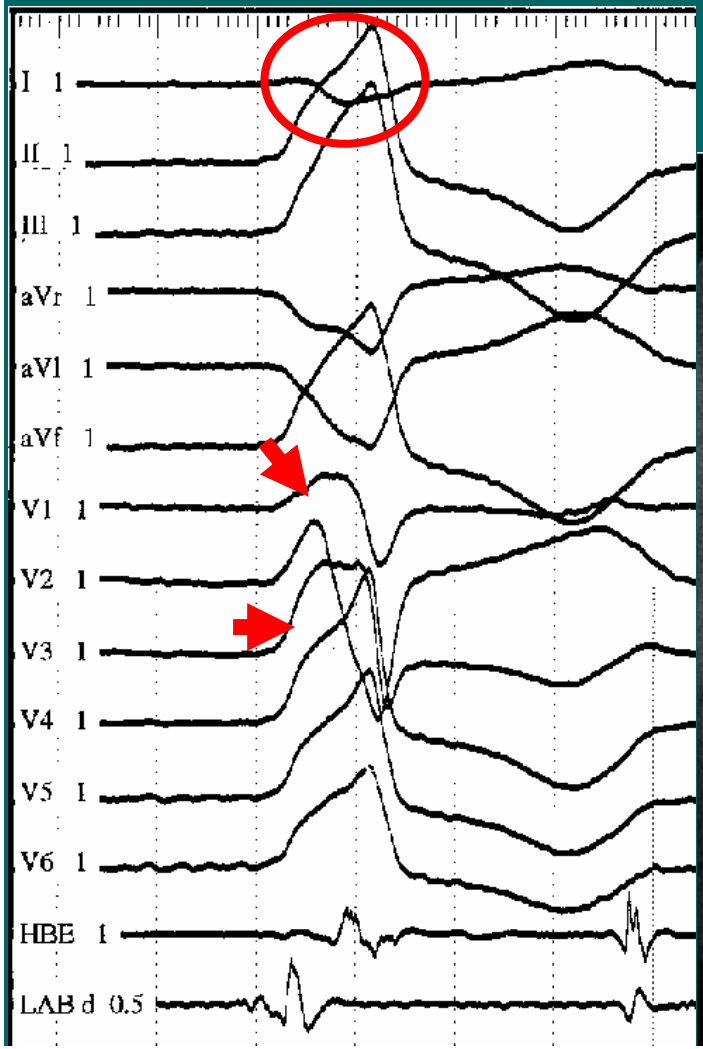
Multiple Origins in RVOT

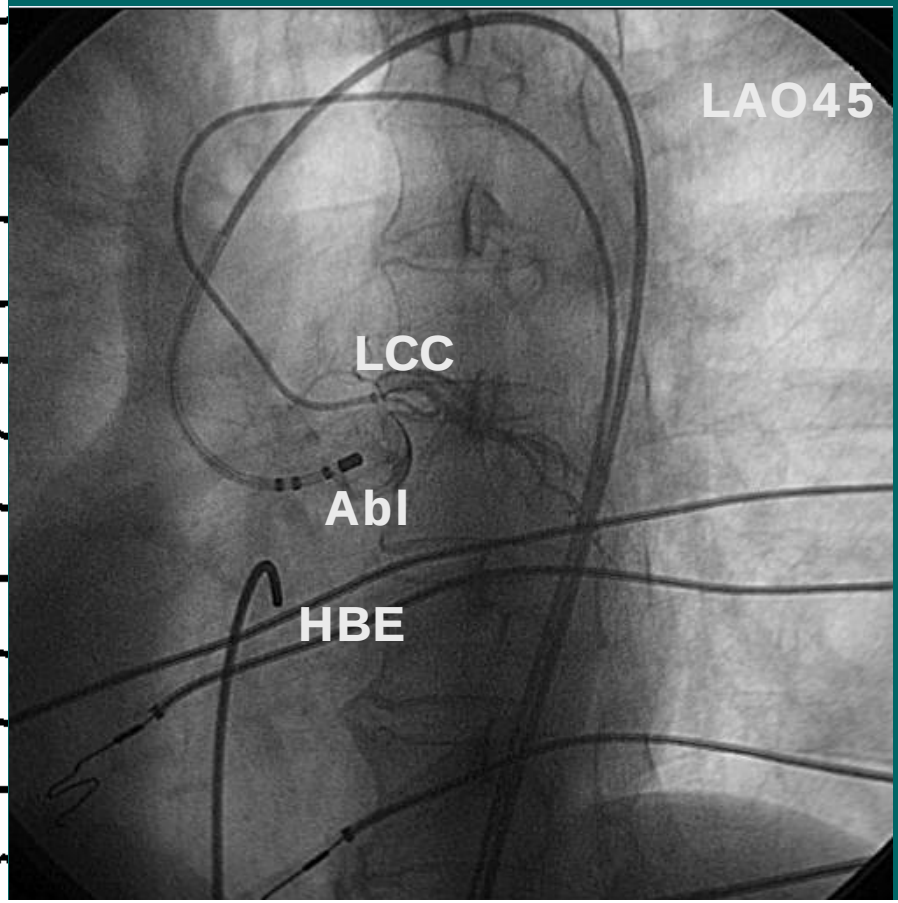
Large substrate (42x38mm)



2, LVOT VT

- **ECG features:** -Inferior QRS axis;
  -Broad R in lead V1(duration >40% of QRS, and amplitude >30%）);
  -Early transition (<V3);

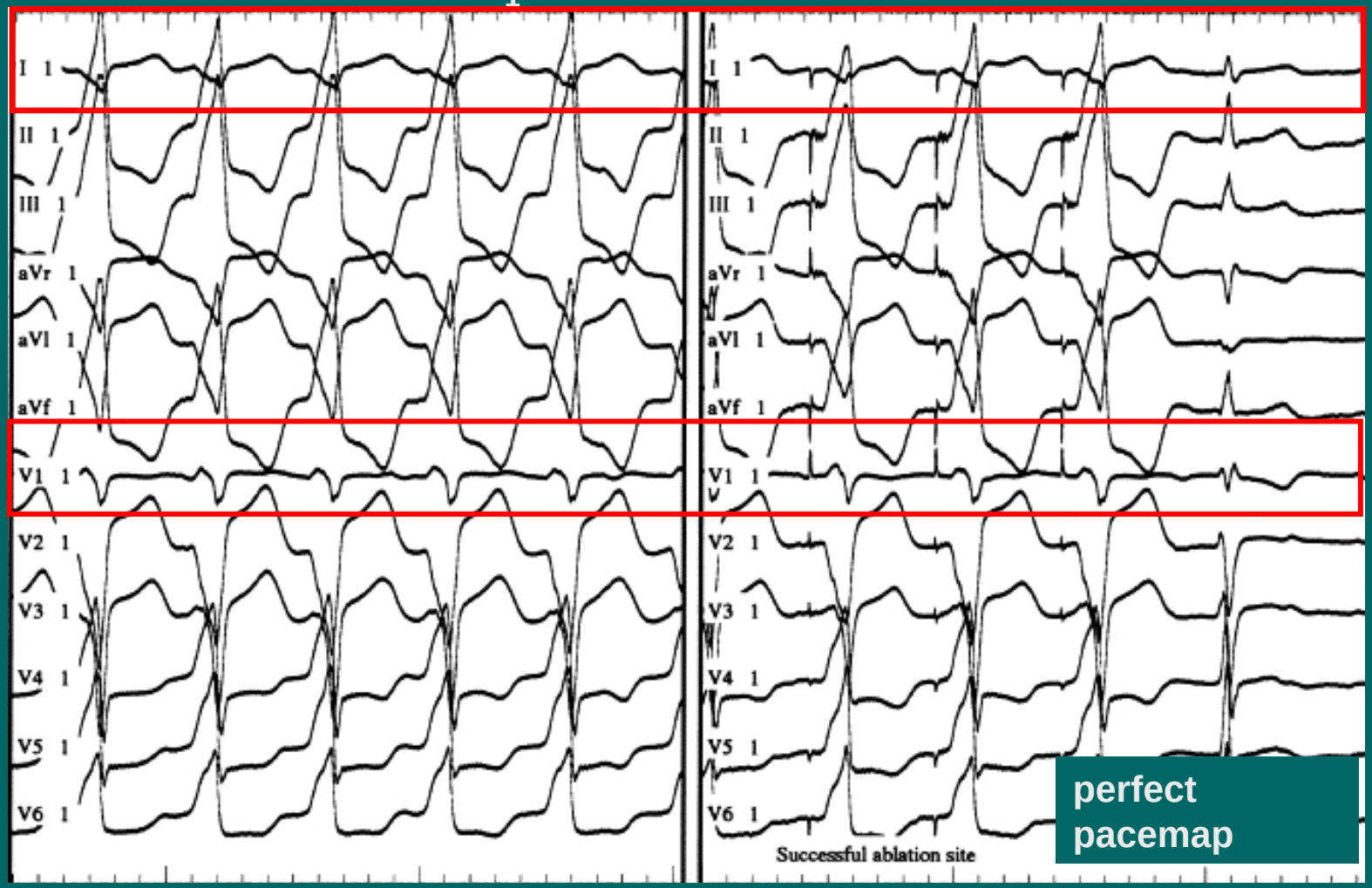




VT with LCC origin

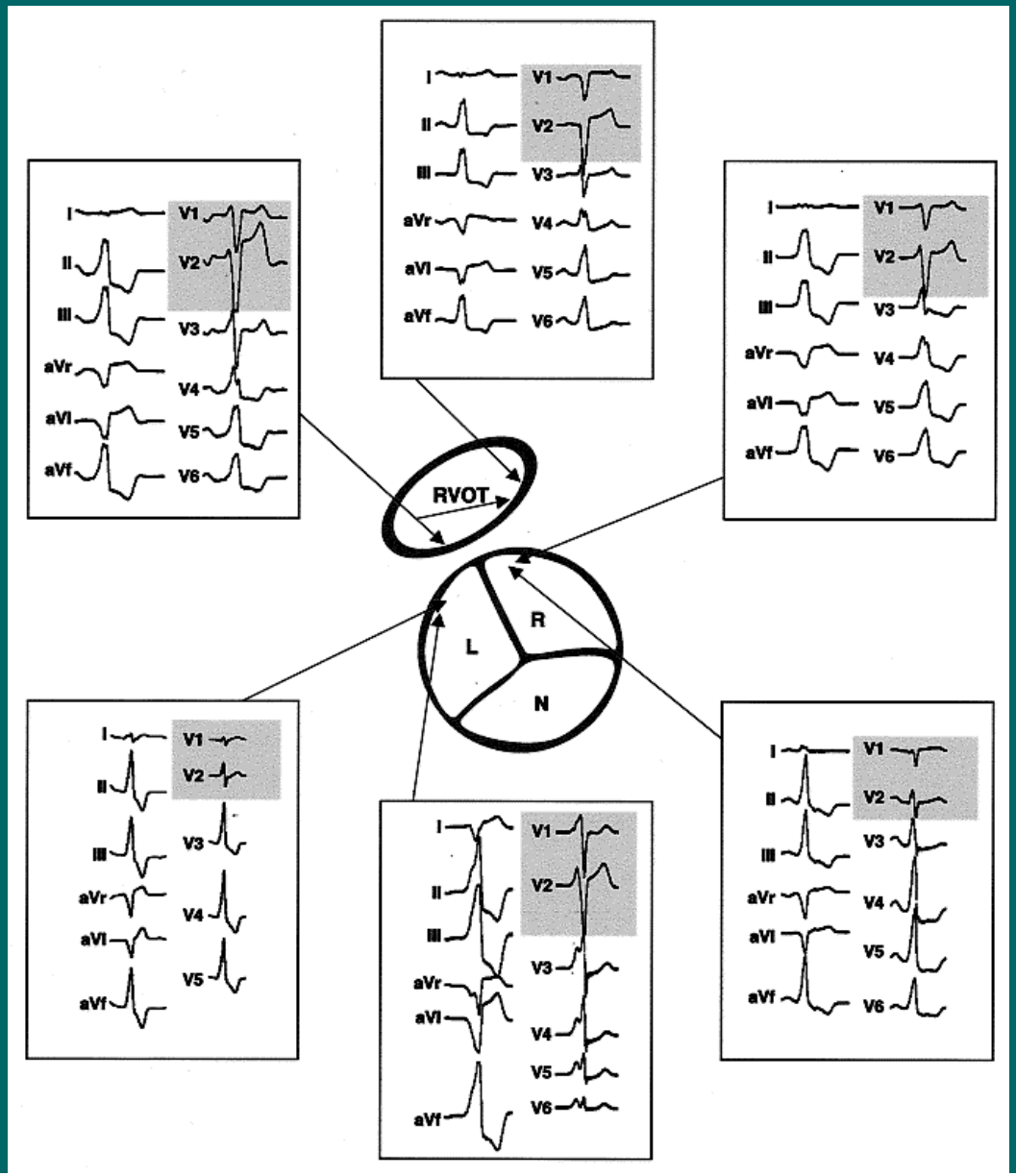
Left Coronary Cusp VT

most leftward cusp → rS in lead I;
broad R in lead V_1



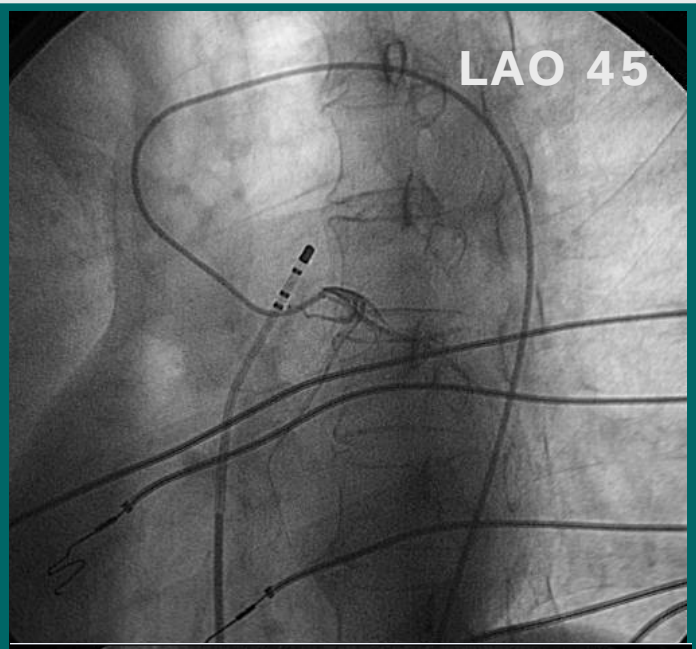
Kanagartnam: JACC 2001;37:1408

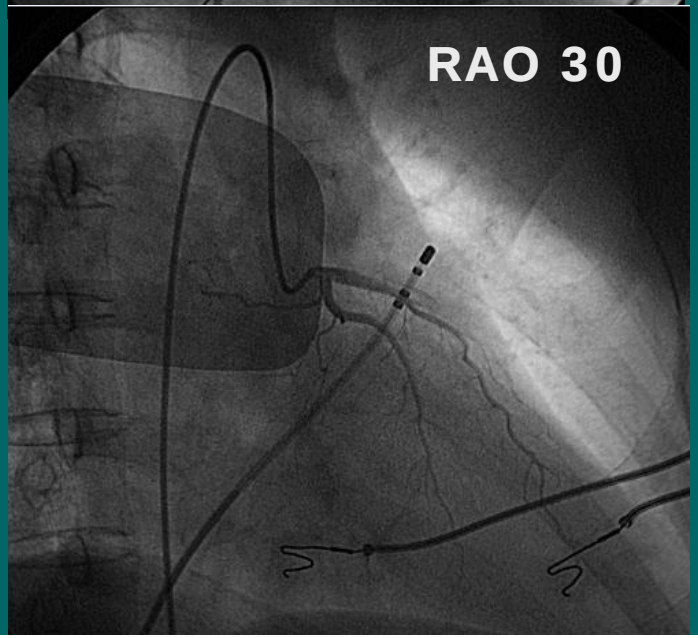
Outflow Tract and Aortic Cusp VT

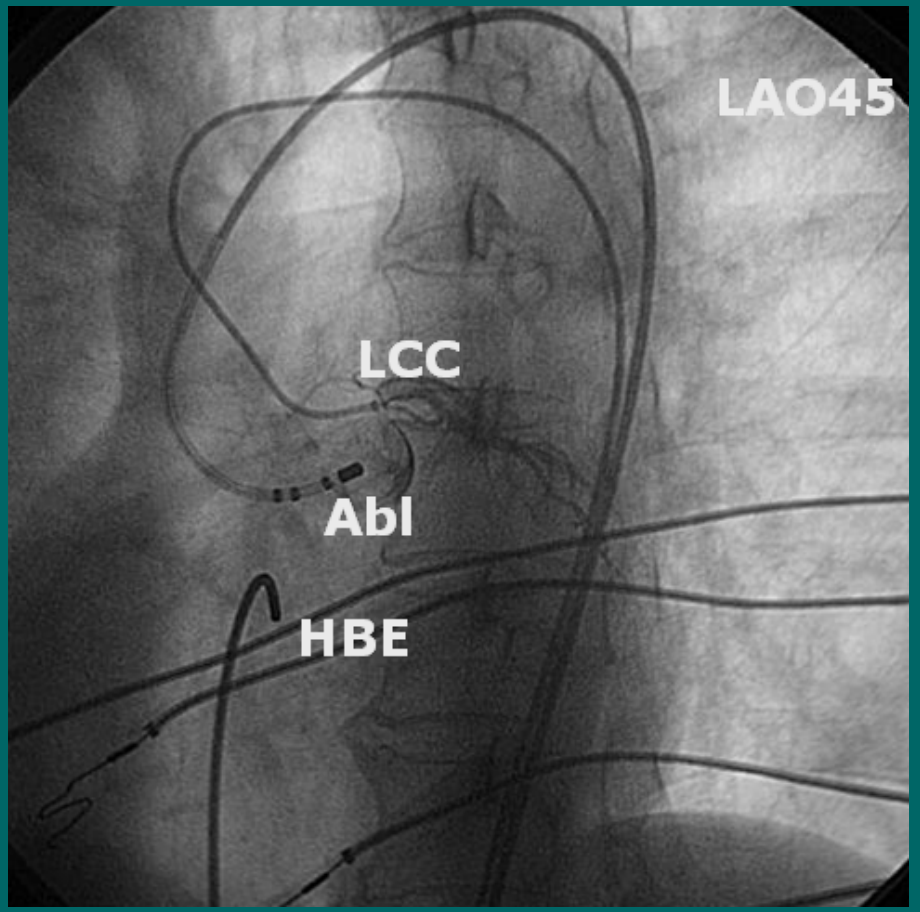


Ouyang F: JACC 2002;39:500

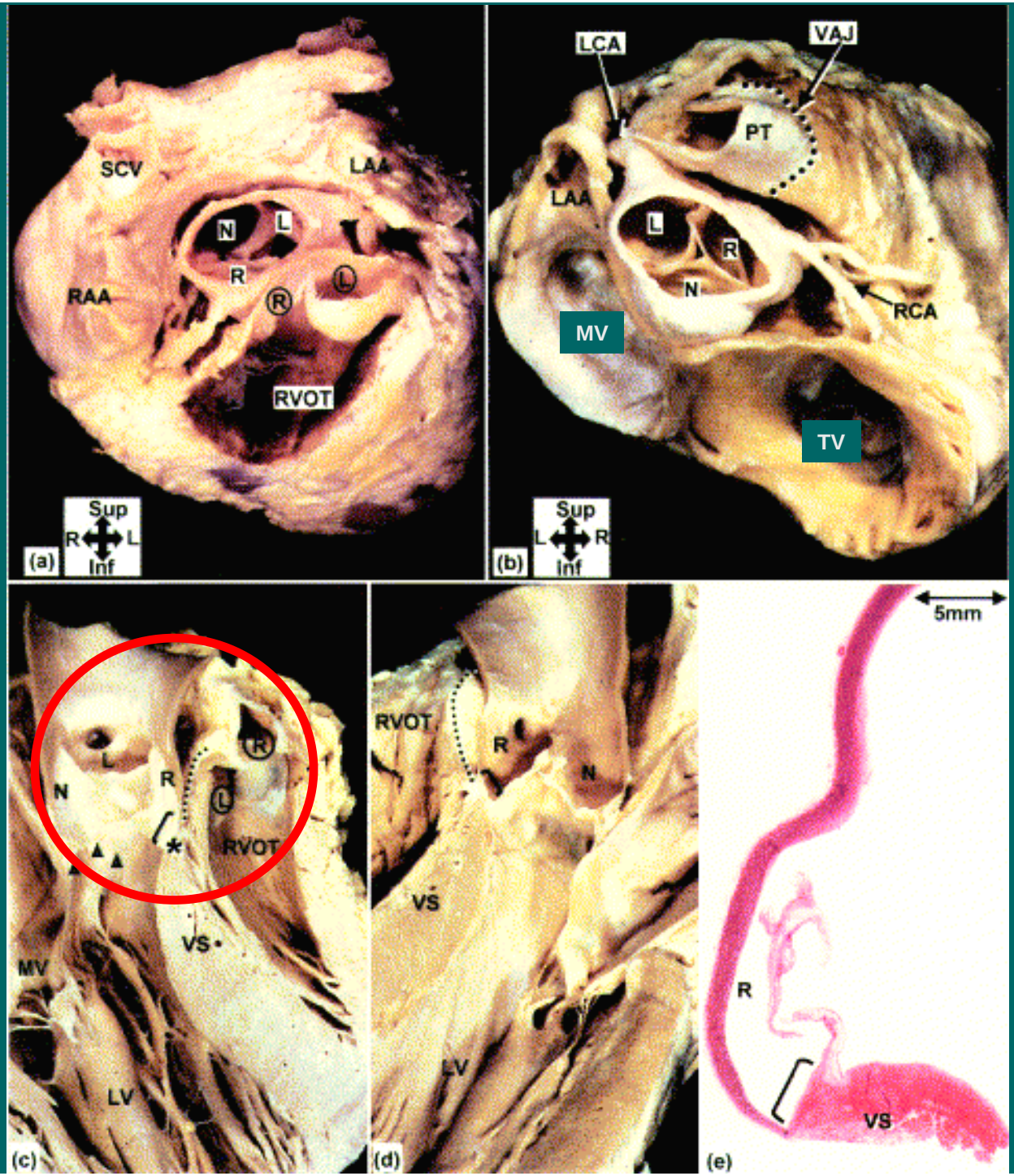
Spatial Relationship of LCC & RVOT Anterior Septal Origins







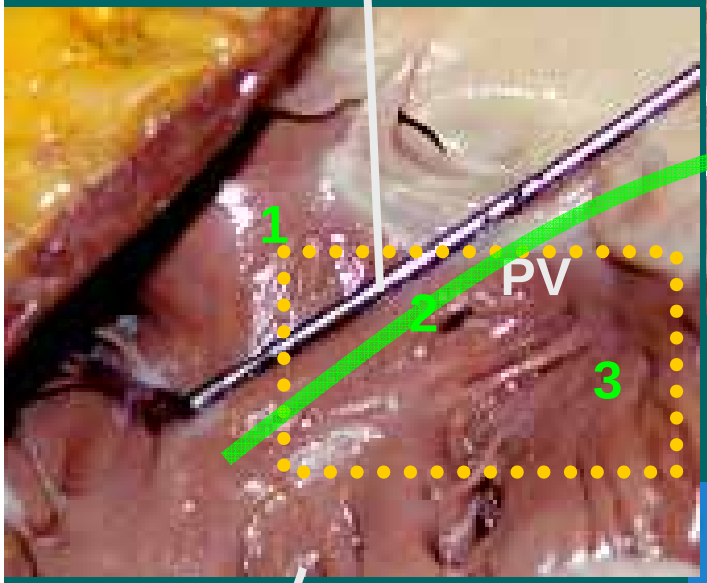
Anatomical Relationship Between RVOT and LVOT

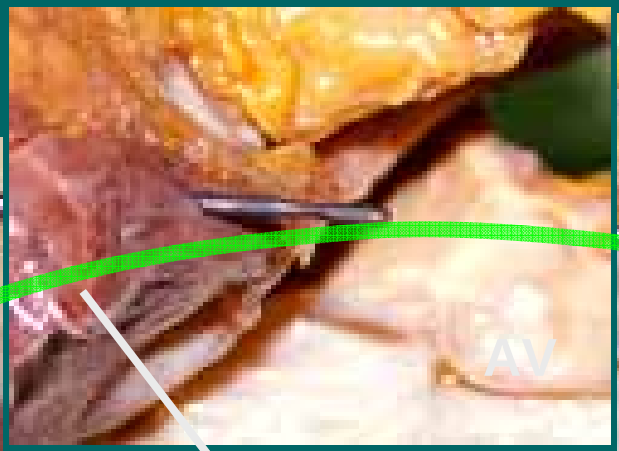


Ouyang F: JACC 2002;39:500

LVOT: Mitral-Aortic Continuity

typical RVOT locations



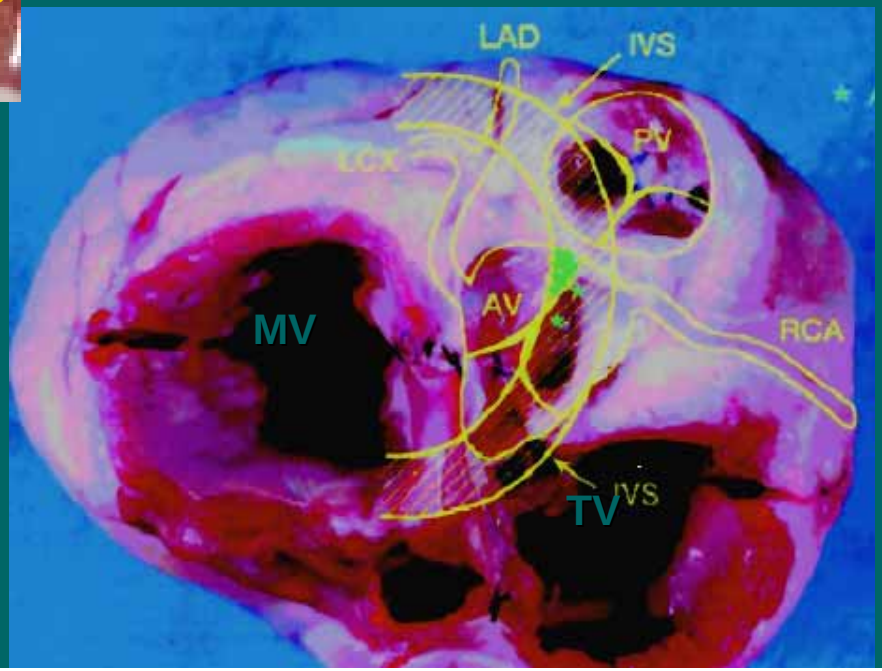


LV epicardium

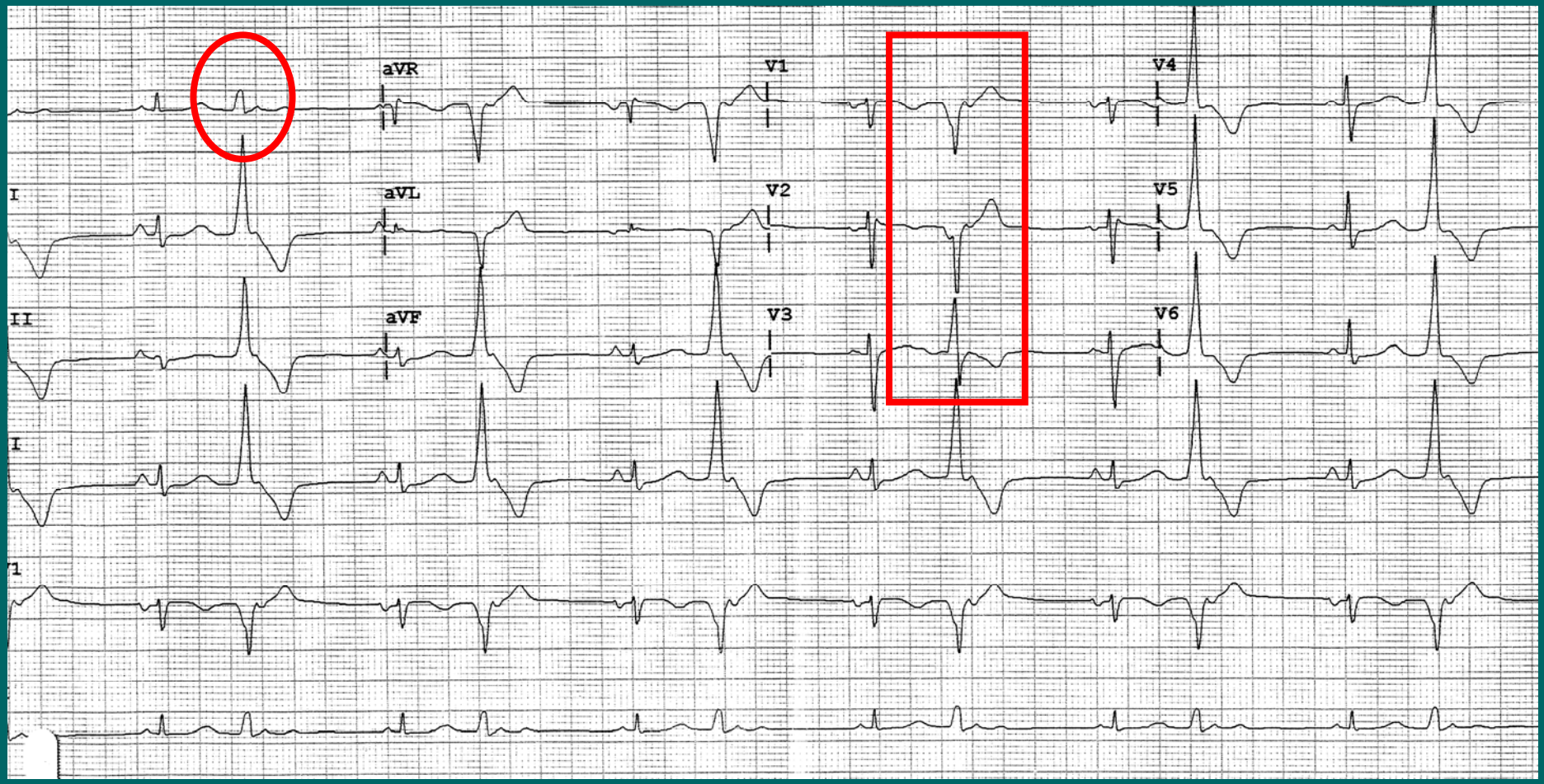
Mitral annulus

TV

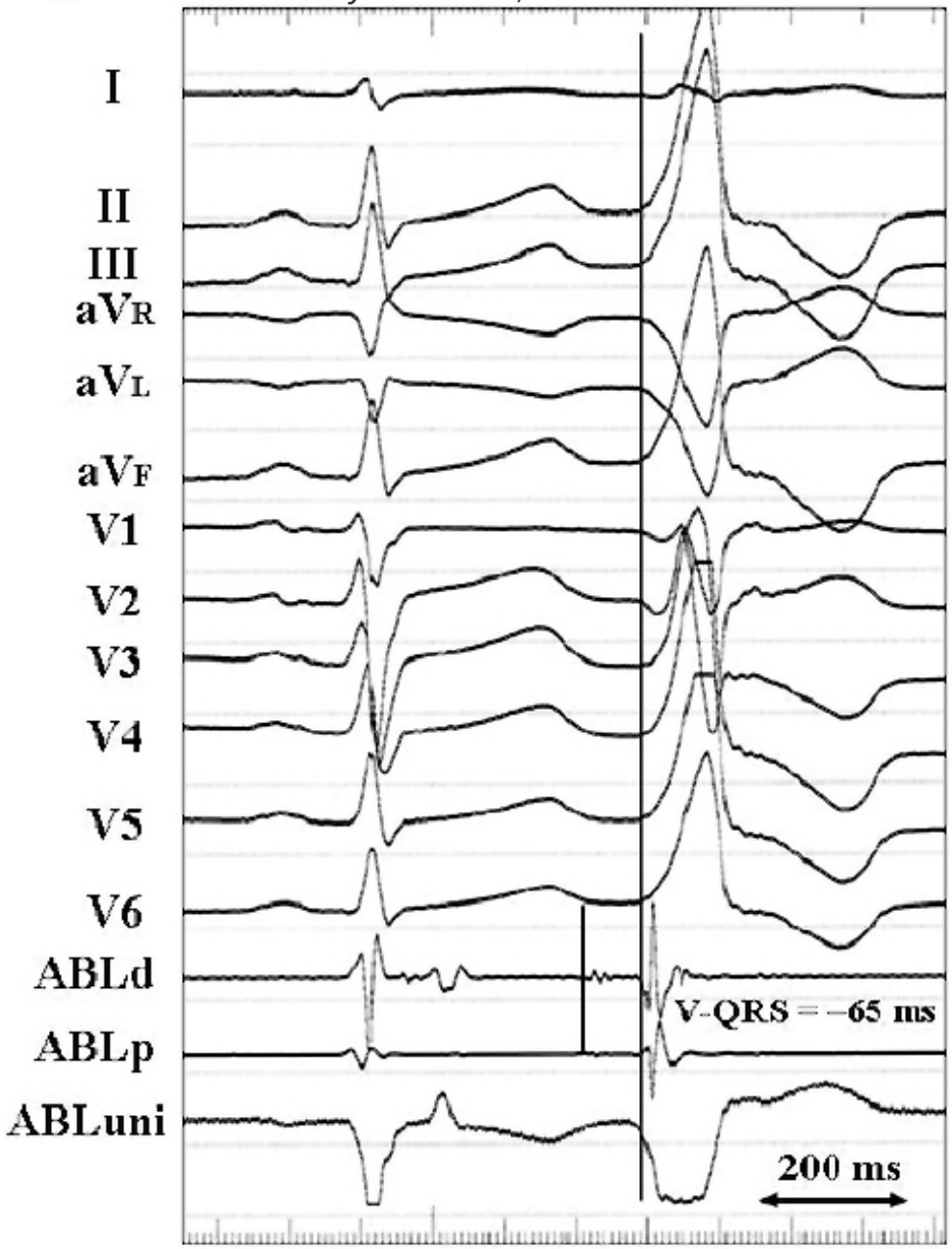
RVOT inflow

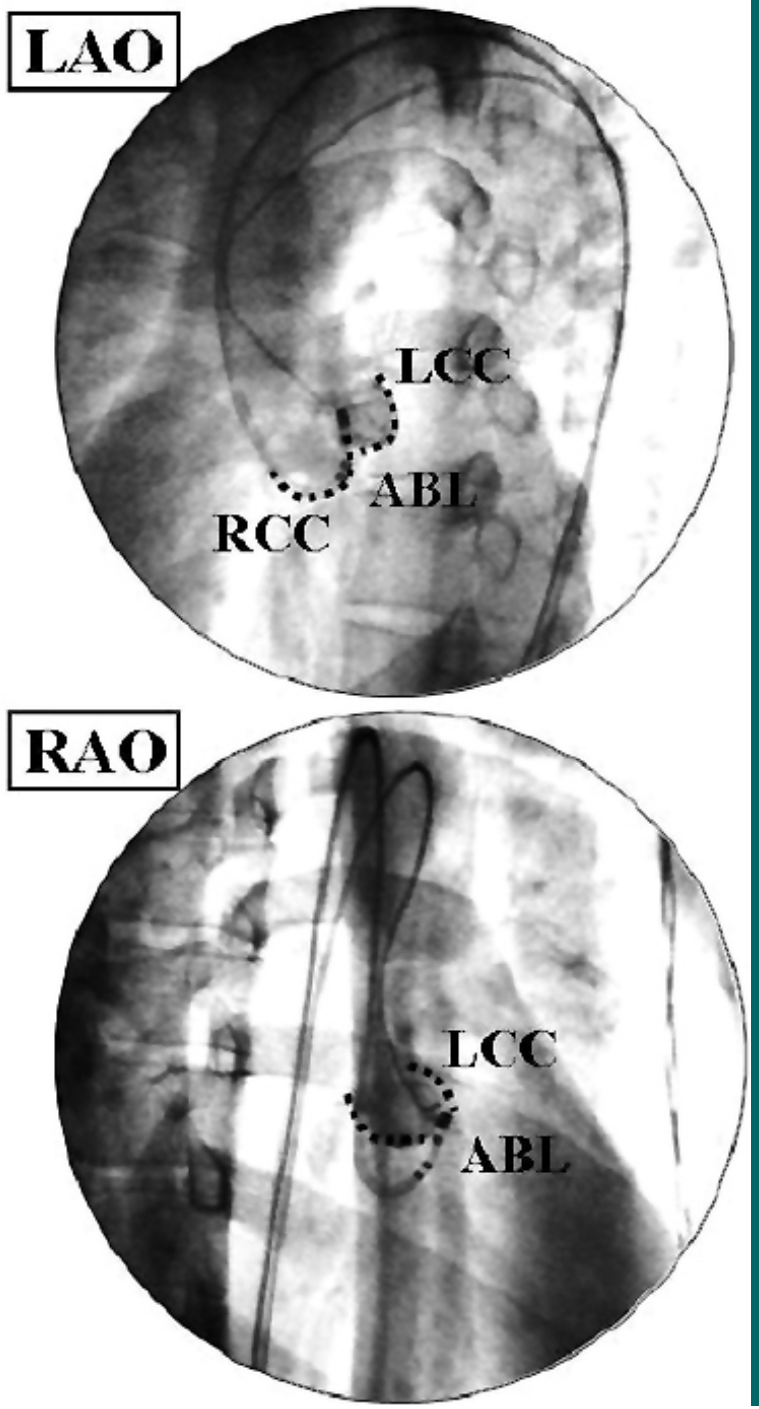


VT/VPC Originating from the Junction of the Left & Right Coronary Sinus of Valsalva



Yamada T: Heart Rhythm 2008;5:184



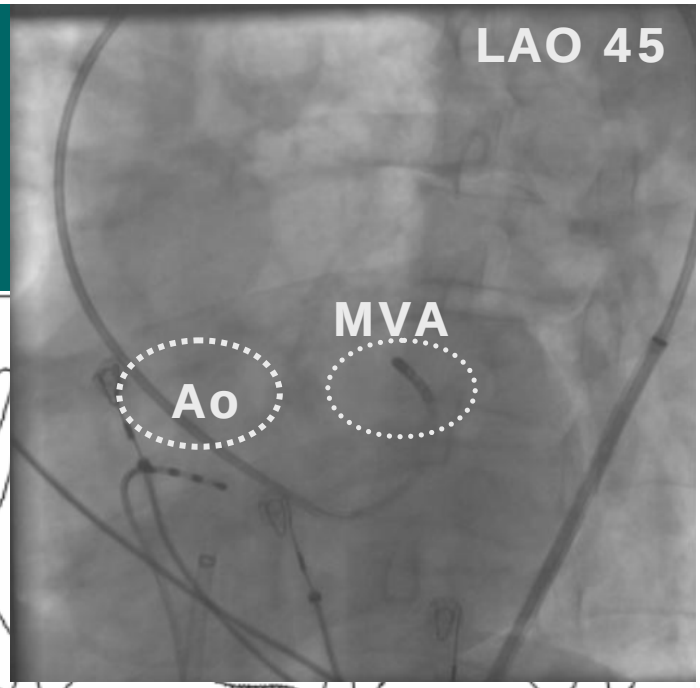


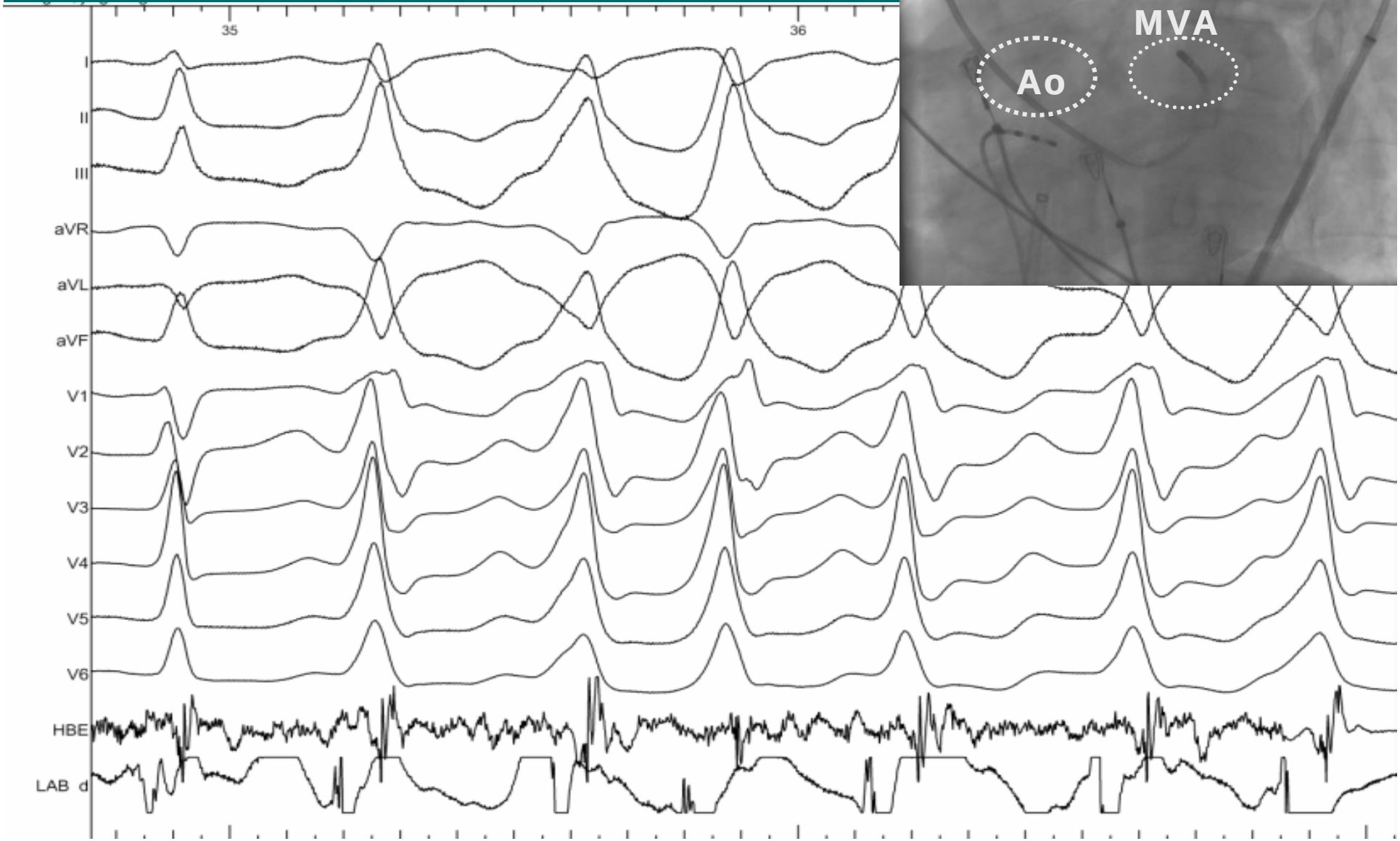
3, **Idipathic LV Basal VT**

- ECG Patterns:
  - The *ratio of QRS complexes in leads II / III:*
    - >1 for septal-parahisian (S-P) and lateral mitral annular (MA) sites;
    - ≤1 for aortomitral continuity (AMC), superior MA, and superolateral MA locations;
  - *Medial* sites (SP/AMC) vs *lateral* sites (superolateral and lateral MA):
    - *narrower* QRS complexes (134±24 msec vs.182±18 msec; *P* <0.05)
    - *initial negative lead V1 and predominantly positive forces in lead I* (amplitude 0.59±0.27 mV vs. 0.16±0.34 mV; *P* <0.05).

Dixit S. Heart Rhythm 2005;2:485

LV Anterior Basal VT



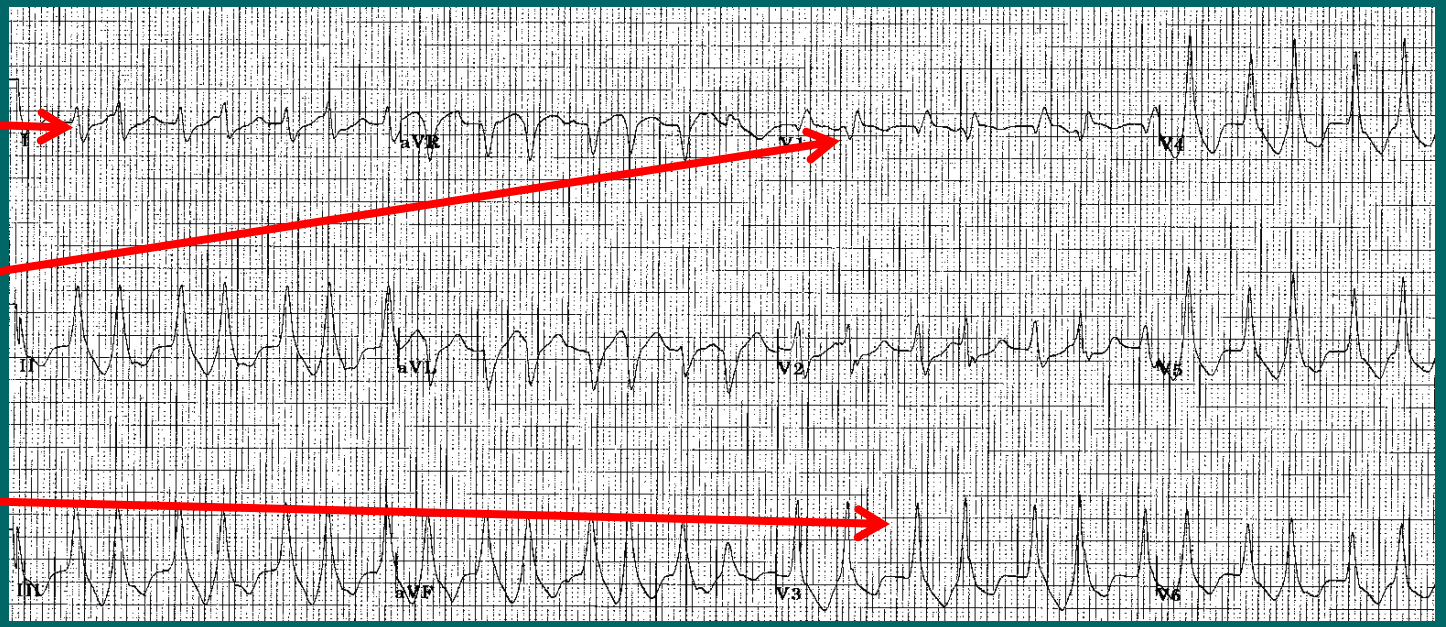


LVOT VT from Aorto-Mitral Continuity

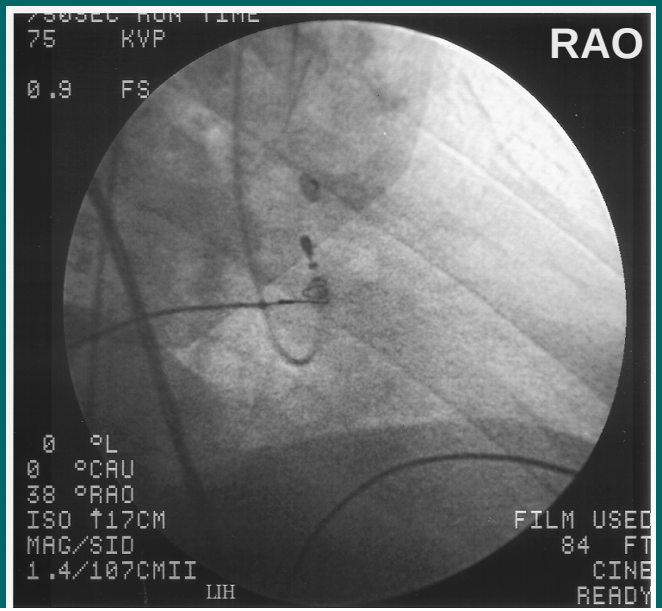
R/s in lead I

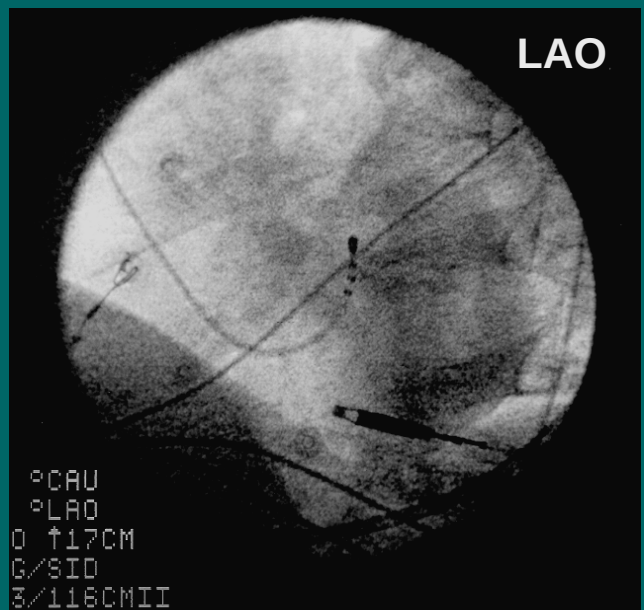
"RBBB" in V_1

early precordial transition by V_3



Site of Successful Ablation





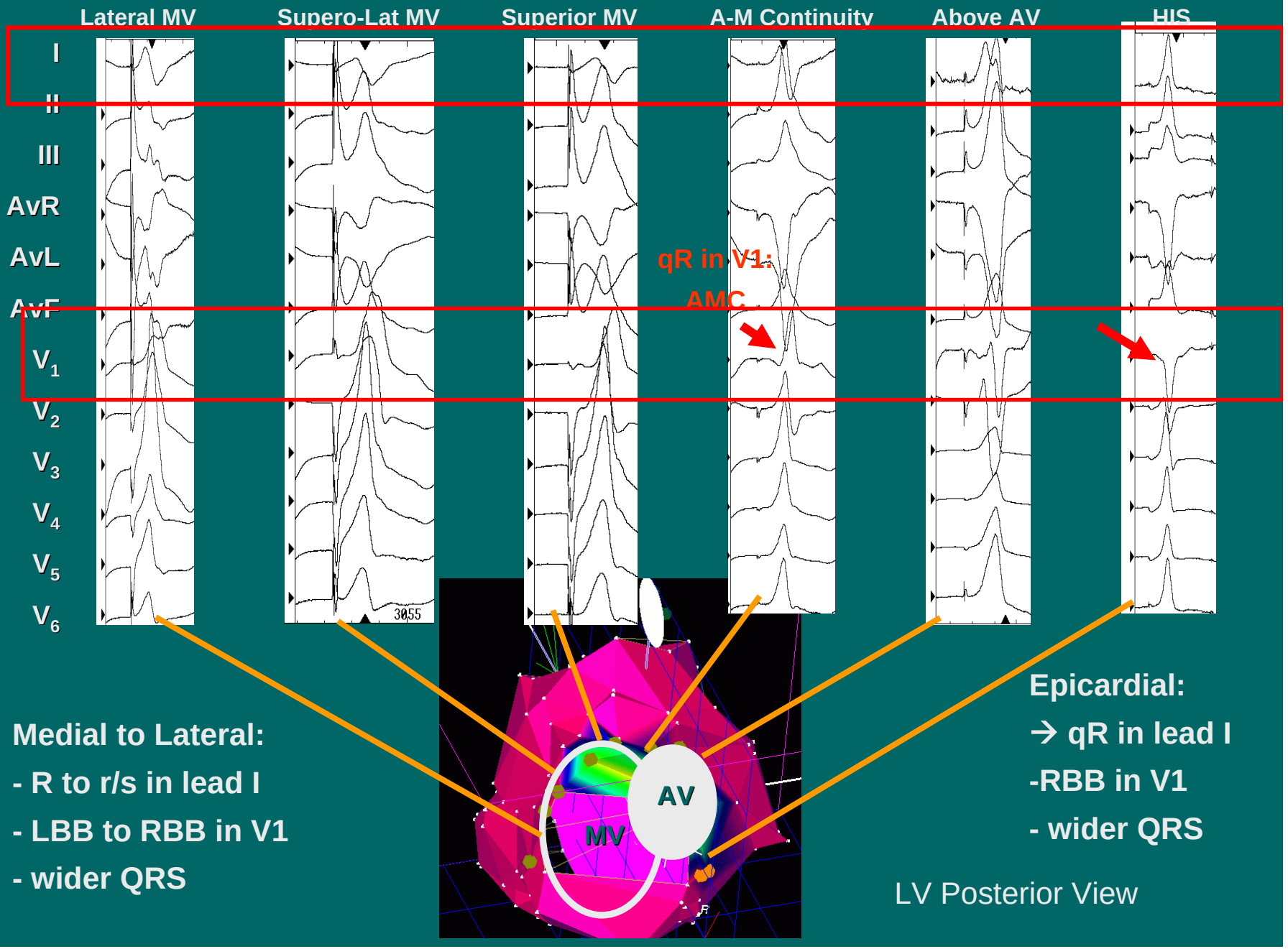
Comparison of ECG Patterns of LVVT: Medial vs Lateral LV Sites

	QRS width (msec)	Initial negative force in lead V1	Early precordial transition	Amplitude in lead I (mV)
Medial basal LV sites (S-P & AMC)	134 ± 28 *	20/24 * (85%)	24/24 * (100%)	0.59 ± 0.27*
Lateral basal LV sites (Sup-Lat & Lat MA)	182 ± 18	0/22	0/22	0.16 ± 34

	Septal-parahisian	AMC	Superior MA	Superolateral MA	Lateral MA
Lead I	R or Rs	Rs or rs	rs or rS	rS or QS	rS or rs
Lead V1	QS or Qr	qR	R or Rs	R or Rs	R or Rs
Precordial transition	Early	None	None	None	None or late
Ratio of lead II/III	>1	≤1	≤1	≤1	>1

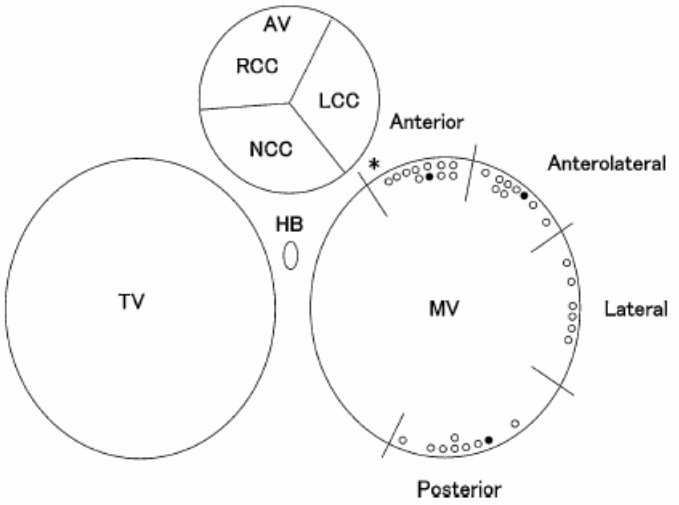
Dixit S. Heart Rhythm 2005;2:485

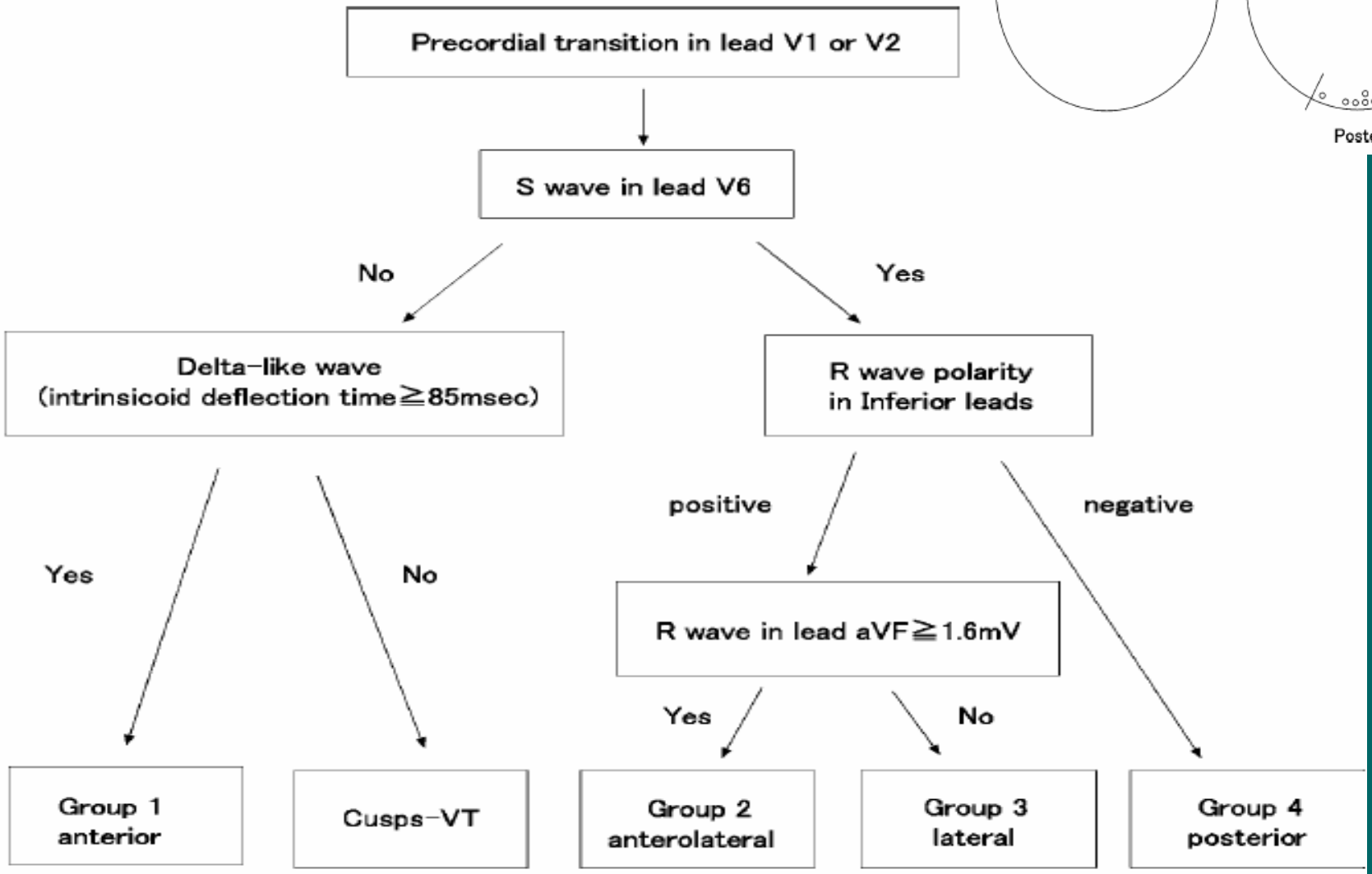
LV Basal VT ECG Patterns



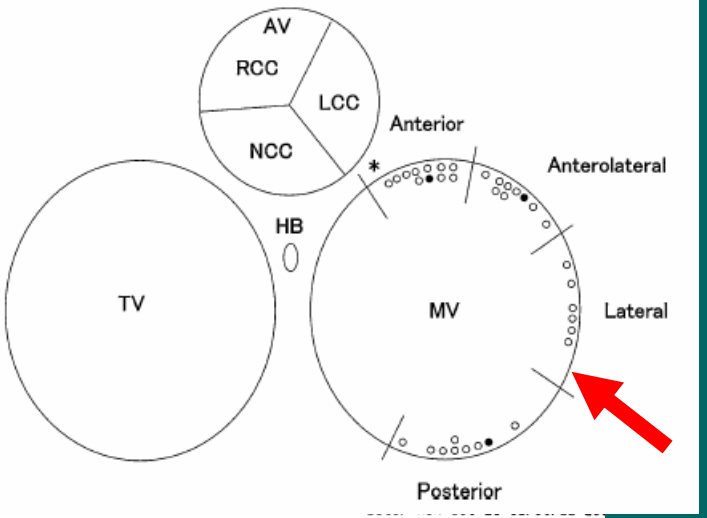
Kumagai K, JCE 2005, 16:1029-1036

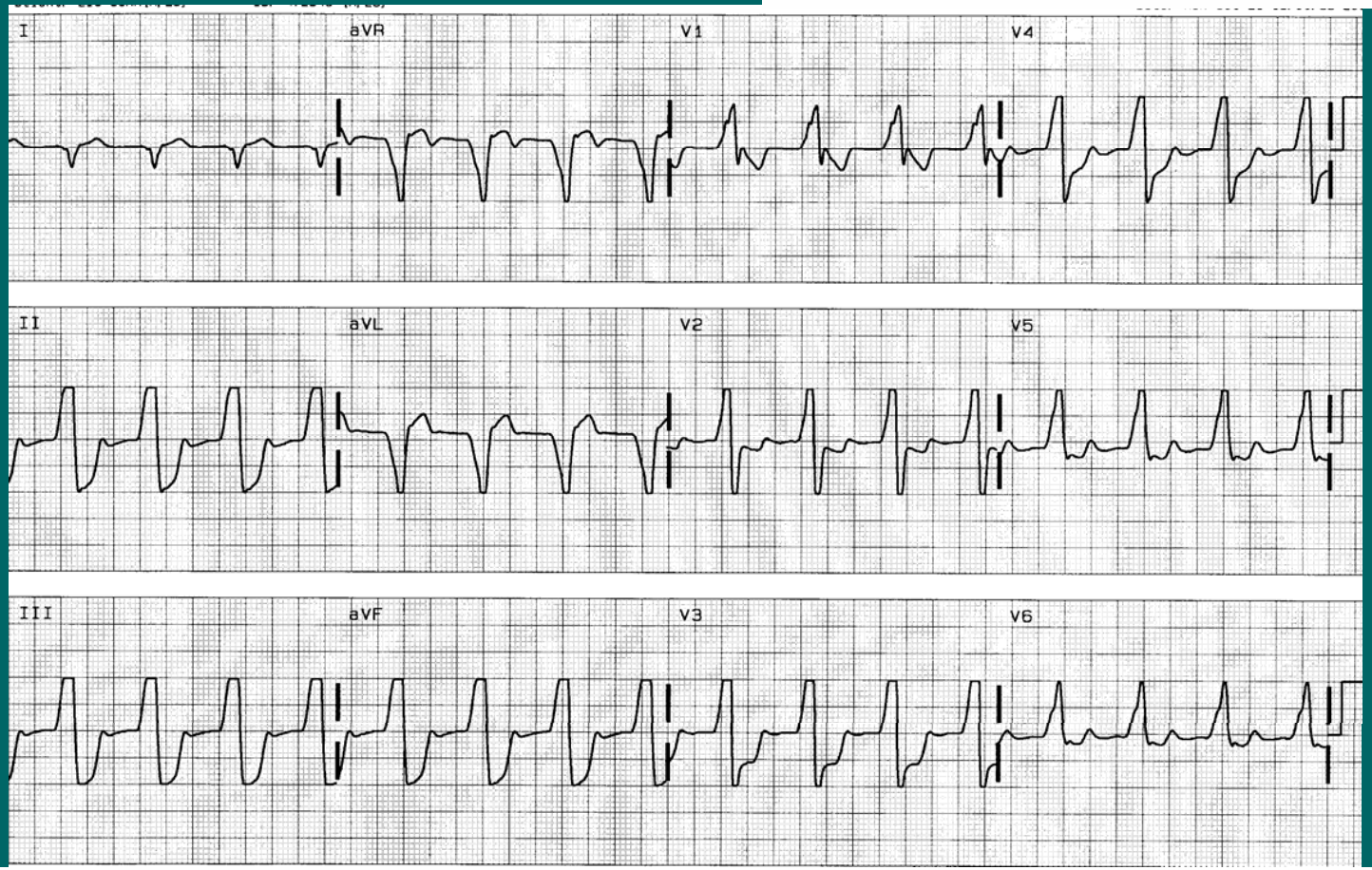
Stepwise ECG algorithm for presuming the sites of the origin





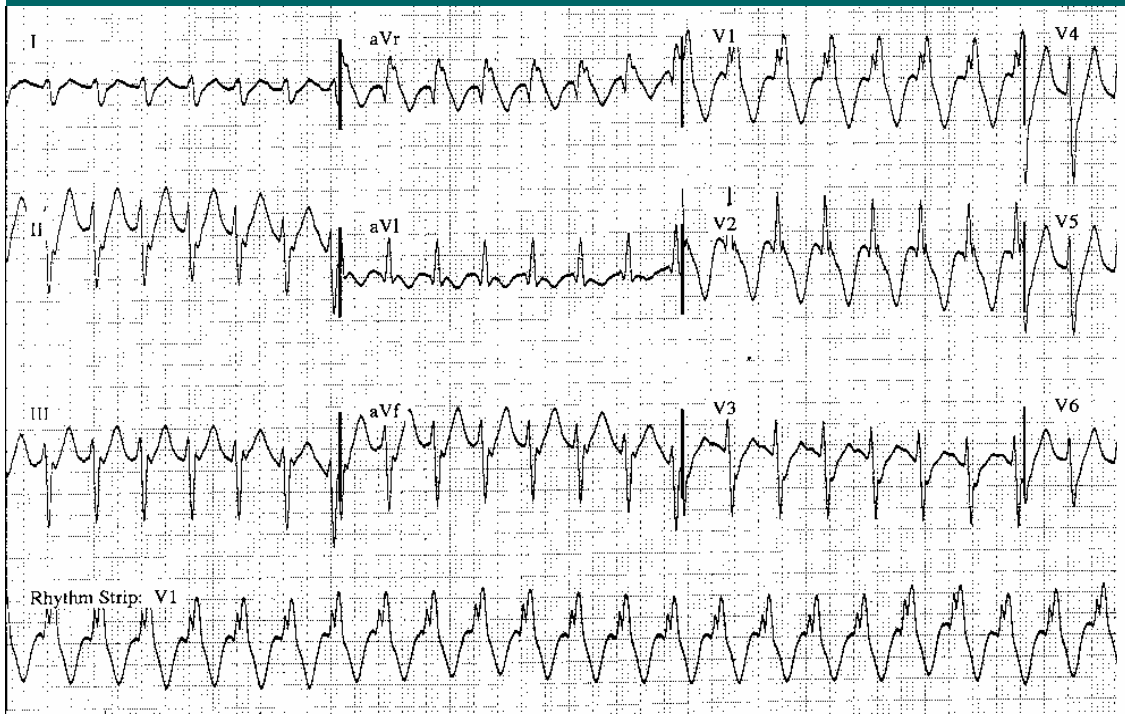
Basal LV VT with poster-lateral MVA origin

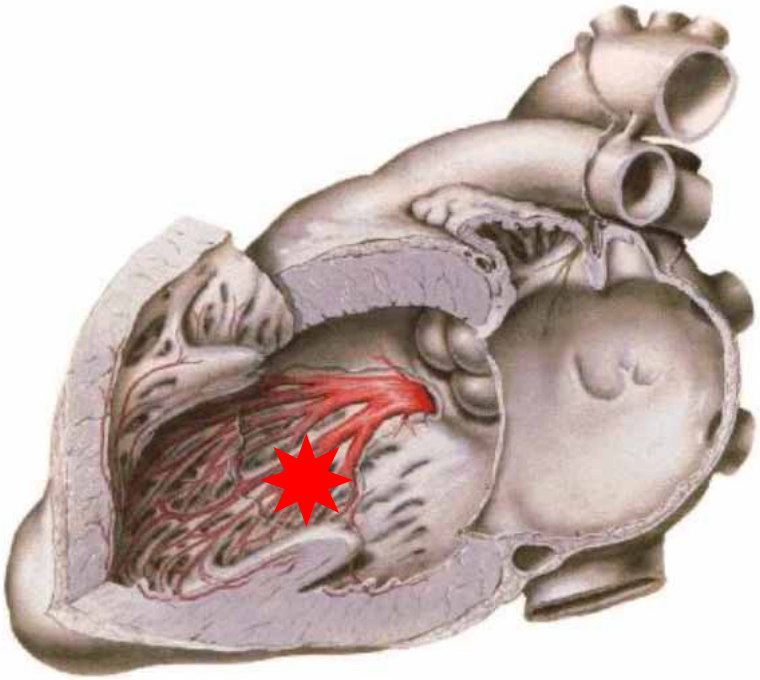




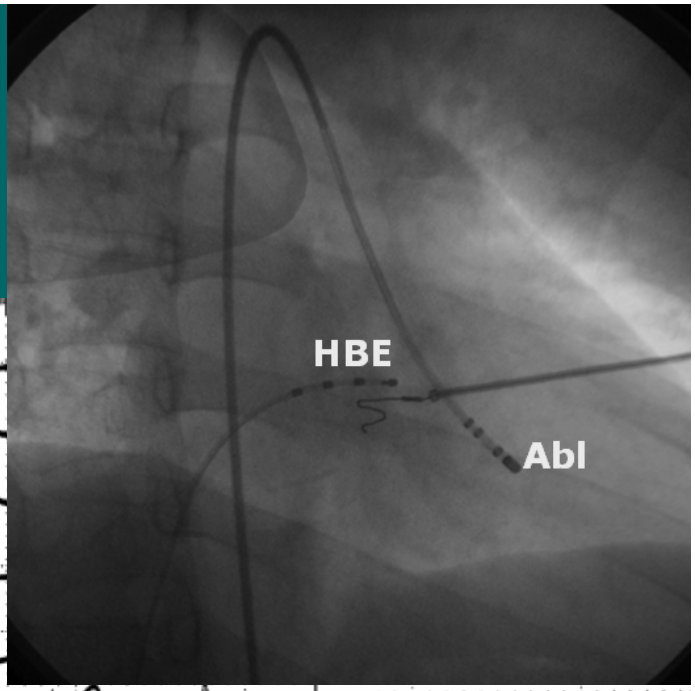
4, Fascicular VT: posterior fascicle origin

- ECG features：RBBB + Left axis deviation;



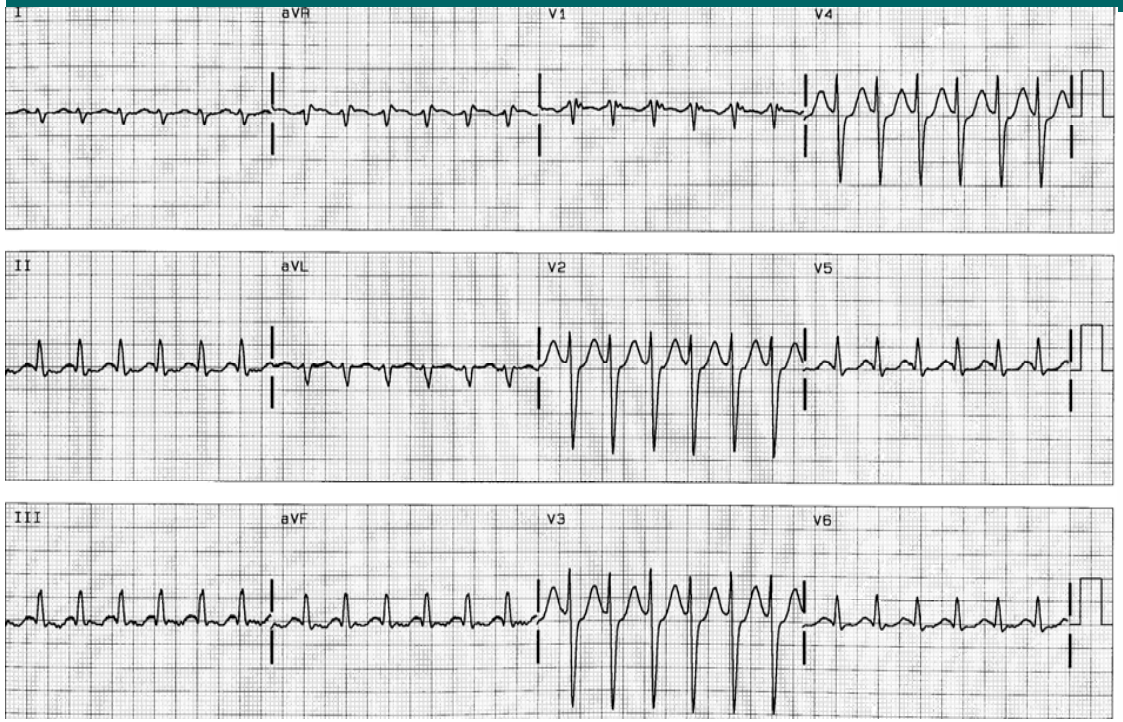


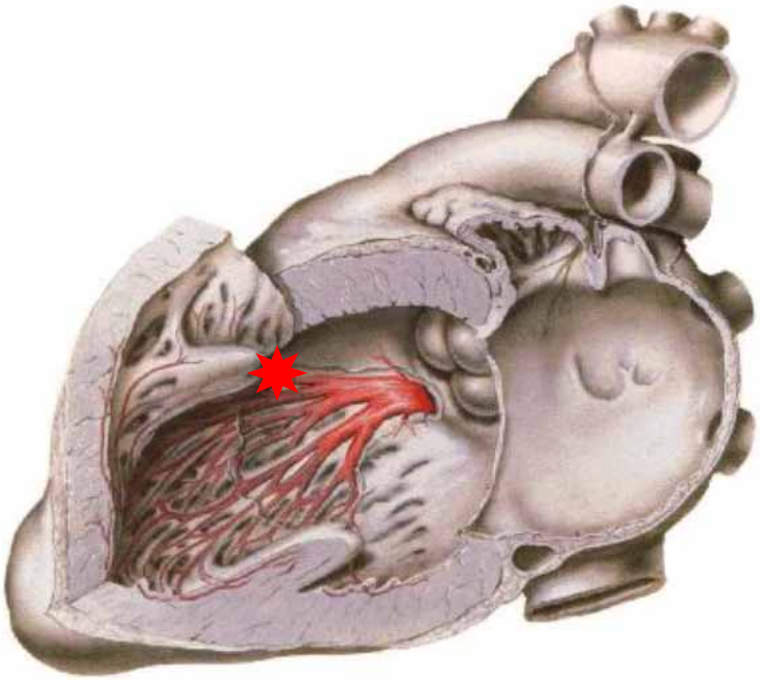
Typical Ablation Target



4, Fascicular VT: anterior fascicle origin

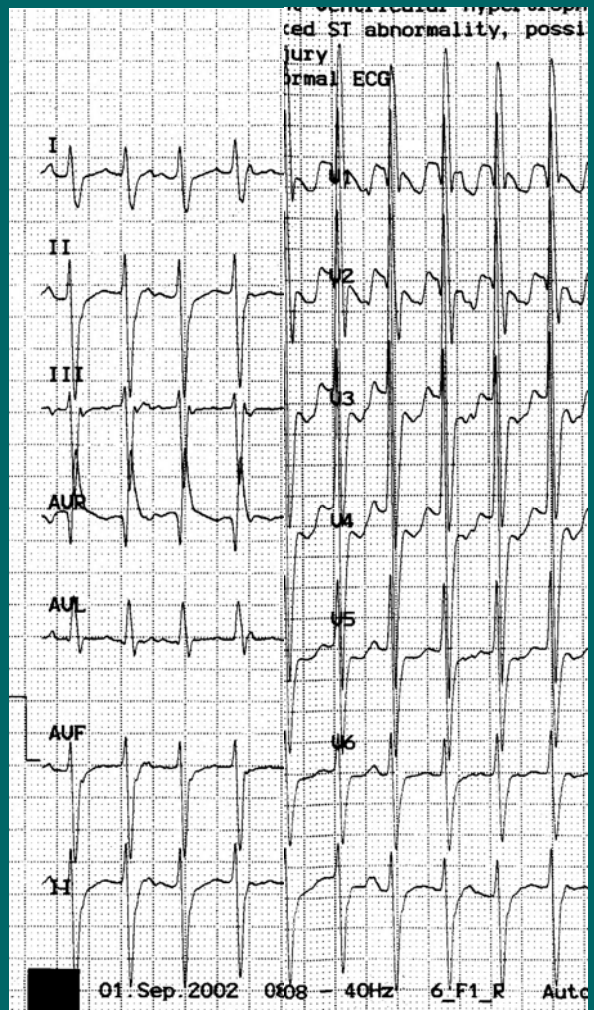
- ECG features: RBBB + Right axis deviation

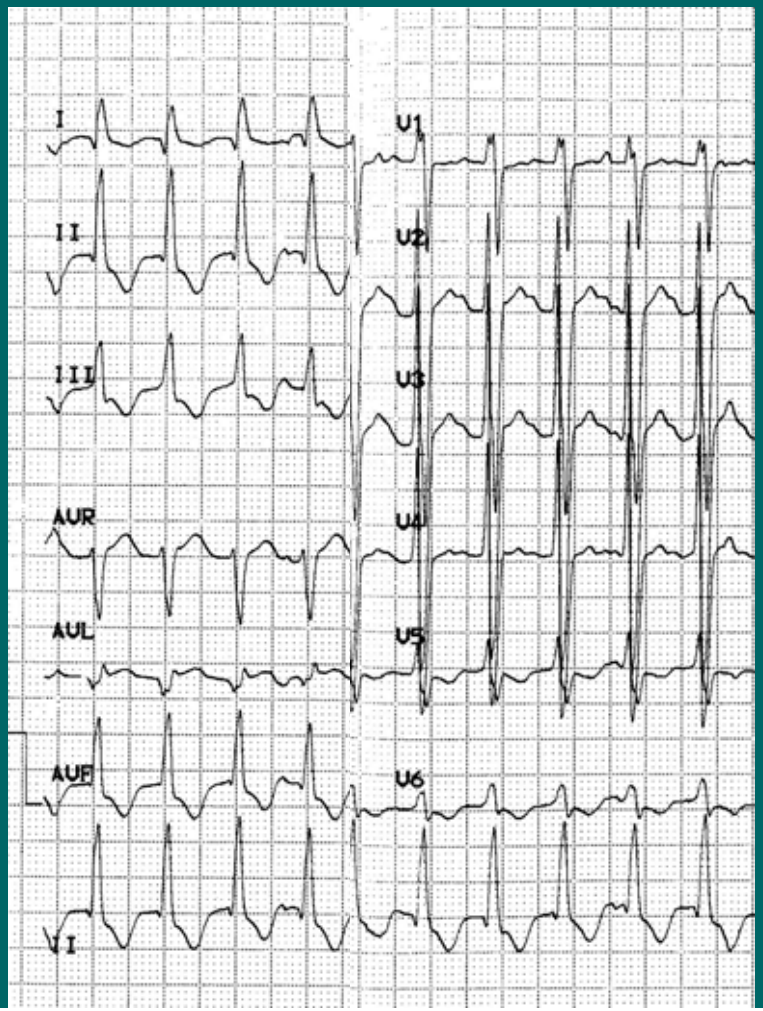




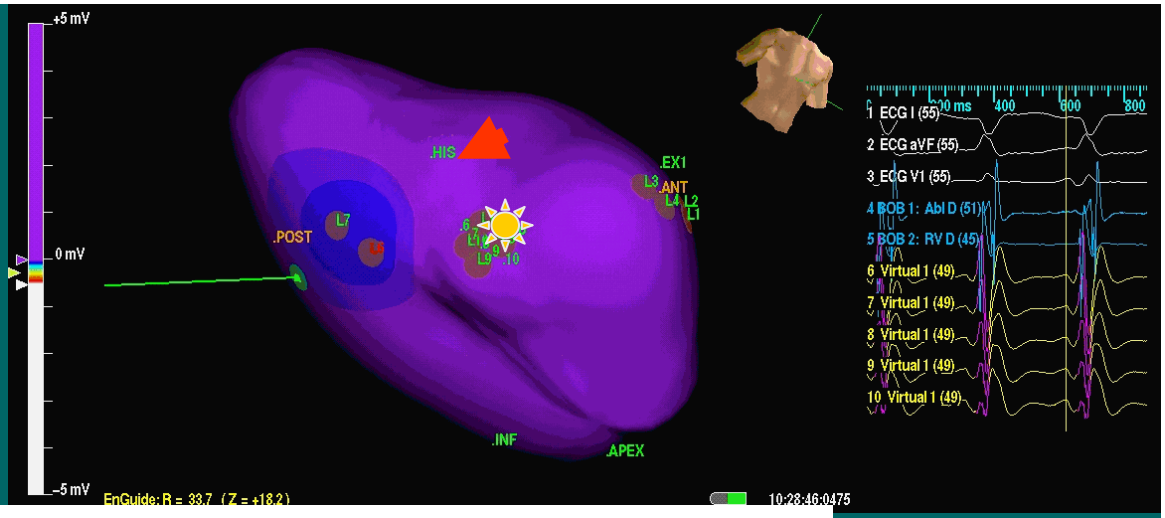
Left Para-Hisian VT

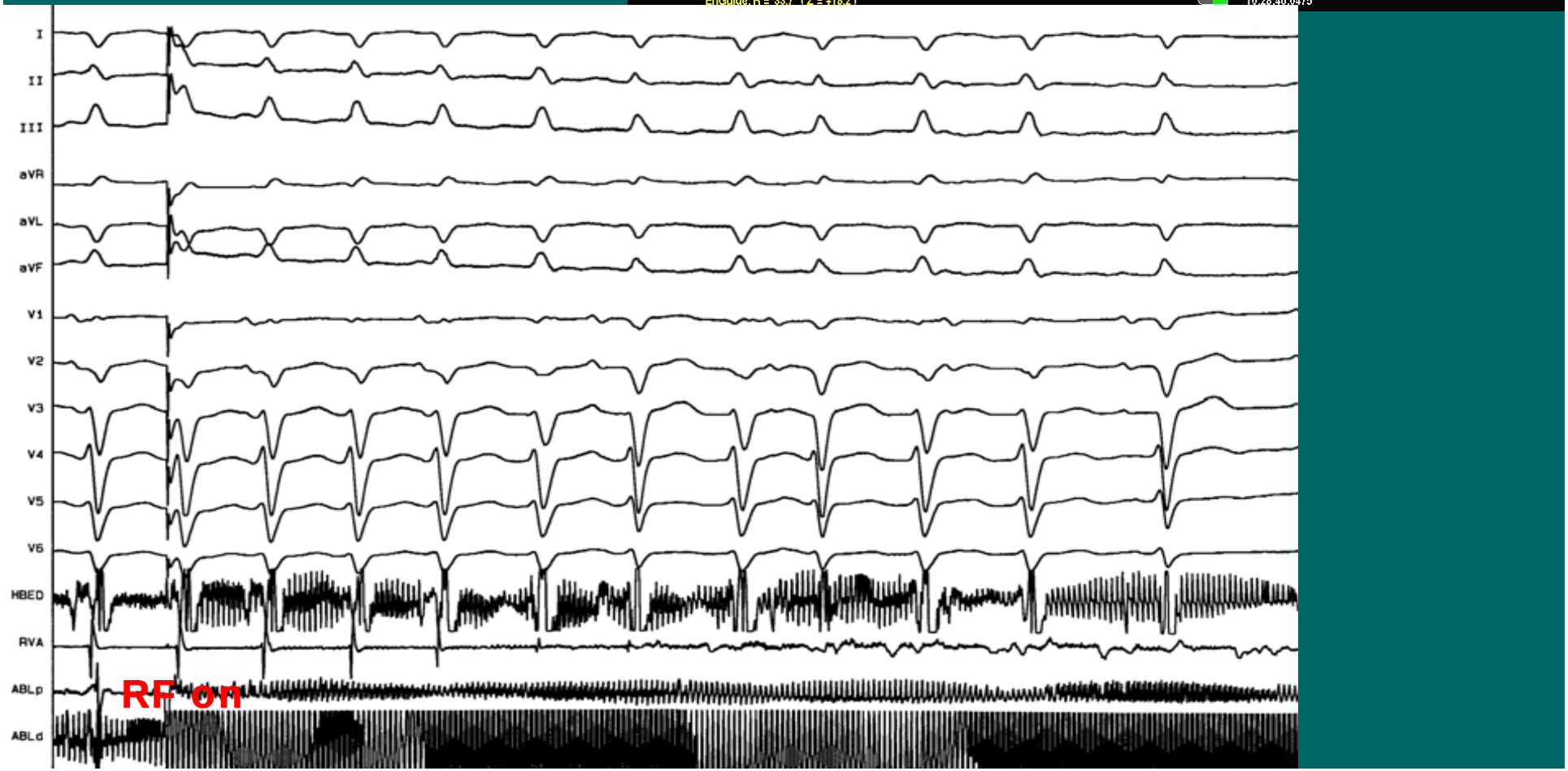
- ECG features: narrow QRS with similar morphology of sinus rhythm;



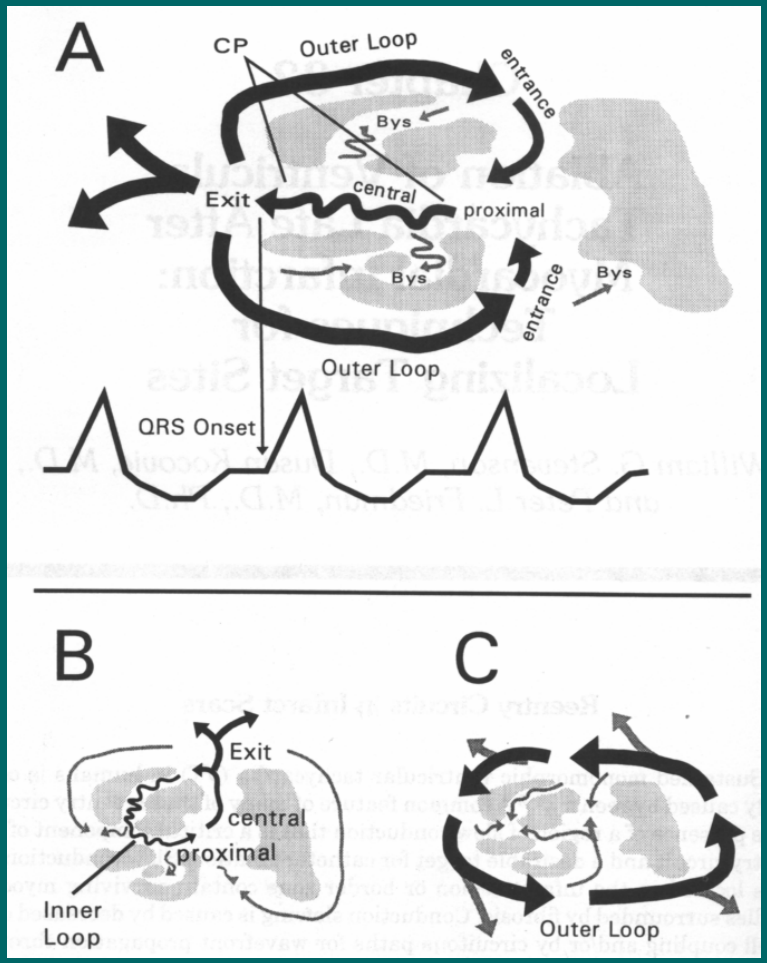


Target site: 3mm below the distal portion of His bundle



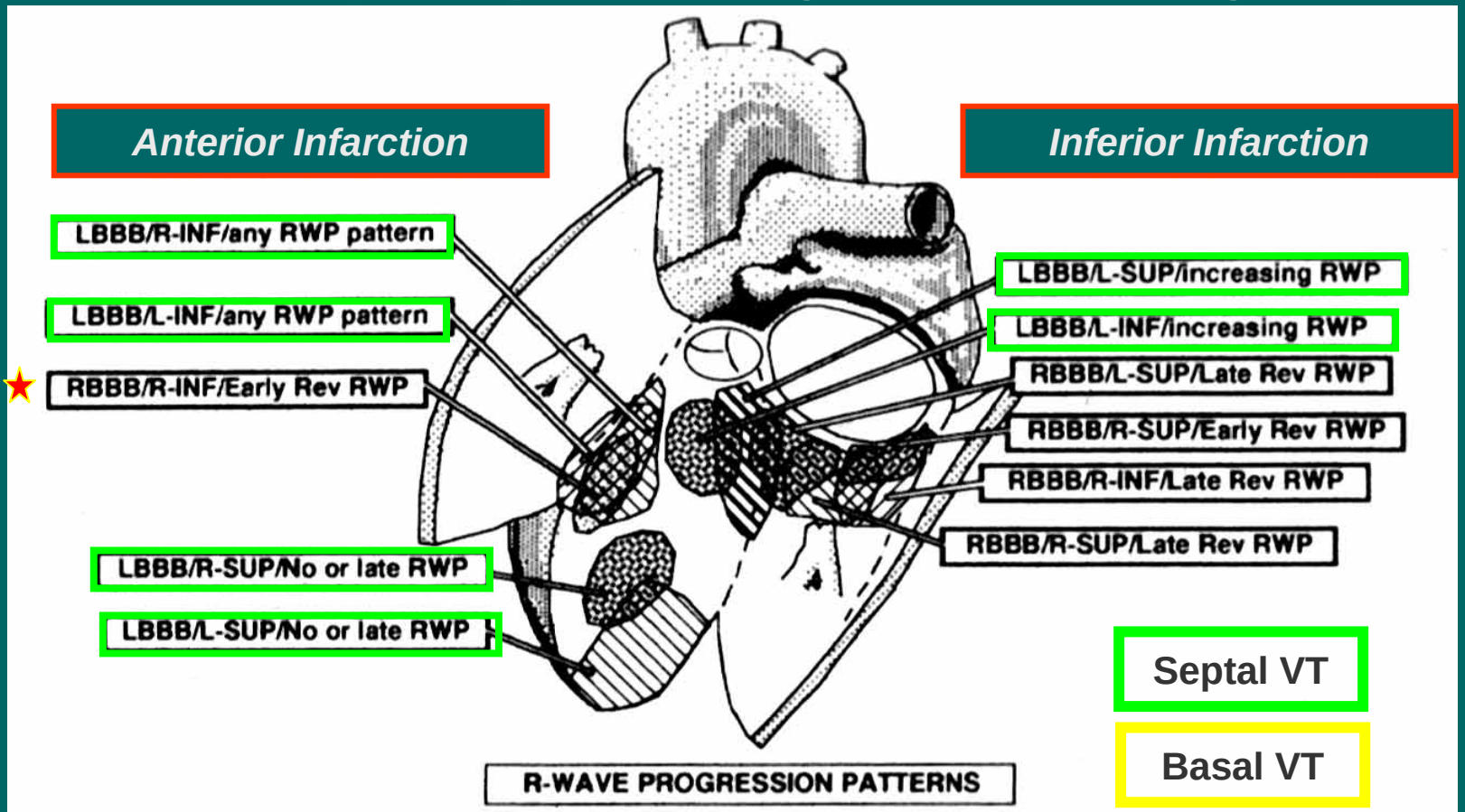


5, Ischemic VT



- Reentrant mechanism;
- The ECG only reflect the location of exit.

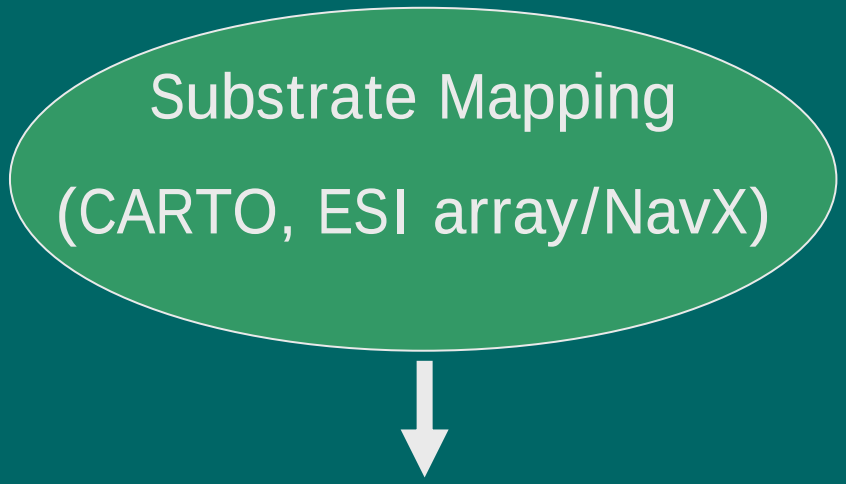
Summary of Specific Regions of VT Origin



R-WAVE PROGRESSION PATTERNS

PATTERN	V1	V2	V3	V4	V5	V6	PATTERN	V1	V2	V3	V4	V5	V6
INCREASING							DOMINANT						
NONE/LATE							ABRUPT LOSS						
DOWN/UP (-) QS							LATE REVERSE						
DOWN/UP (+) QS							EARLY REVERSE						

Current Mapping Strategy to Ischemic VT



Entrainment Mapping

Entrainment Mapping

Stimulate with a CL that 20-30ms shorter than spontaneous VT at the site with MDP recorded:

1, QRS identical with VT in12 leads ;

2, Stim-QRS is about equal with MDP－QRS (±10 ms);

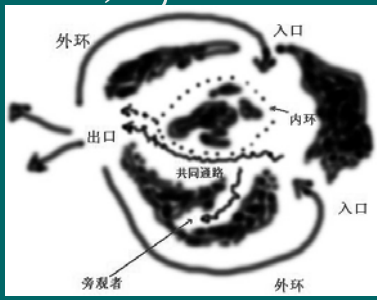
3, Post pacing interval (PPI) is equal with the CL of VT （±10 ms）;

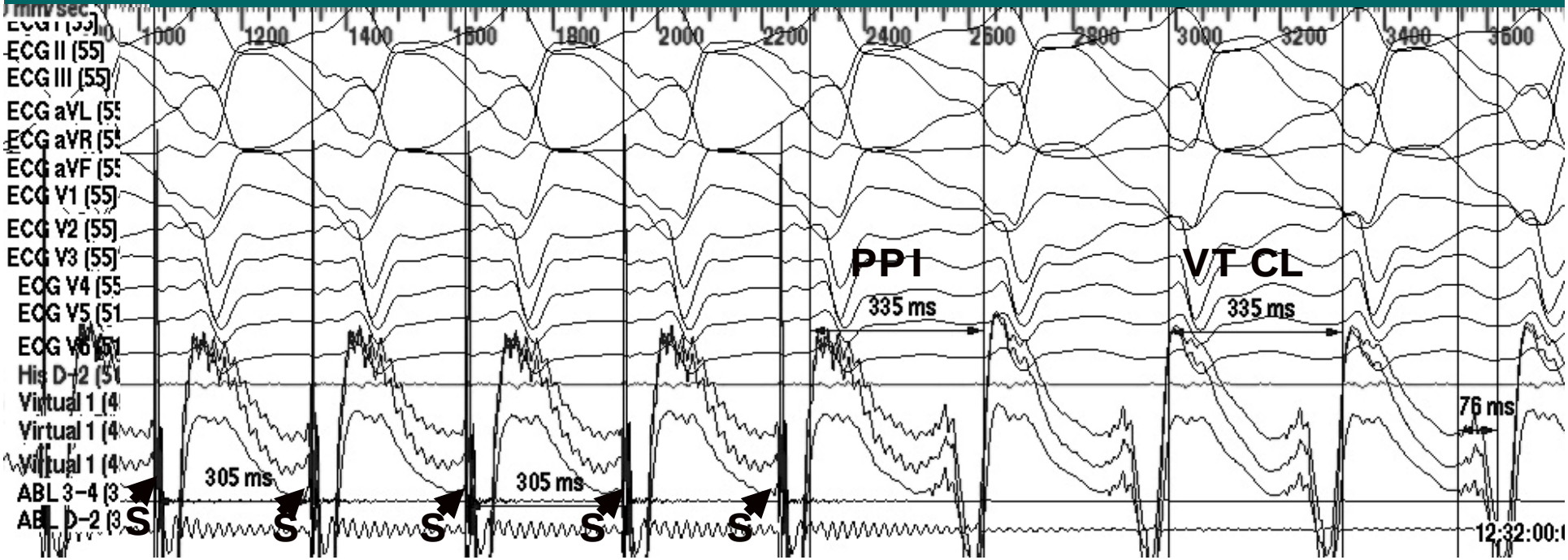
Pacing at the common pathway of reentrant：1＋2＋3 ;

Pacing at out loop: fusion + 3 ;

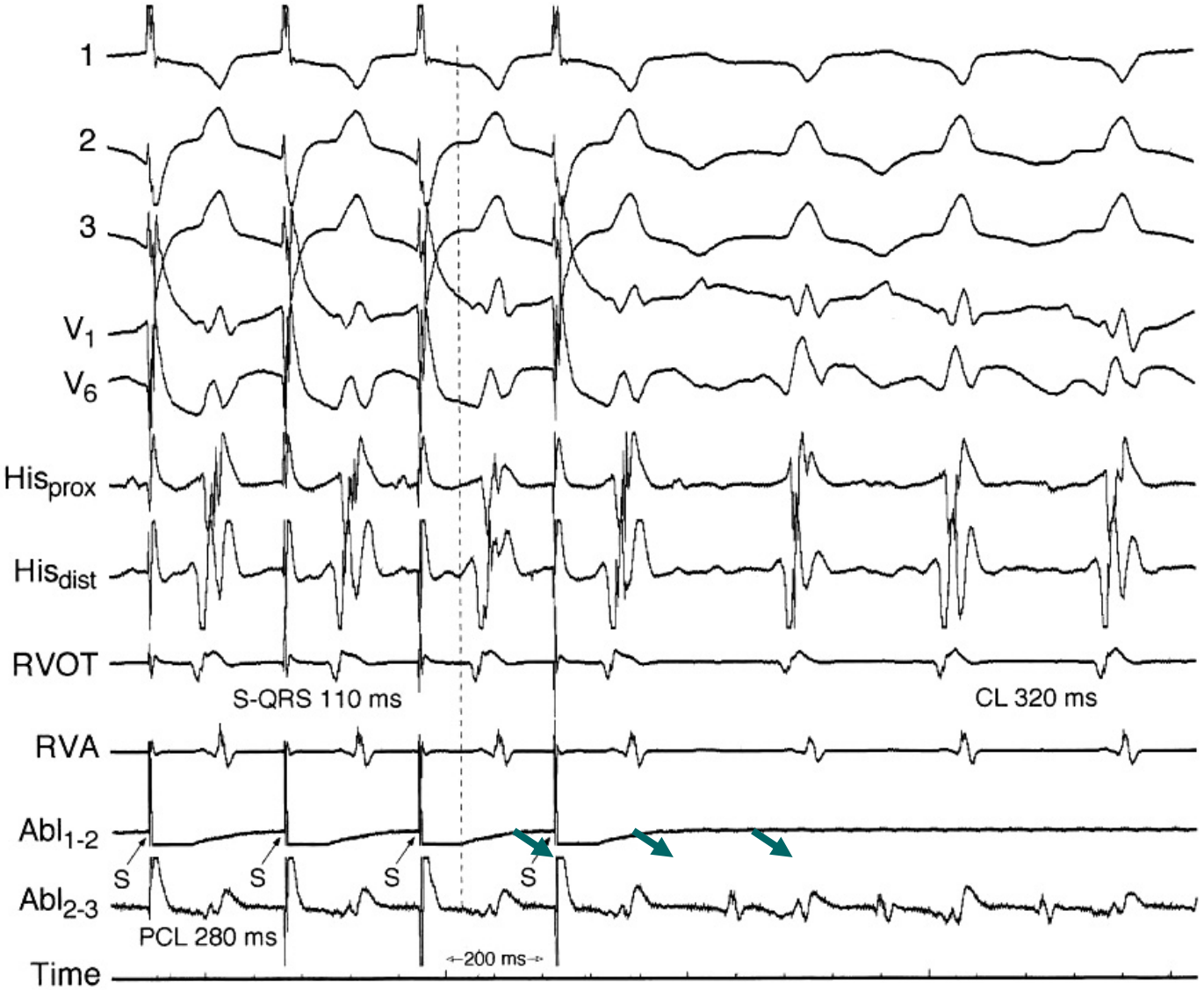
Pacing outside of reentrant circuit: different morphology & PPI ;

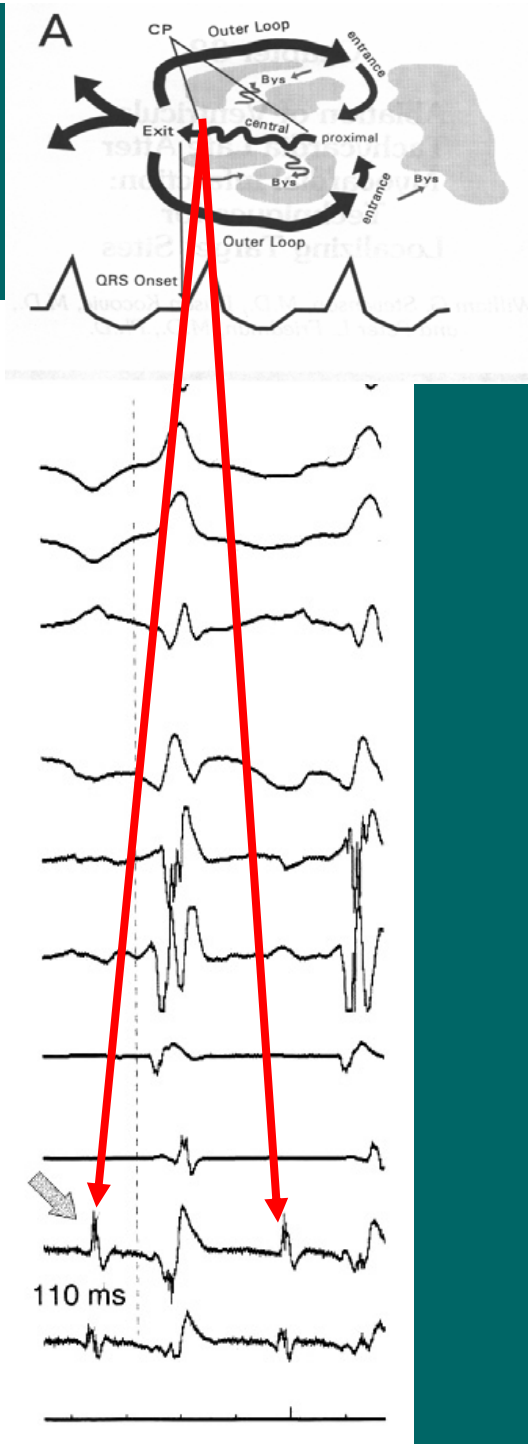
Pacing at bystander:1+prolonged 2&3 ;





MDP & Entrainment

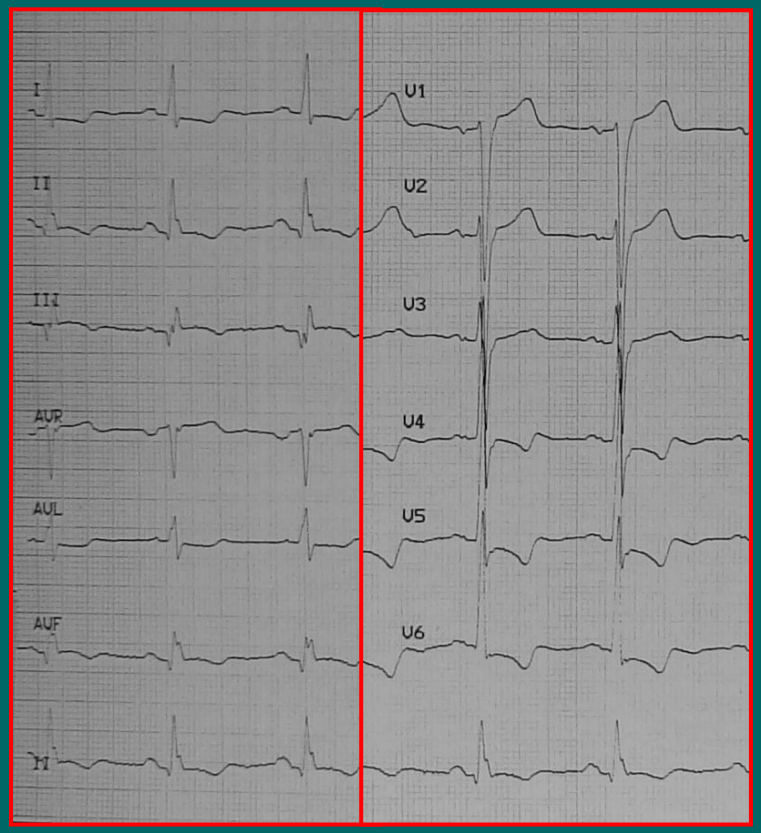




Ischemic VT Case

- 47 yro male with prior MI（inferior、posterior wall history.
- 2 years history of VT after CABG;
- UCG: LVED 65mm , LVEF 40％.

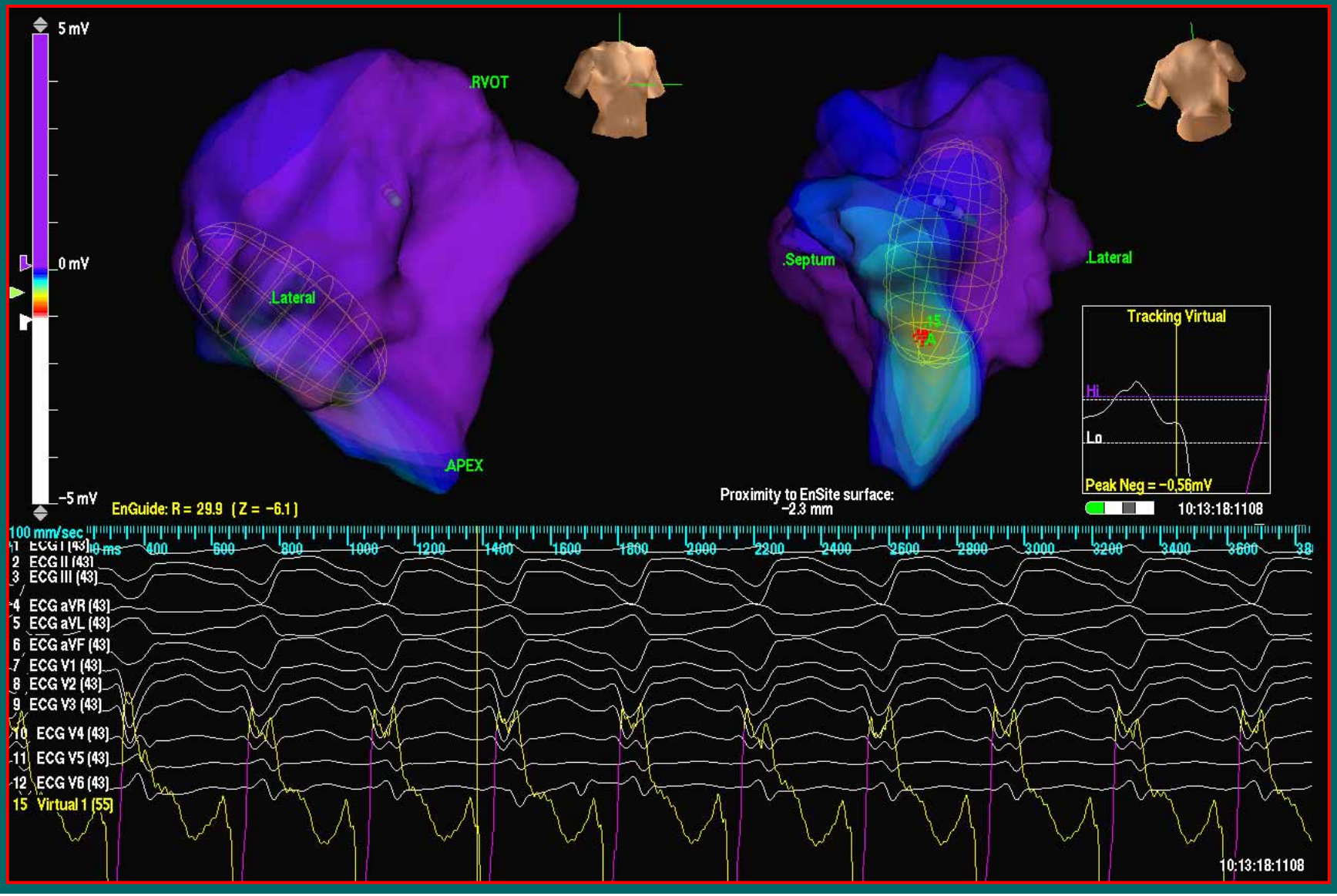
Sinus Rhythm



Clinical VT

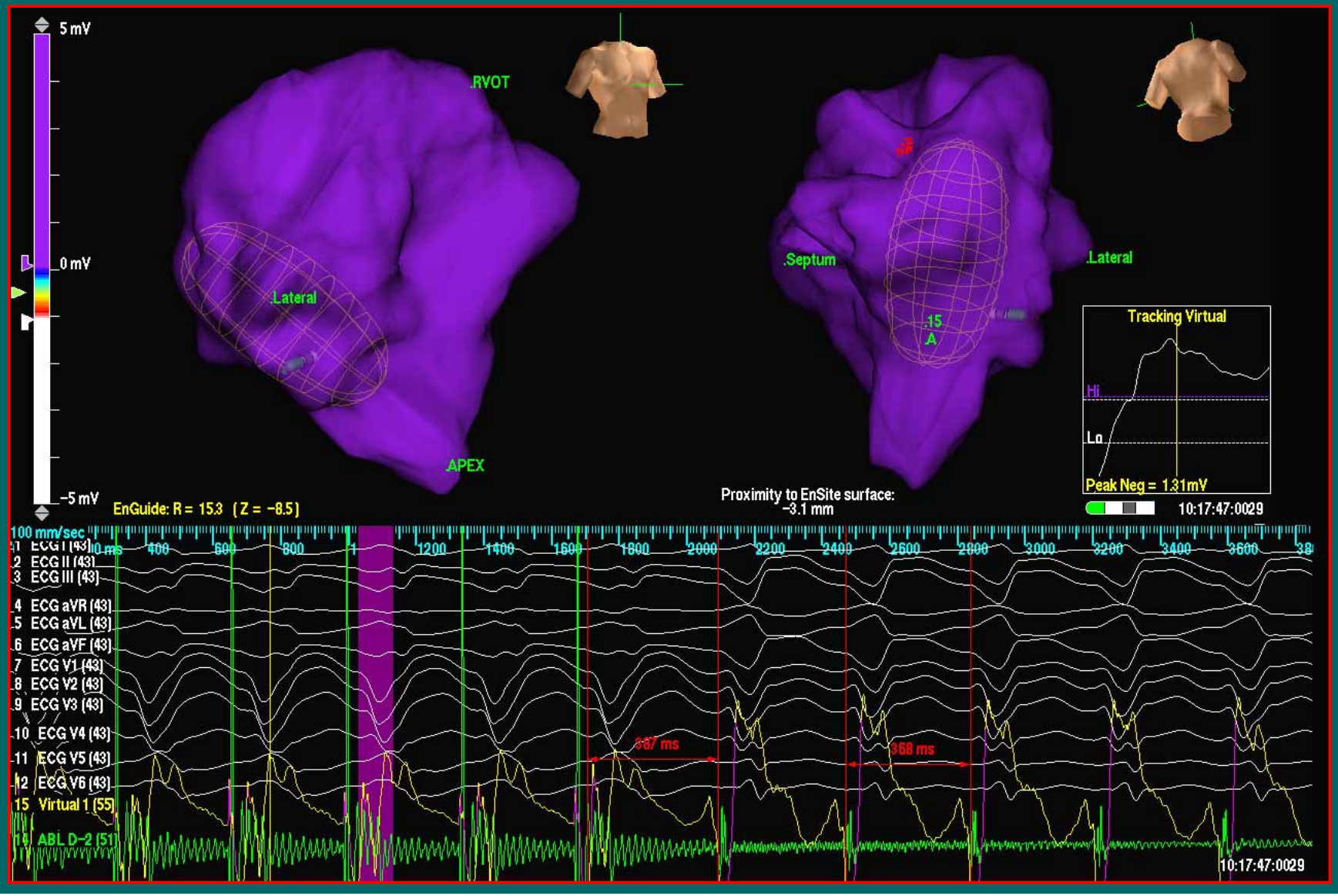
Mapping in RV

- The earliest potential was 14 ms earlier that ECG ;



Mapping in RV

- Entrainment mapping failed.

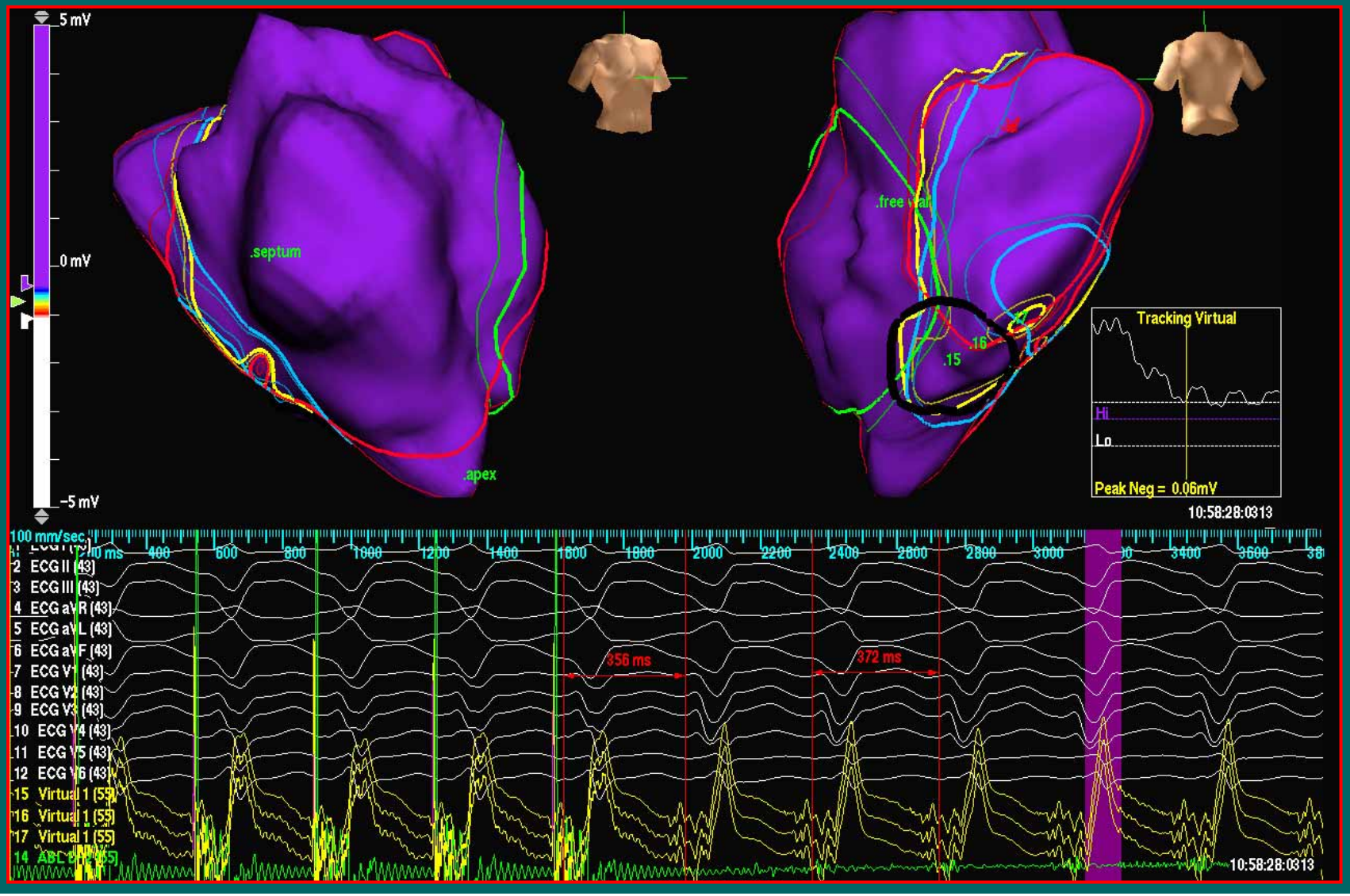


Mapping in LV

- The earliest potential was 28 ms earlier that ECG;

Mapping in LV

- Concealed entrainment， S-QRS：24ms；VTCL 356ms；PPI 372ms



6, VT with Epicardail Origin

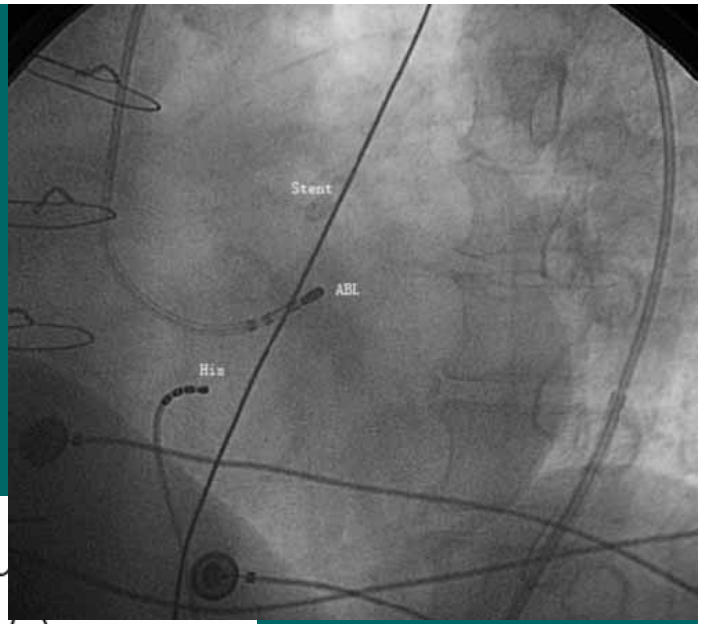
Berruezo A. Circulation 2004;109:1842

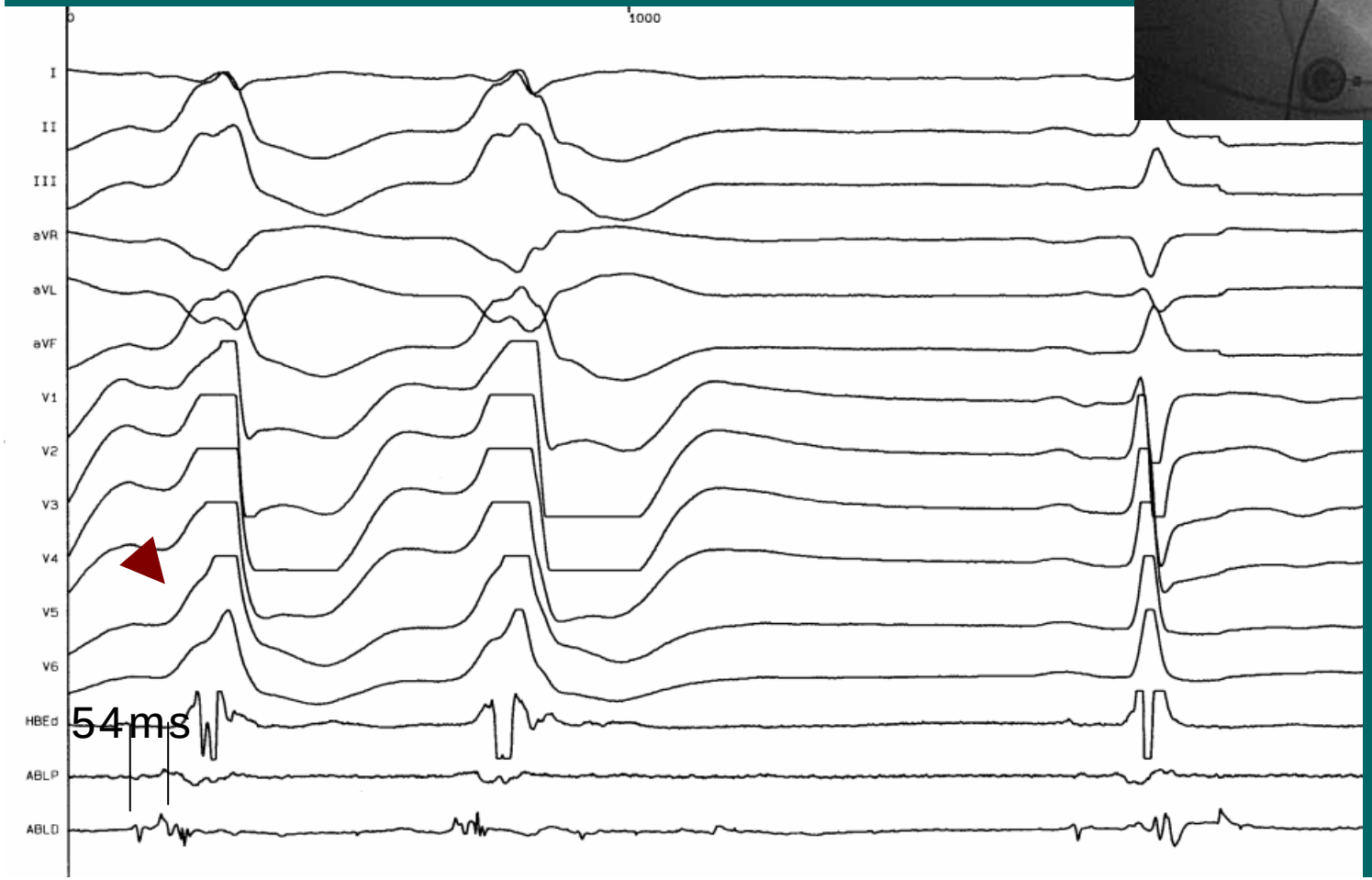
- ECG features: significantly longer pseudo-delta wave (≥ 34 ms) , intrinsicoid deflection and RS complex duration compared to VT with endocardial origin.

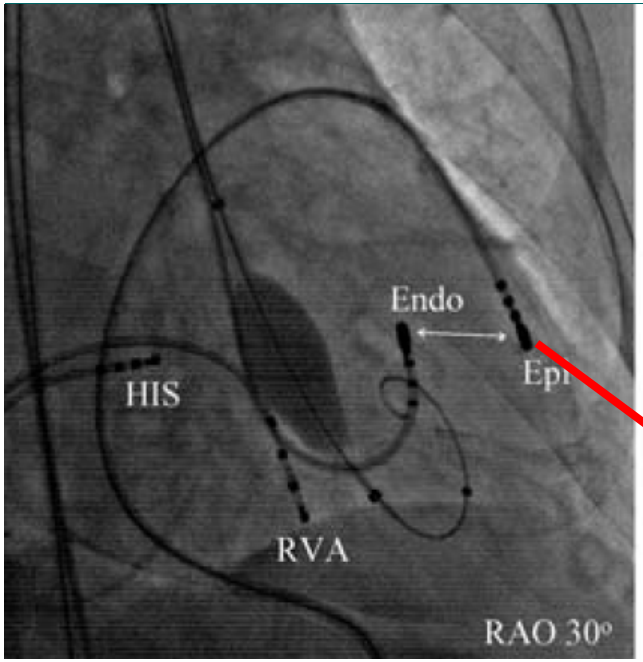
Identification of Epicardial Origin of VT

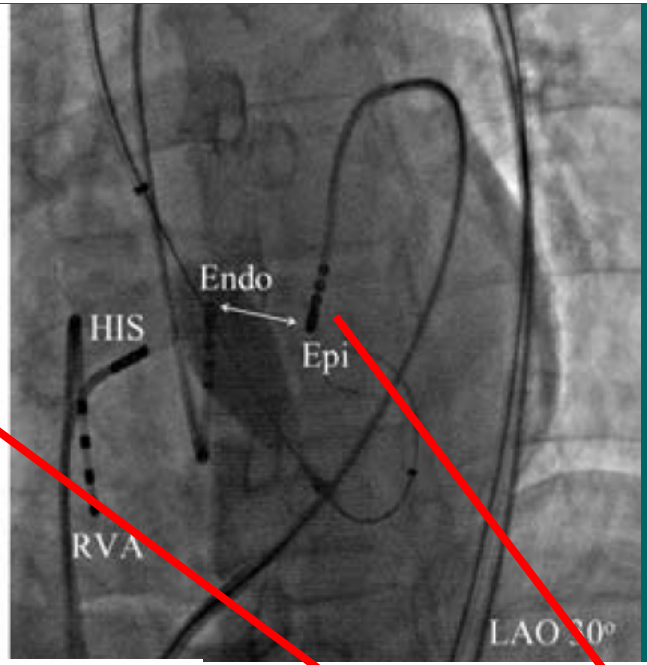
	Sensitivity	Specificity
Pseudo-delta wave ≥ 34 ms	83%	95%
intrinsicoid deflection ≥ 85 ms	87%	90%
RS complex duration ≥ 121 ms	76%	85%

65 yro male;
Post-MI and PTCA+CABG;
Incessant VT for 1 month;
Irrigation ablation at endocardial with 50 Watts terminated VT after 60 sec.



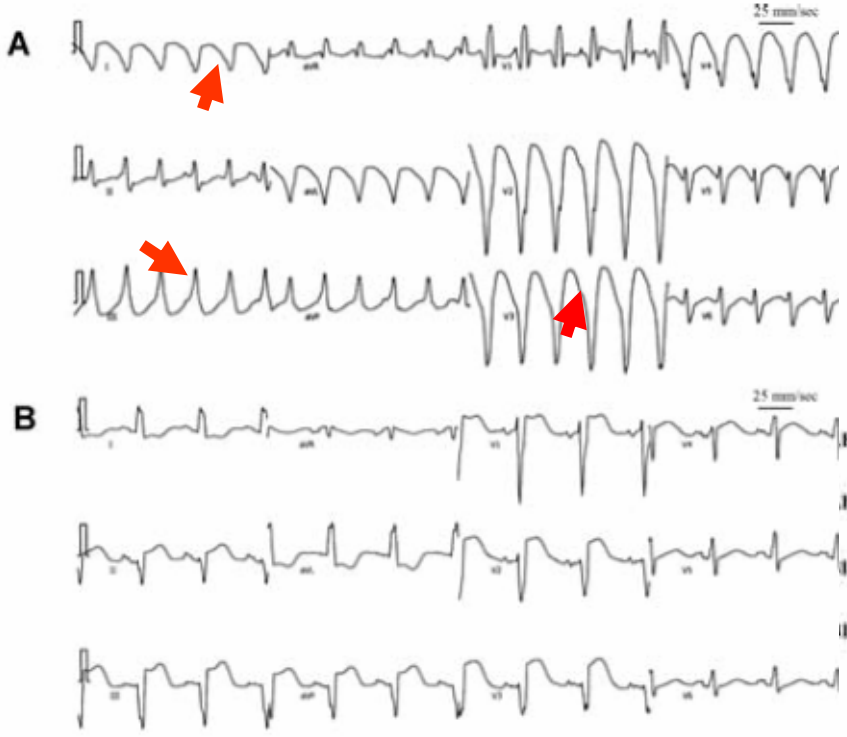


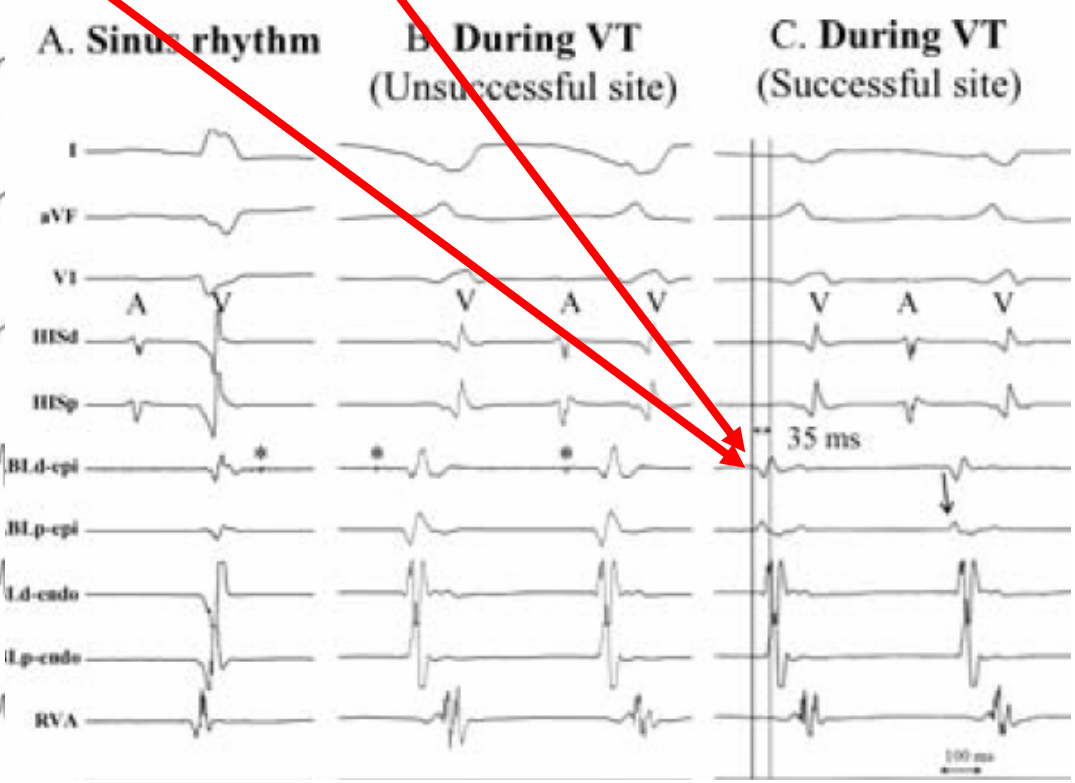




Epicardiac mapping of VT with isolated noncompaction of ventricular myocardium

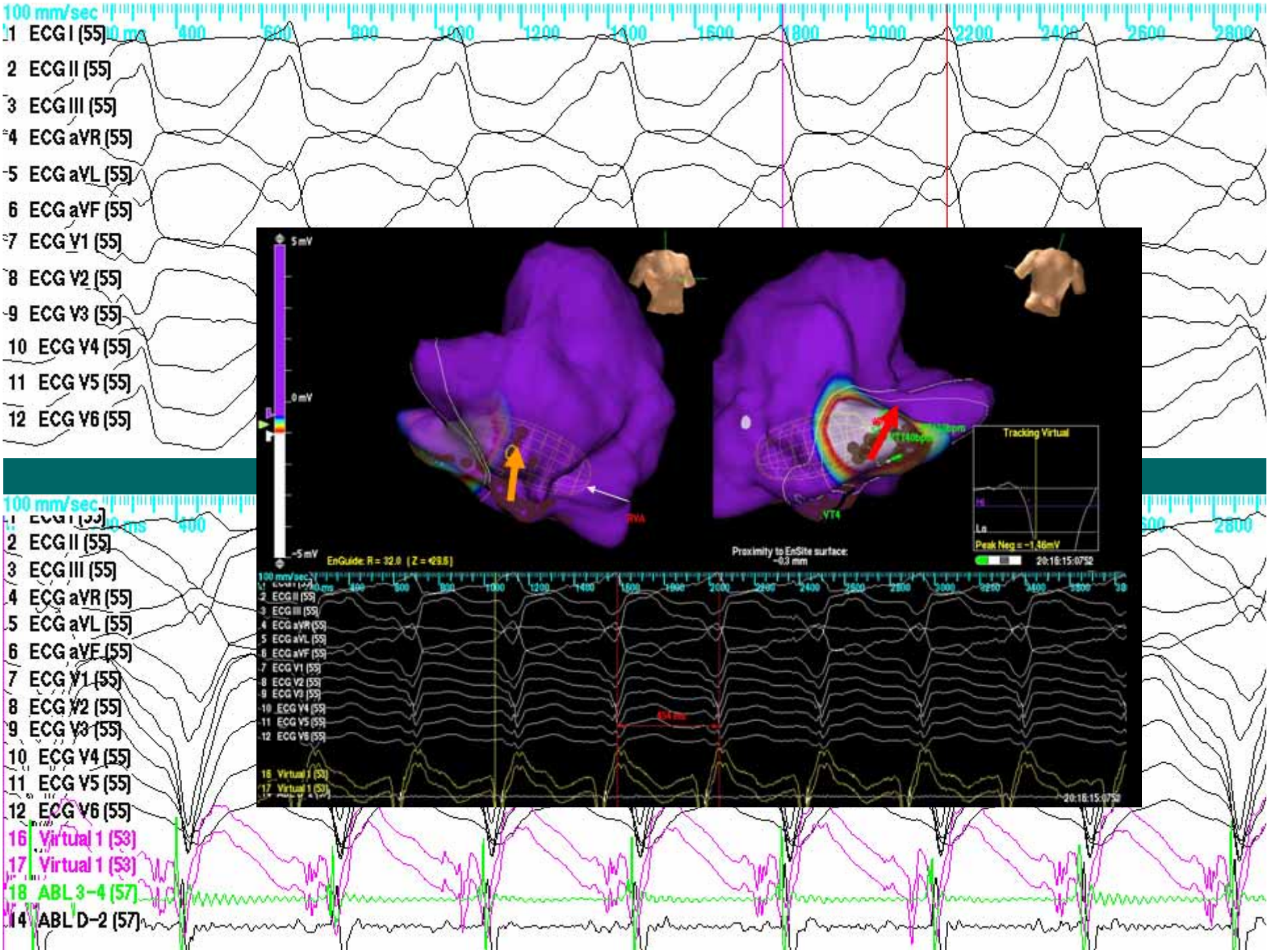
Lim H, PACE 2006



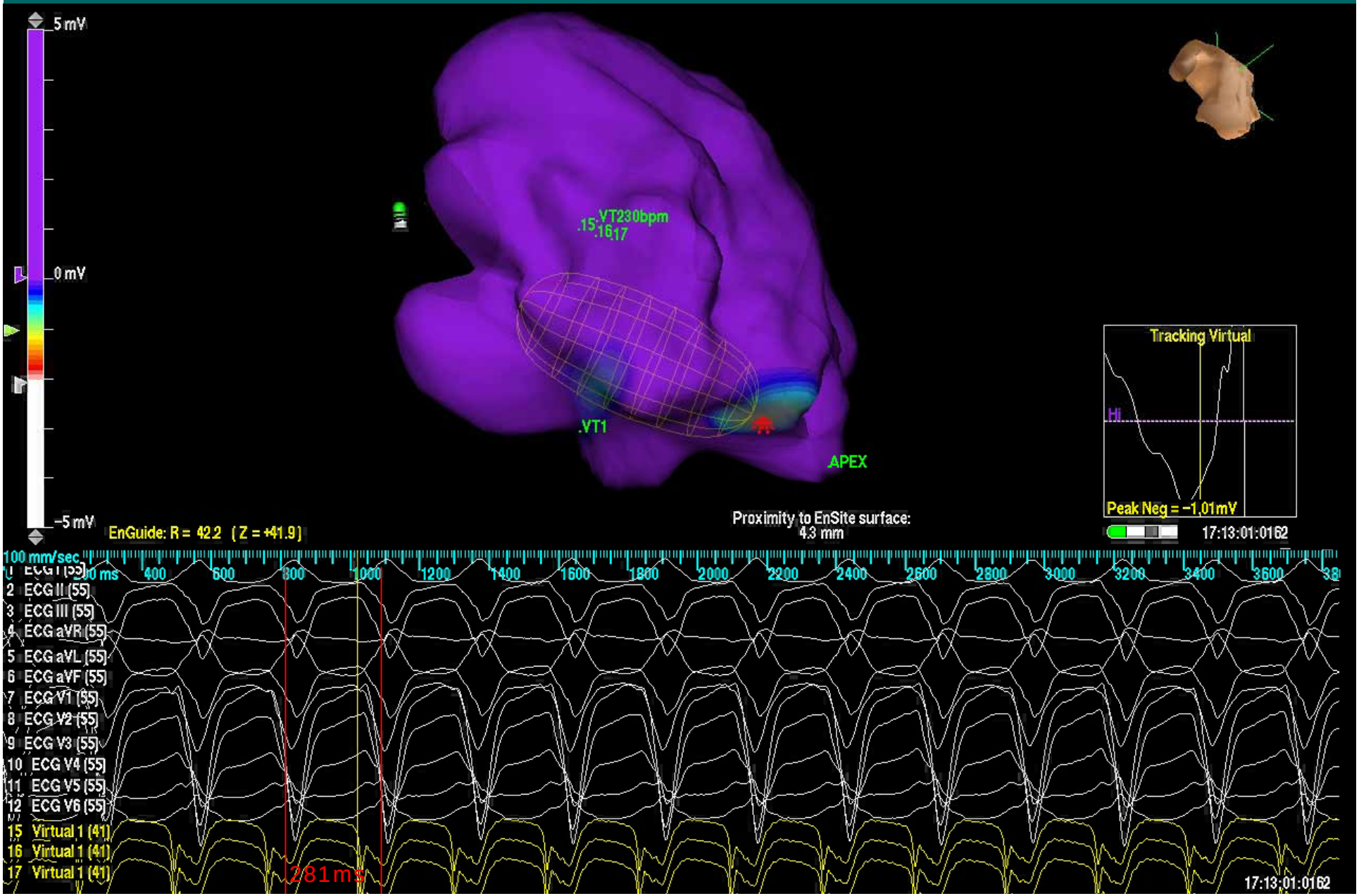


7, ARVC VT

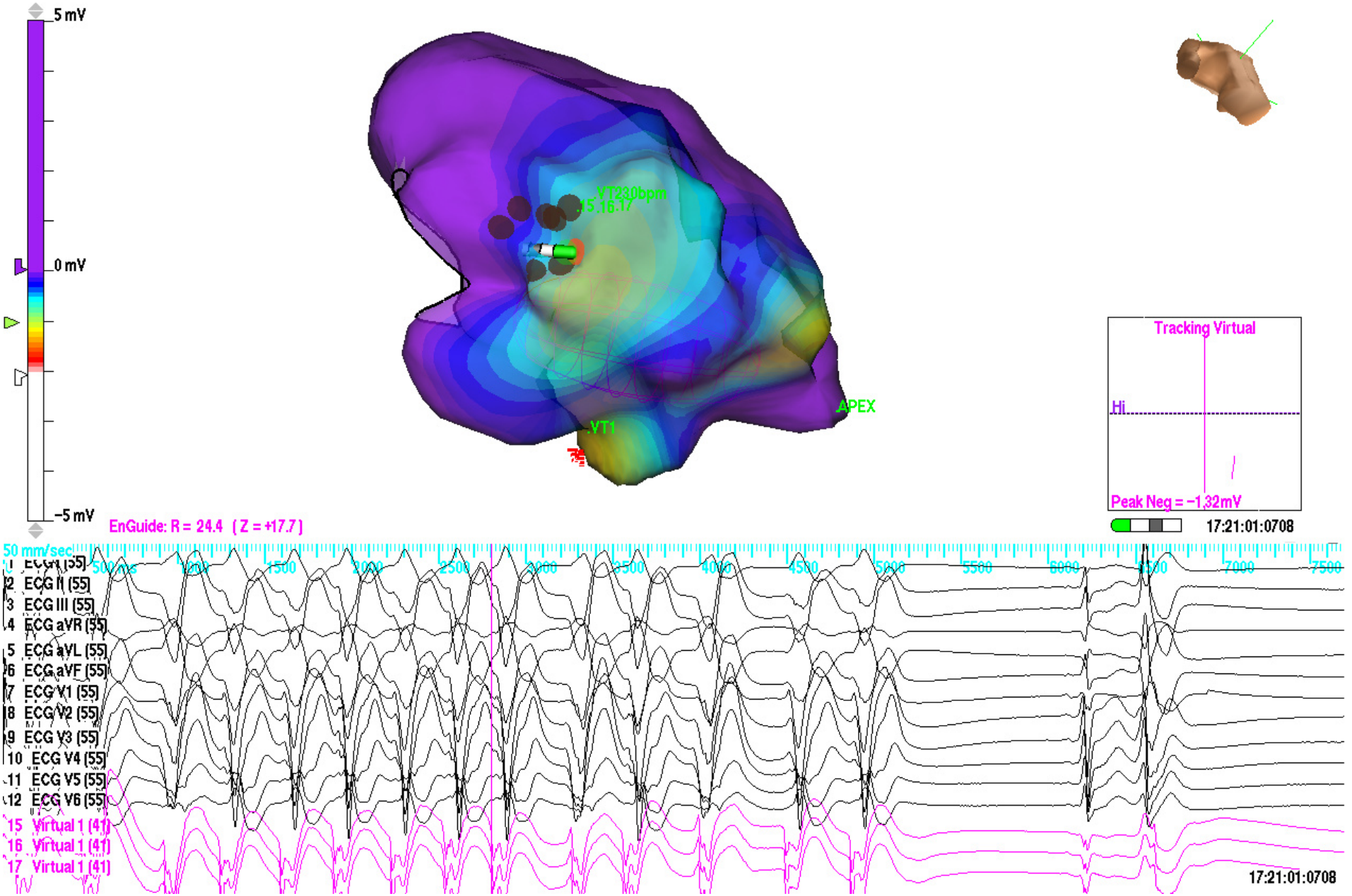
- ECG features: LBBB + S or s wave in any of the inferior leads.


100 mm/sec
1 ECG I (55)
2 ECG II (55)
3 ECG III (55)
4 ECG aVR (55)
5 ECG aVL (55)
6 ECG aVF (55)
7 ECG V1 (55)
8 ECG V2 (55)
9 ECG V3 (55)
10 ECG V4 (55)
11 ECG V5 (55)
12 ECG V6 (55)
16 Virtual 1 (53)
17 Virtual 1 (53)
18 ABL 3-4 (57)
14 ABL D-2 (57)
5 mV
0 mV
-5 mV
EnGuide: R = 32.0 (Z = 49.8)
Proximity to EnSite surface:
-0.3 mm
Tracking Virtual
Peak Neg = -1.46mV
20:16:15:0752
RVA
VT4

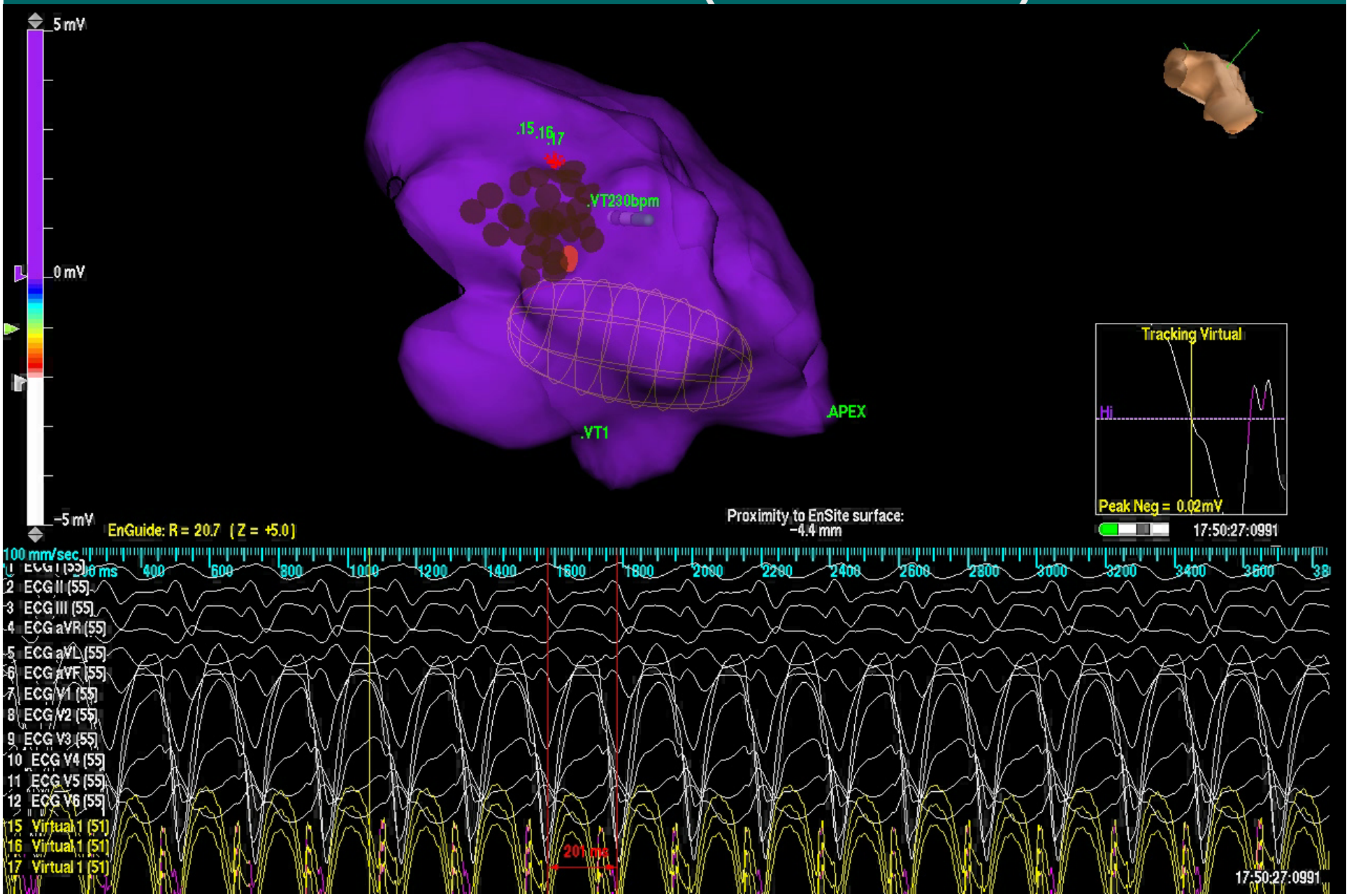
ARVC VT 40yr/M with history of presyncope



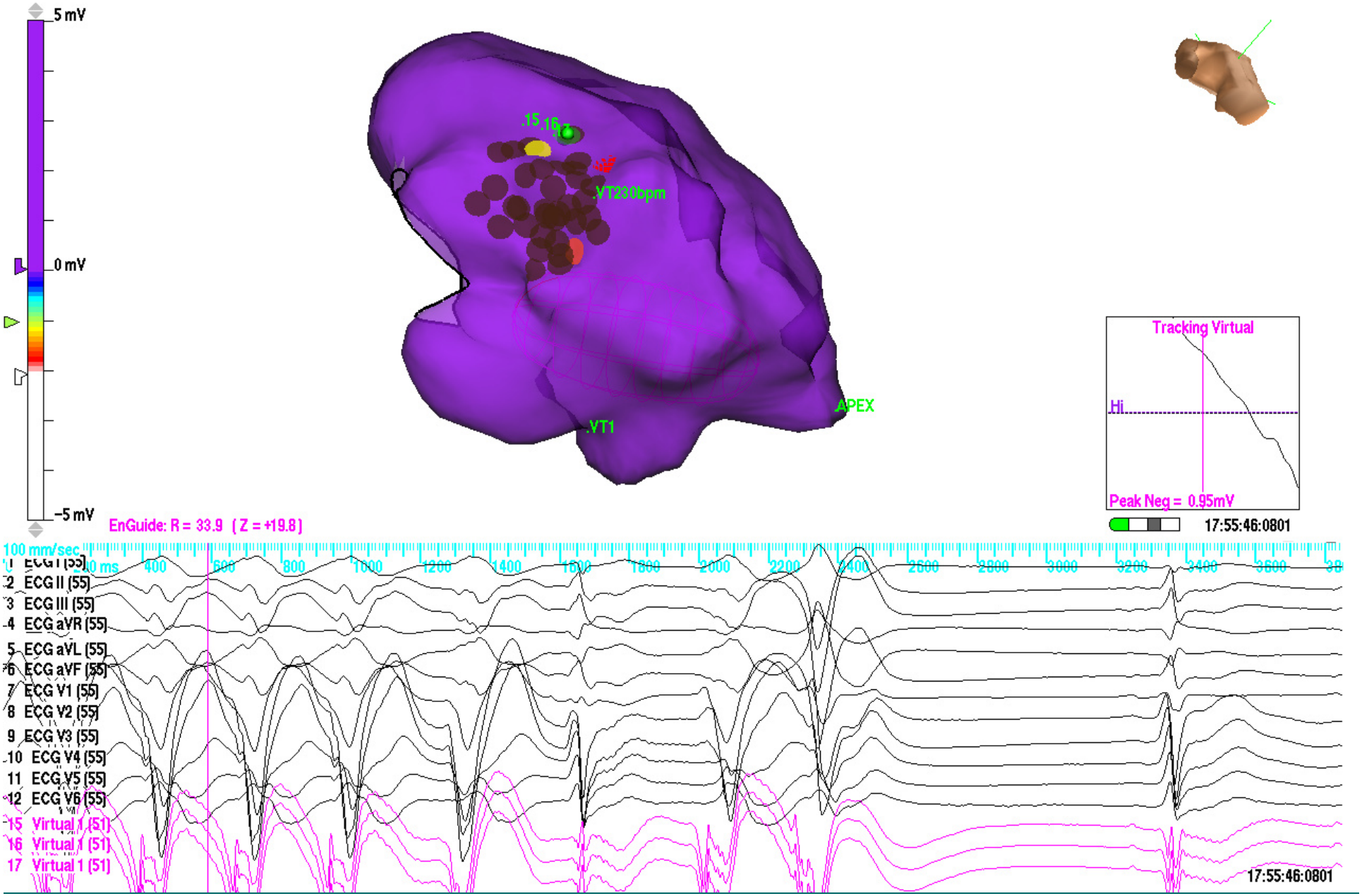
VT 1 (210bpm) terminated



VFL induced (CL 201ms)

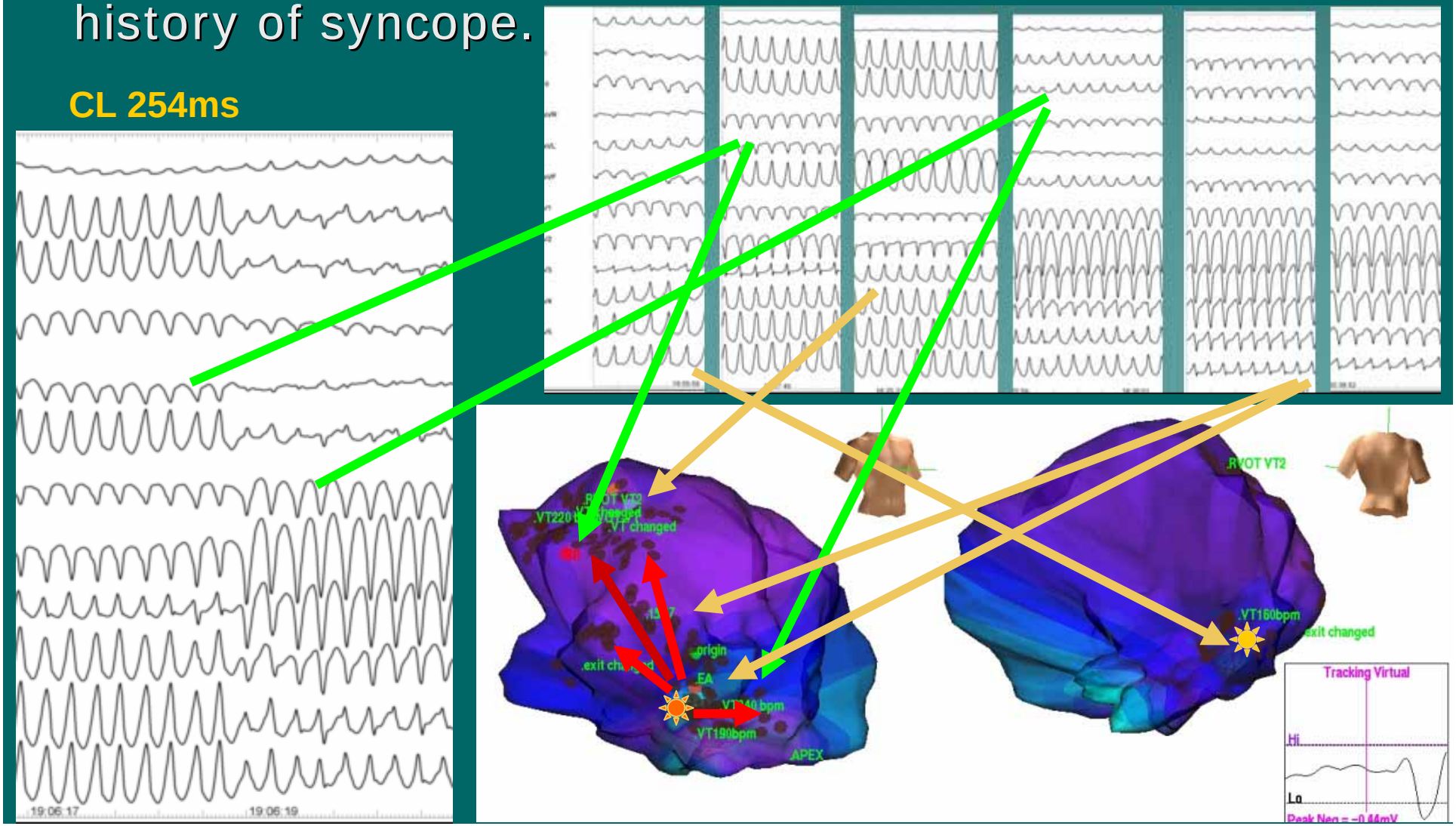
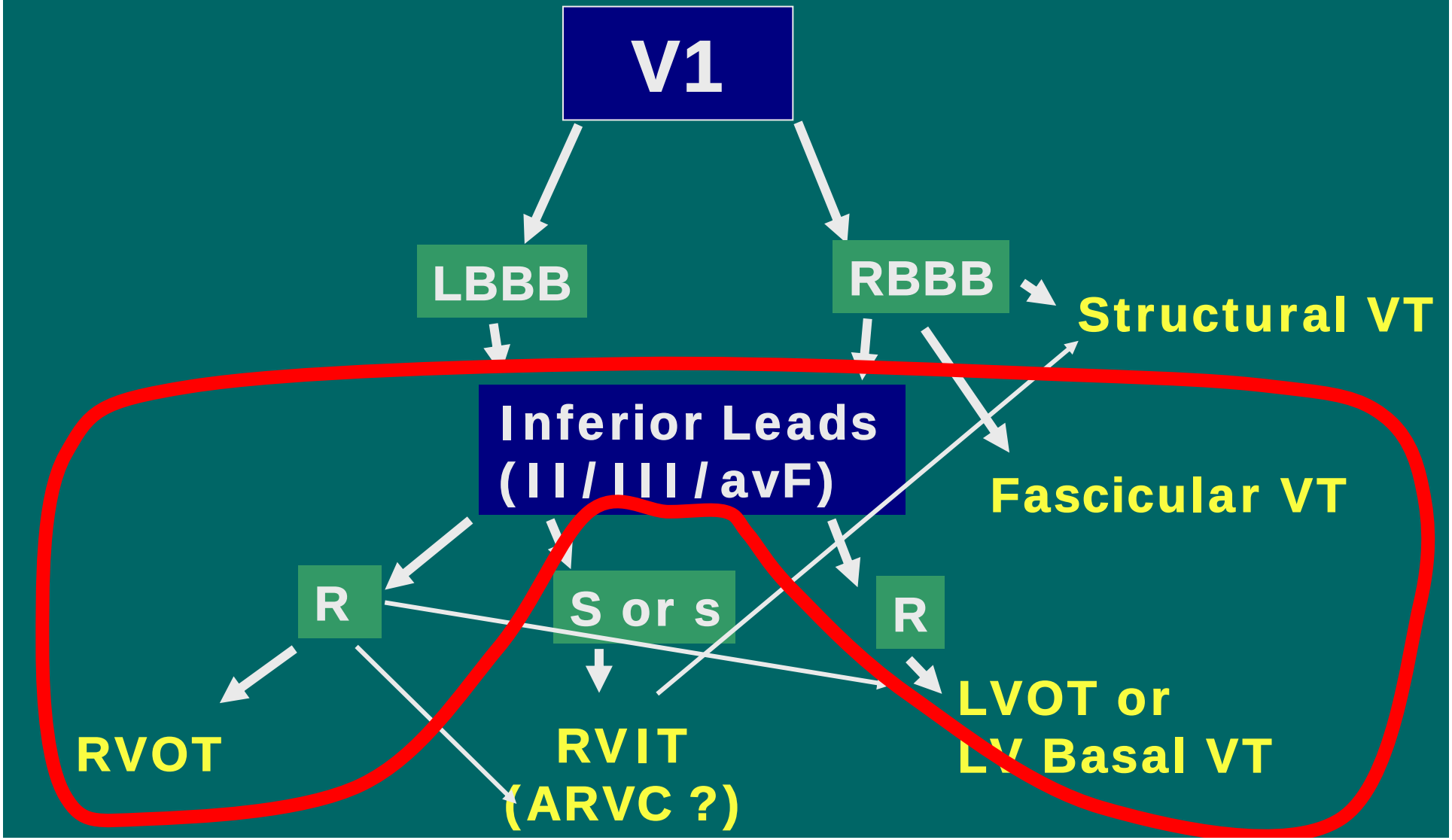


Fast VT terminated



ARVC VTs with Multiple Exits

- 36 yro male with history of syncope.



Simple Steps for VT Origin Identification