Catheter Ablation of VT Without Structural Heart Disease

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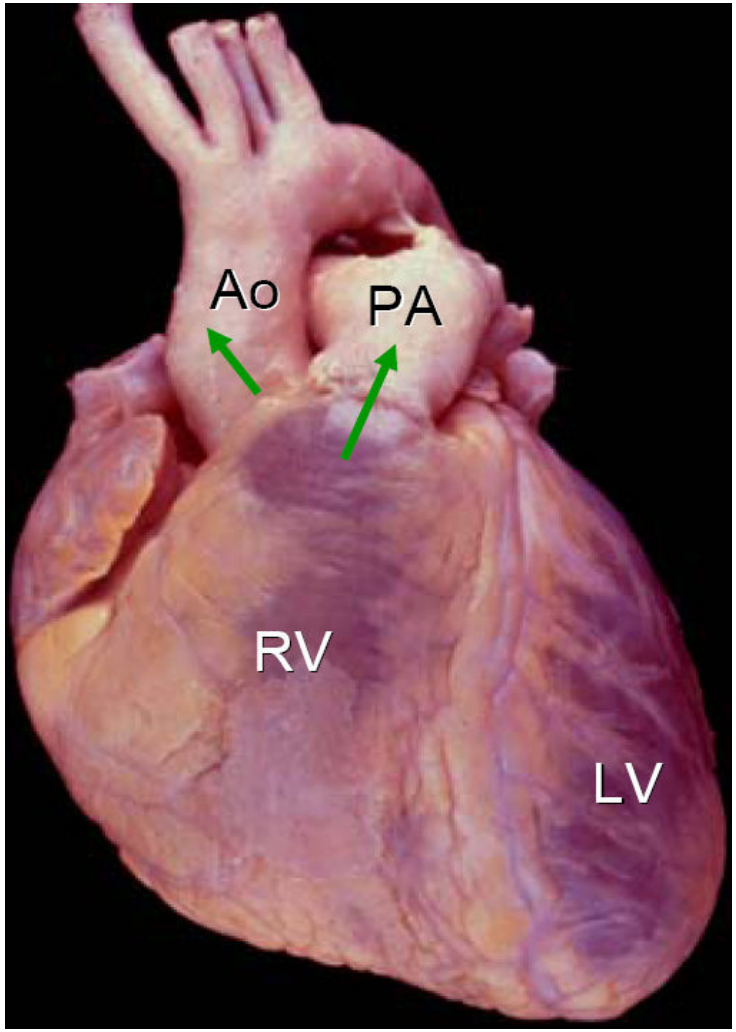
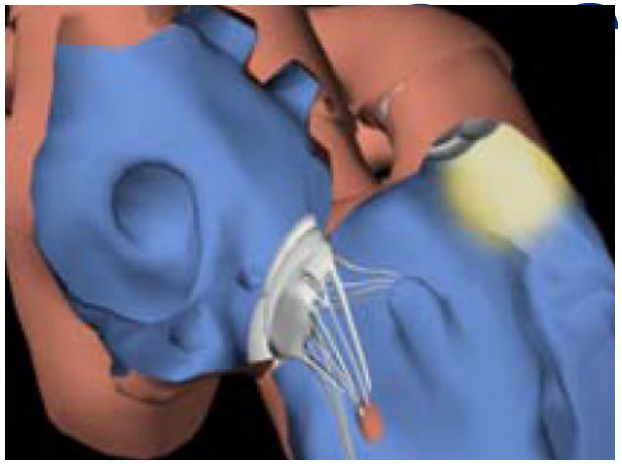
Idiopathic Monomorphic Ventricular Tachycardia

	Adenosine-sensitive	Verapamil-sensitive	Propranolol-sensitive
Mech	*(Triggered activity)*	*(Fascicular reentry)*	*(Automaticity)*
	1) Exercise-induced	Fascicular	1) Exercise-induced
	2) Repetitive monomorphic		2) Incessant
Induction	PES c/s cathecholamine	PES c/s cathecholamine	Cathecholamine
ECG	LBBB with inferior axis	RBBB with superior axis	RBBB, LBBB, Polymorphic
	RBBB with inferior axis	RBBB with rt inferior axis	
Origin	RVOT/LVOT	Lt posterior fascicle	RV/LV
		Lt anterior fascicle	
Entrainment	No	Yes	No
Adenosine	Terminate	No effect	Transient suppression
Verapamil	Terminate	Terminate	No effect
Propranolol	Terminate	No effect	Terminate/Transient supp

Ventricular Outflow Tract Tachycardia



RVOT Tachycardia



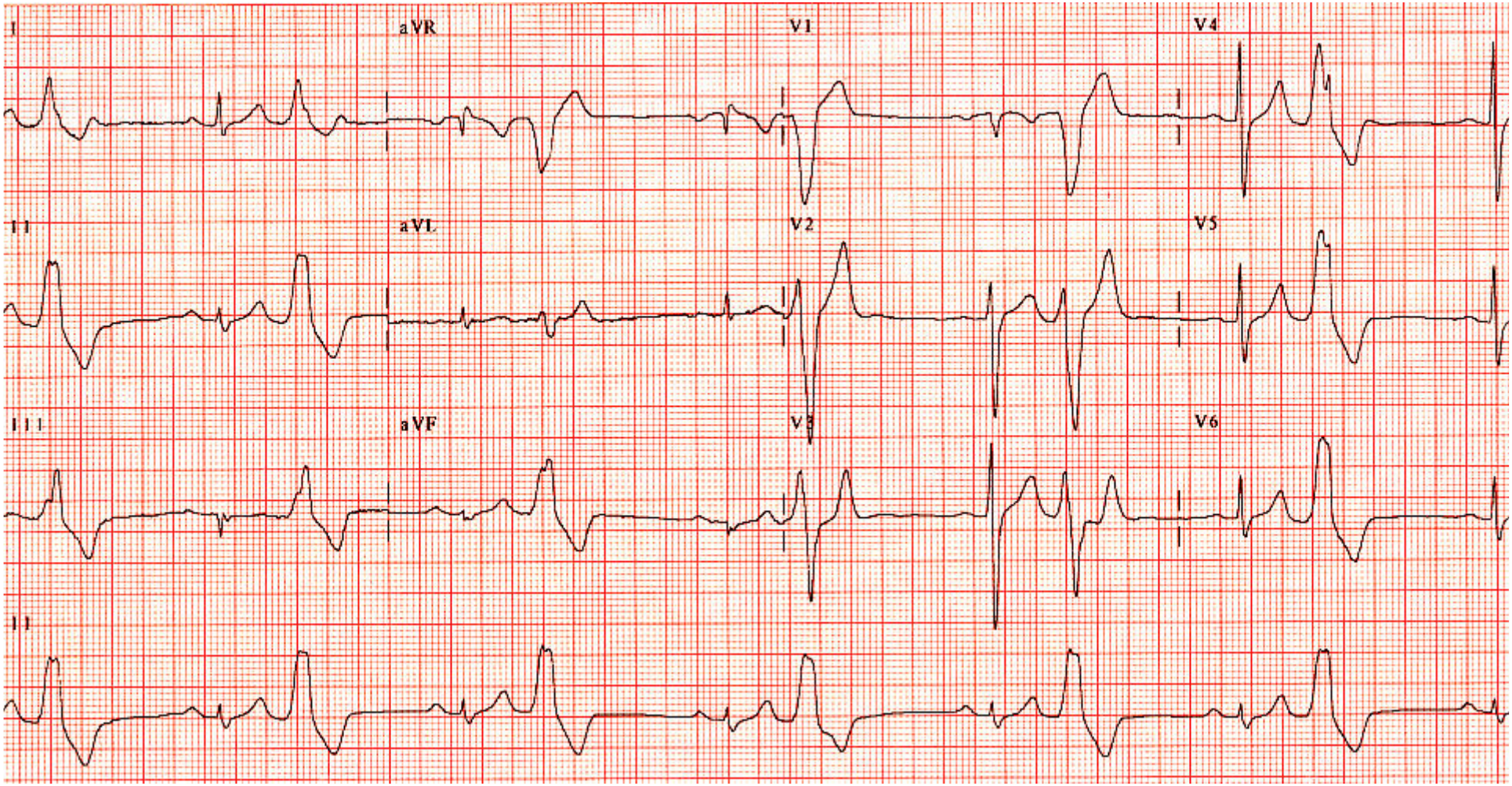
- ages of 30~50 yrs
- More frequent in women
- LBBB-like complex with tall R-waves in the inferior leads.
- 70~90% of VT patients with a structurally normal heart.
- Arrhythmia episodes

  : rare or frequent isolated PVCs, bursts of nonsustained VT, or sustained tachycardia often facilitated by catecholamines.

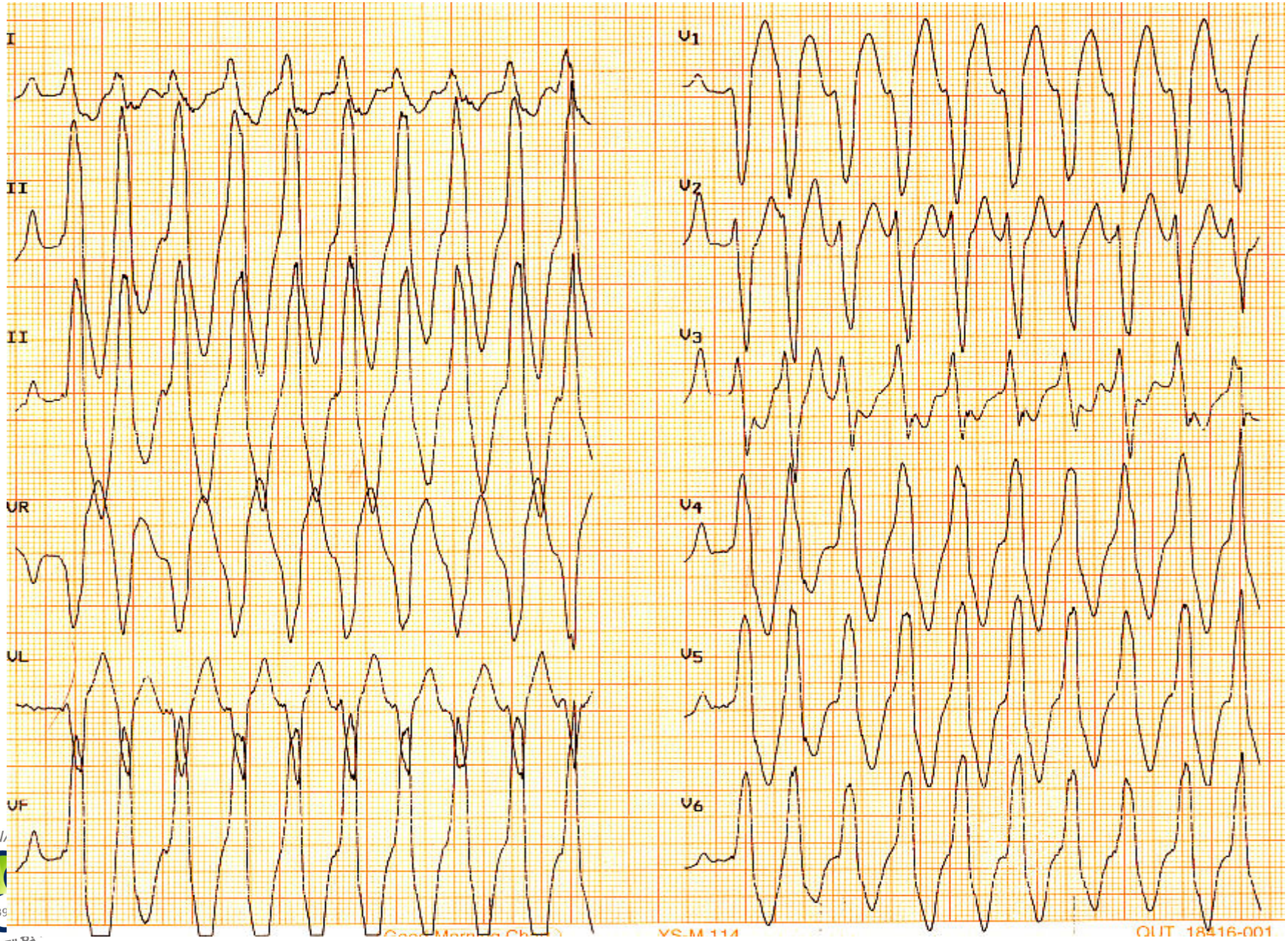
  : Exercise/emotion induced

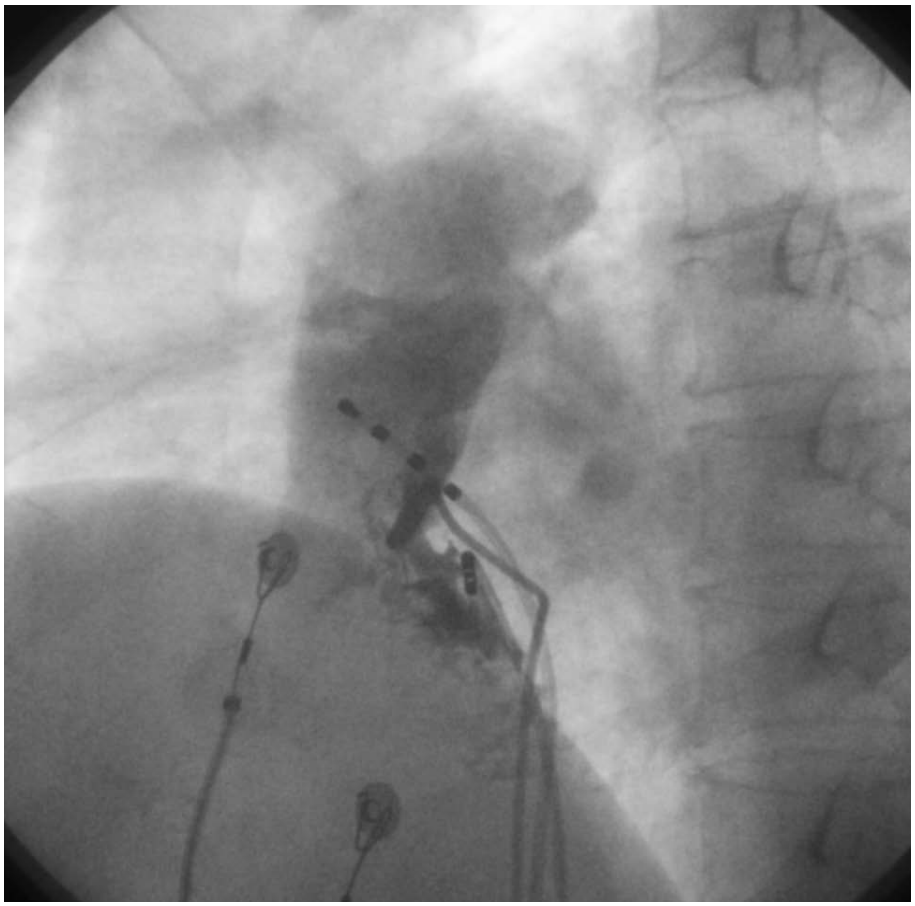
- Symptoms; ranging from none to palpitations, lightheadedness, dyspnea, presyncope, or syncope.

Case 48/M recurrent palpitation

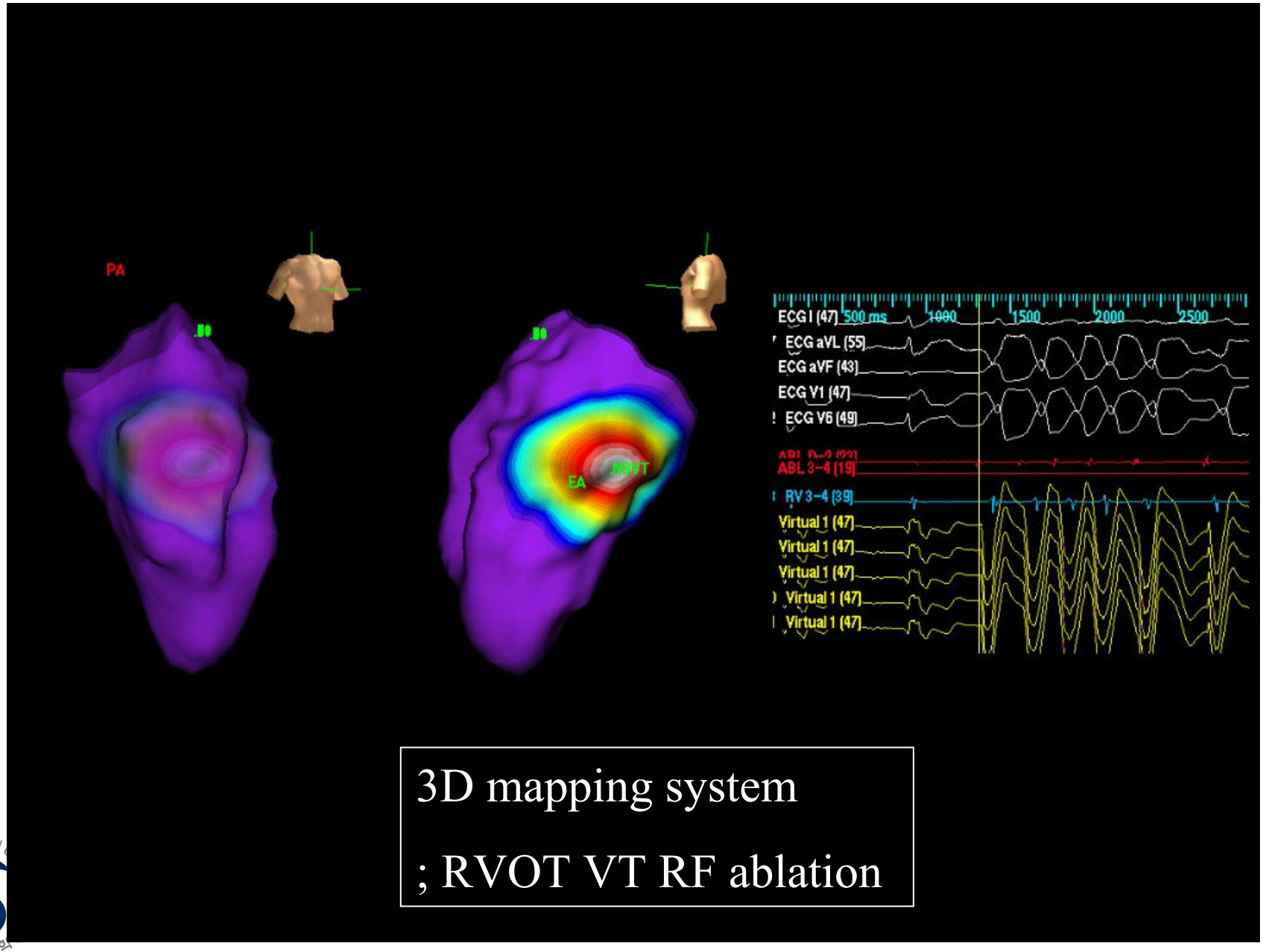


Exercise induced VT





3D mapping



3D mapping system

; RVOT VT RF ablation

Evaluation of RVOT Tachycardia

- Exclude structural heart disease
  - Physical examination
  - ECG
  - Echo
  - SAECG
  - MRI
  - RV angiogram and biopsy
- Rare evolution to cardiomyopathy

RVOT VT

- No evidence of underlying structural heart disease.

  : generally benign,

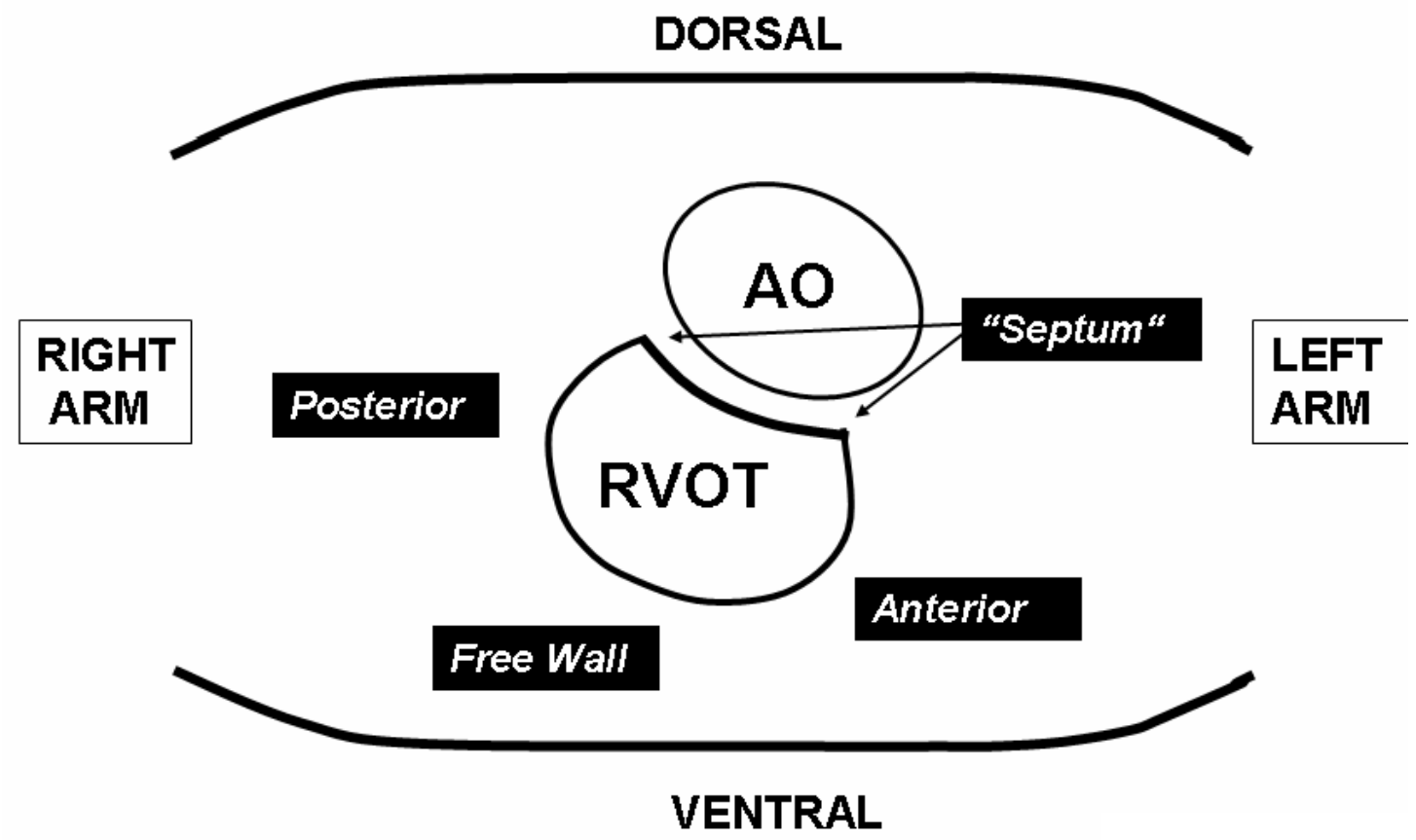
  It must be distinguished from other disorders associated with RV VT, such as RV dysplasia and sarcoidosis.

- Patients with symptoms not readily treated with medications are candidates for ablation.

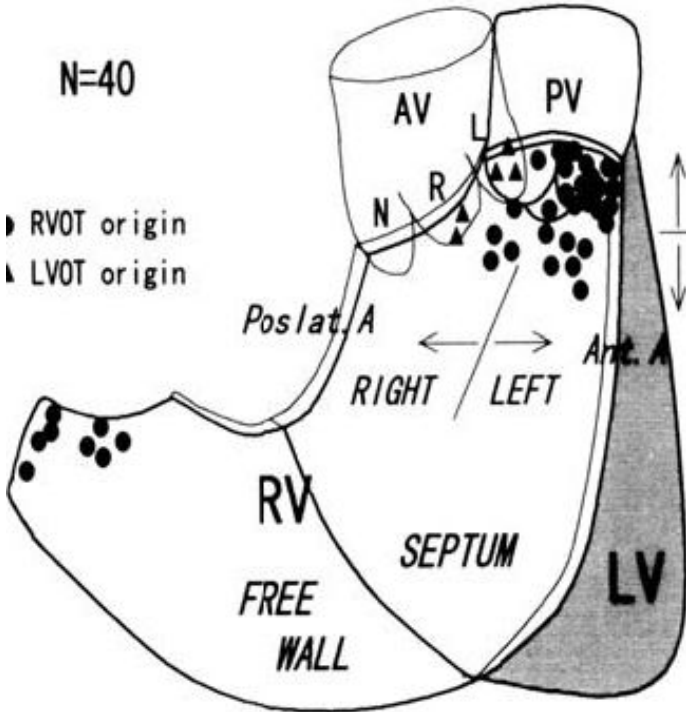
- An ECG showing PVCs or VT can suggest the likely region of origin of the arrhythmia to assist in mapping.

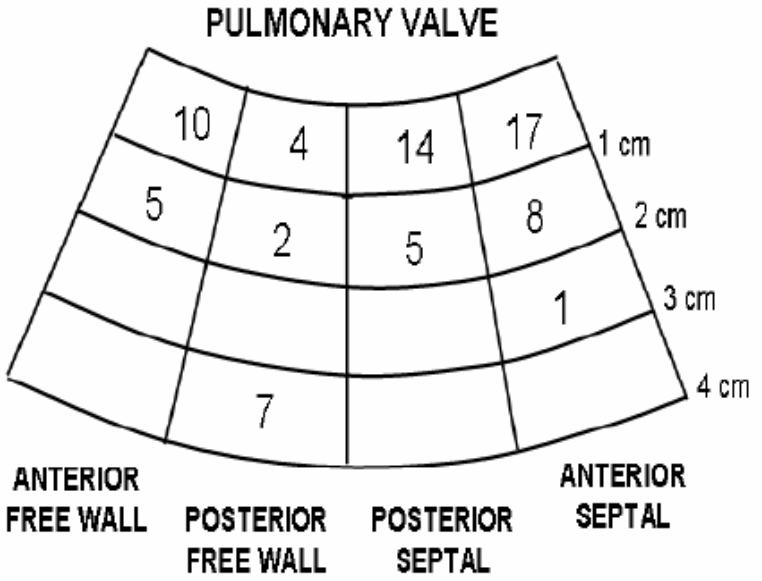
- Mapping based on earliest activation

RVOT Orientation



RVOT Distribution



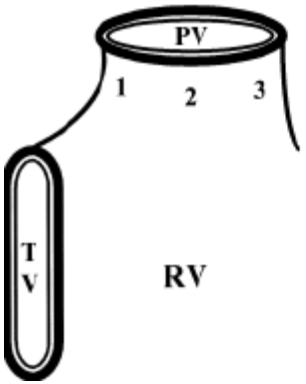


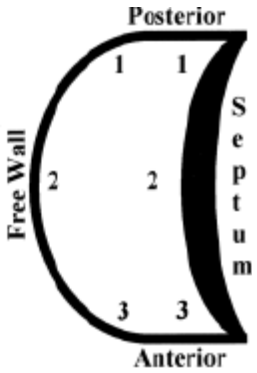
- Majority arise 1-2 cm below the PV
- 20-30 % are free wall

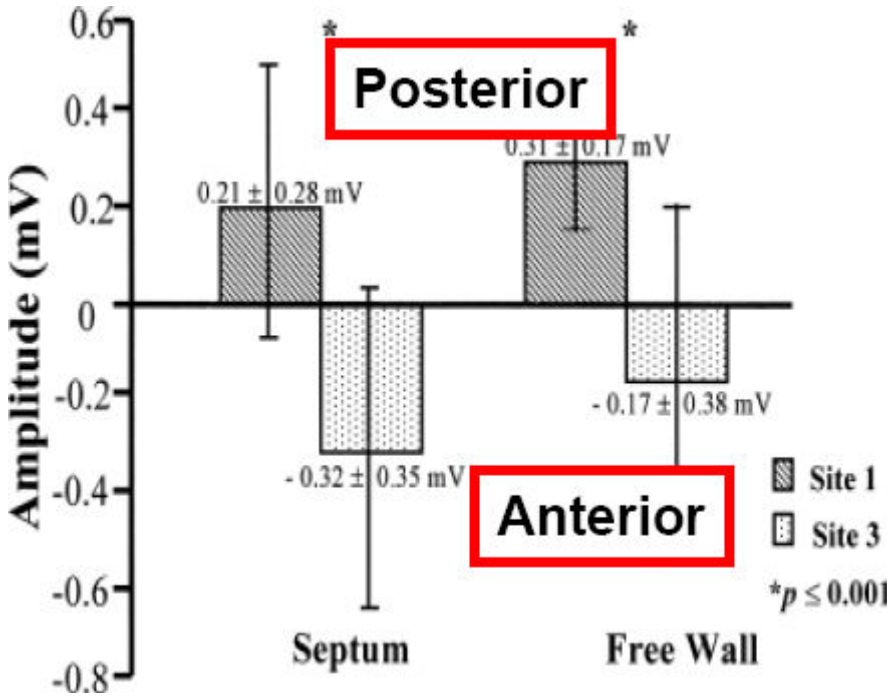
Joshi et al, JCE 2005;16suppl:S52

RVOT Localization

Lead I: Anterior vs Posterior





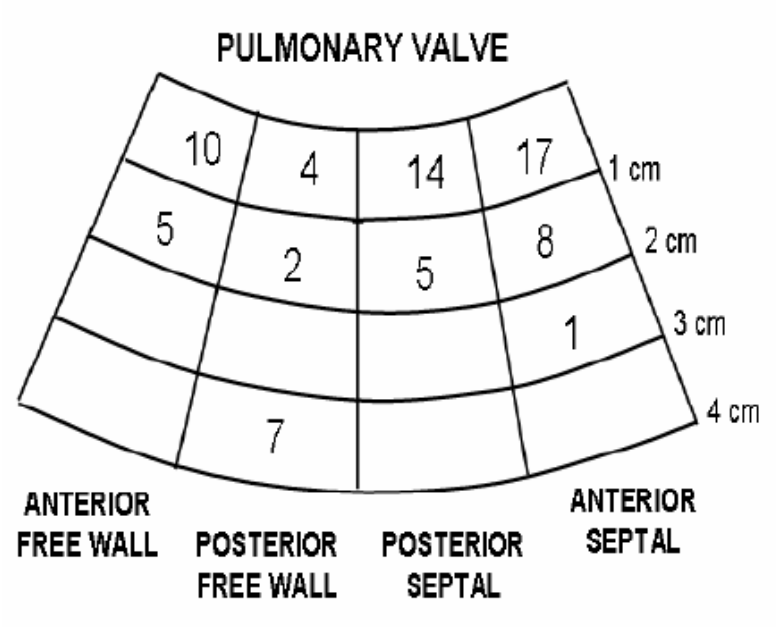


Dixit et al, JCE 2003;14:1

Joshi et al, JCE 2005;16suppl:S52

RVOT Localization

QRS: Free wall vs Septal

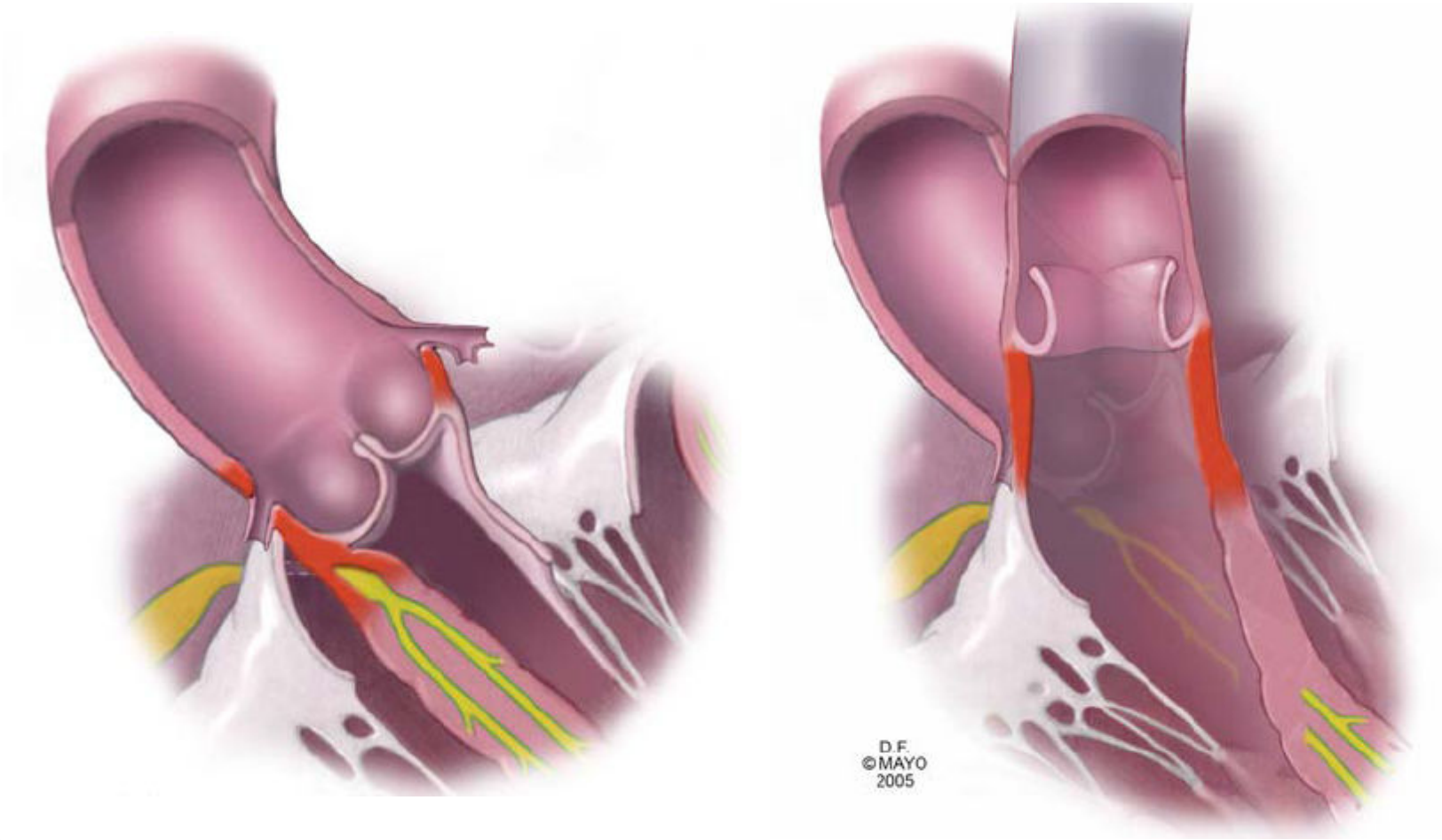


- QRS duration ≥ 140 msec
- QRS notching in inferior leads
- Lead V_3 R/S ratio ≤ 1

Dixit et al, JCE 2003;14:1

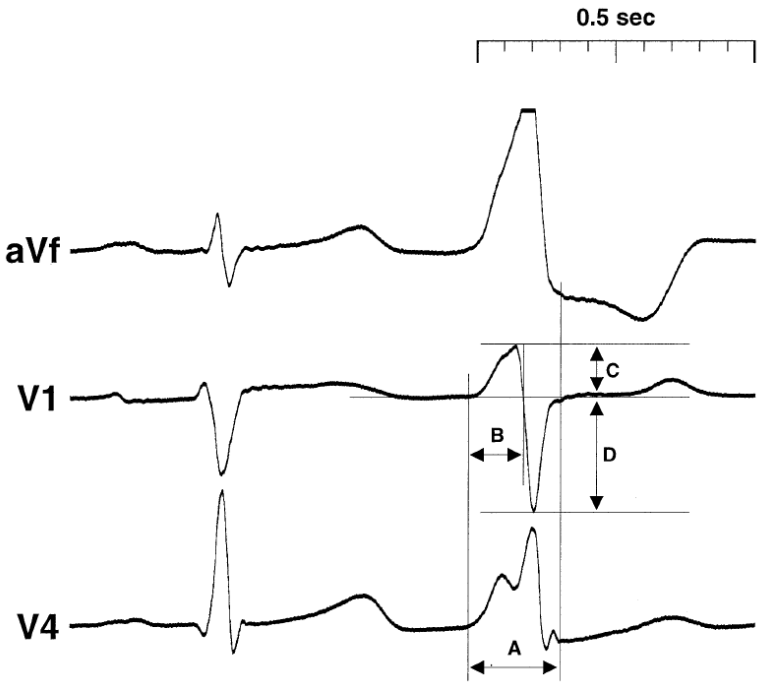
Joshi et al, JCE 2005;16suppl:S52

Relationship between RVOT and LVOT



Monomorphic ventricular tachycardia with LBBB morphology and an inferior axis.

: DDx of RVOT and ASC origin

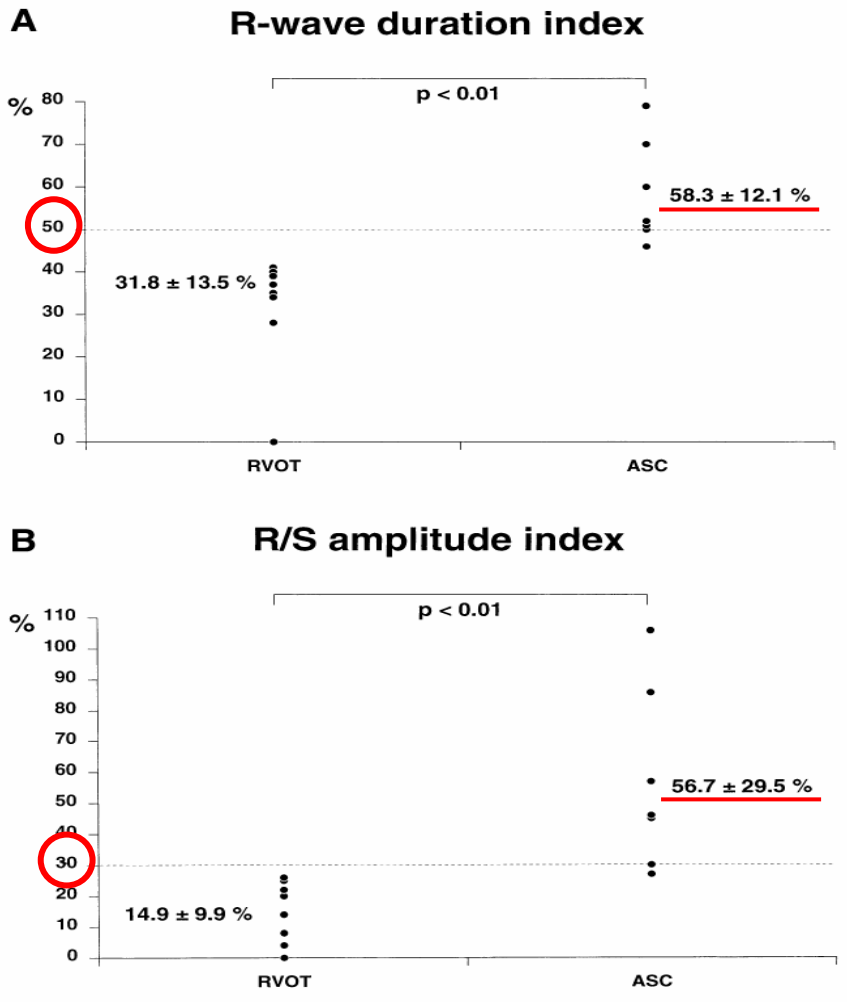


A Total QRS duration(ms)

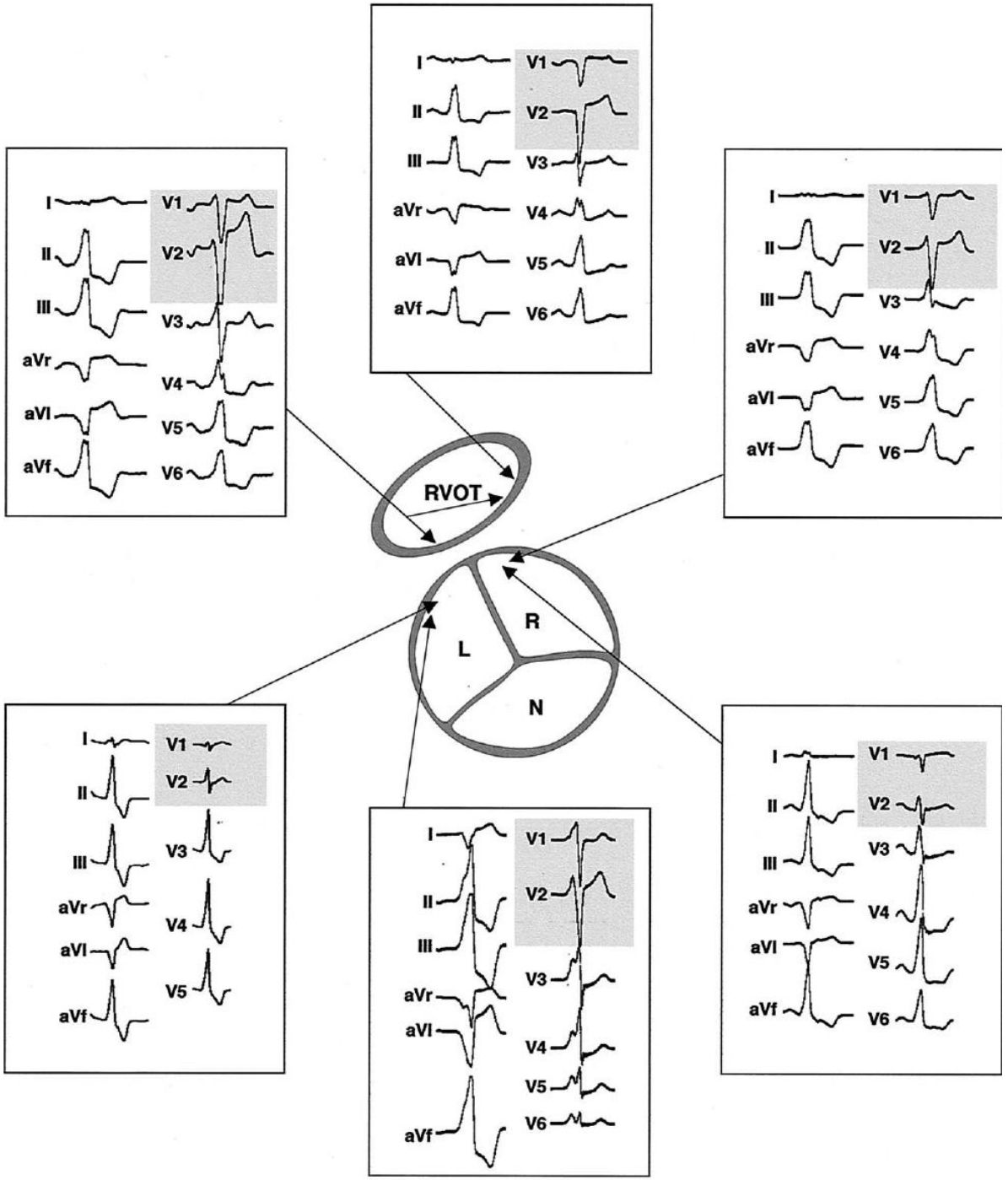
B R-wave duration (ms)

C R-wave amplitude (mV)

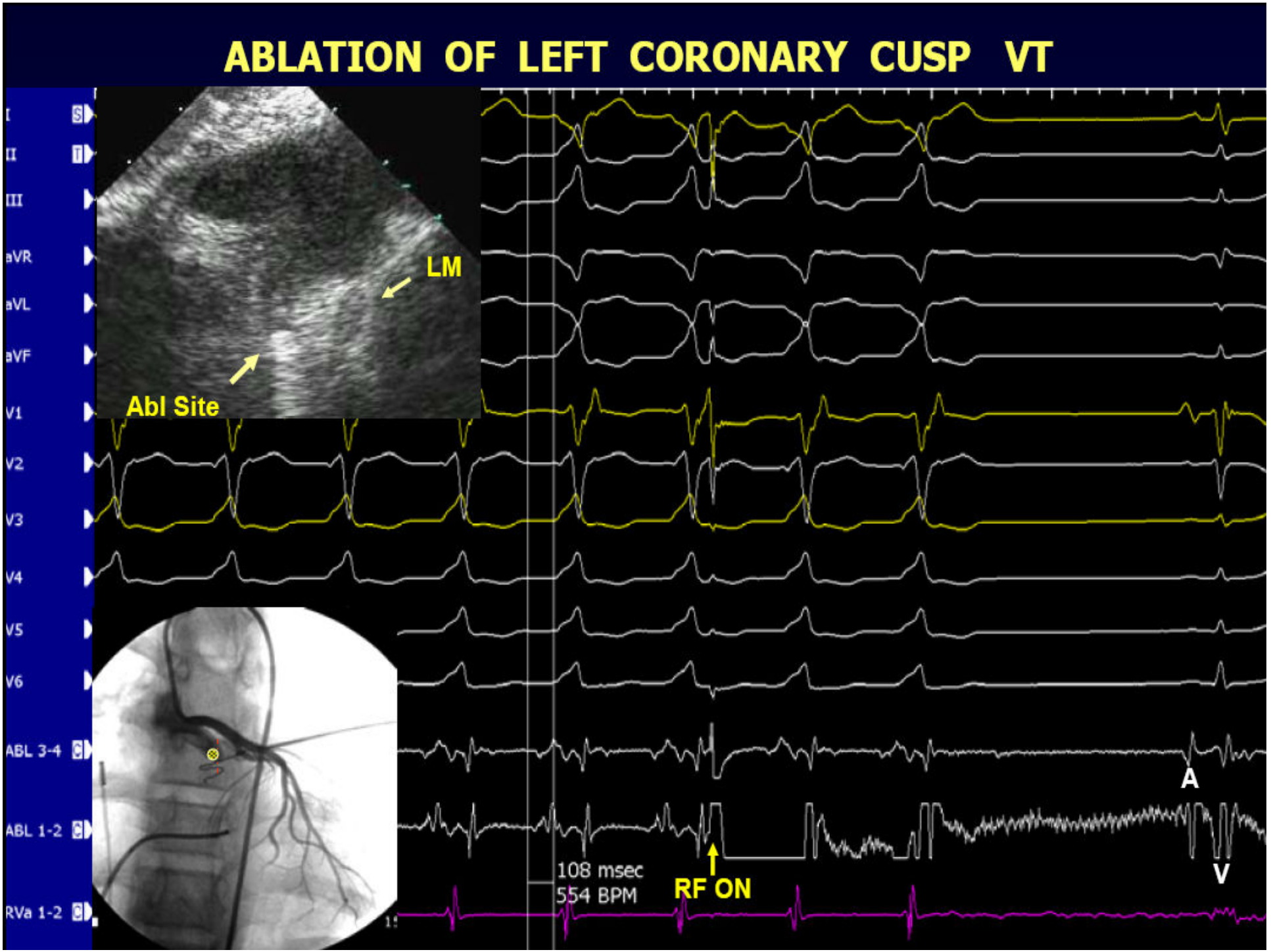
D S-wave amplitude (mV)



Ouyang F, et al. J Am Coll Cardiol 2002;39:500


I
II
III
aVr
aVl
aVf
V1
V2
V3
V4
V5
V6
RVOT
L
R
N

ABLATION OF LEFT CORONARY CUSP VT



- LBBB morphologies with right inferior axis

: VT arising from the anterior septal side of the RVOT,

from the right or left coronary cusp, and

from the pulmonary artery.

- R-wave progression : LV or the aortic cusp
- R waves in V1 and V2 and a transition by lead V3

: left-sided outflow tract VT,

- Later transitions at V3 and V4 : RVOT or the pulmonary artery

- RBBB morphology

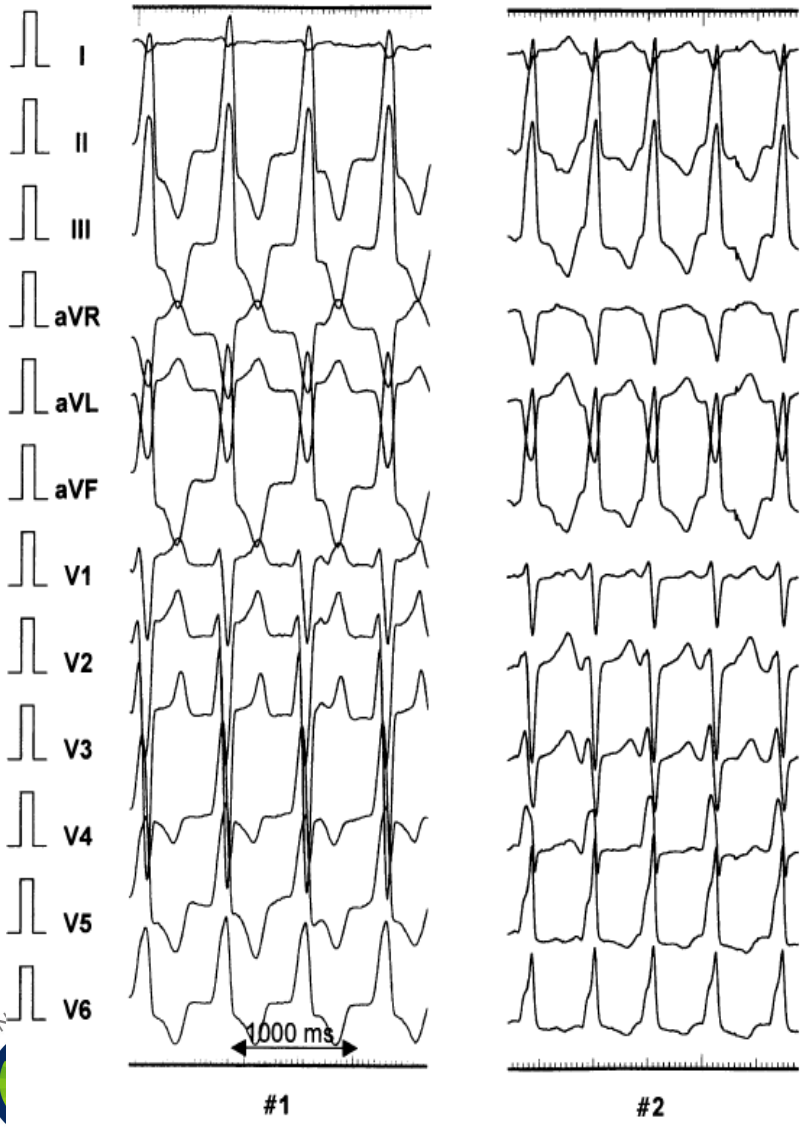
: VT arising in the mitral annulus adjacent to the aortic valve

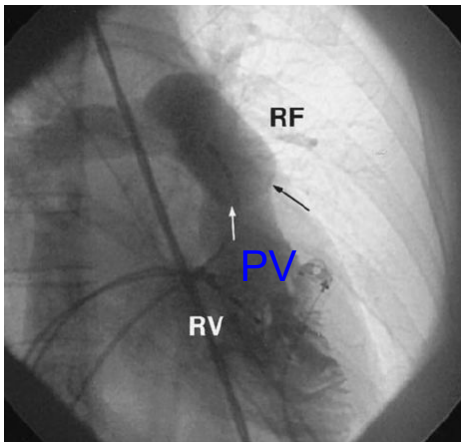
or from the epicardium at the outflow tract.

- RBBB patterns with dominant R waves across the precordium

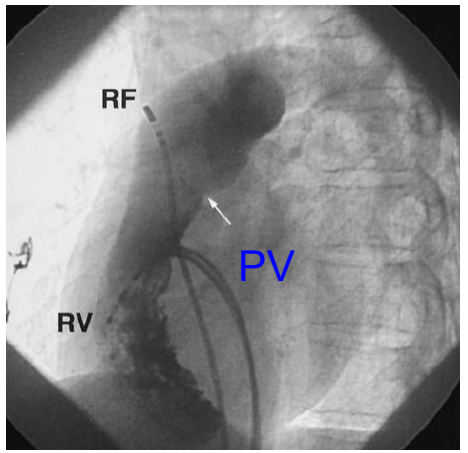
: mitral annulus

Pulmonary artery VT





RAO

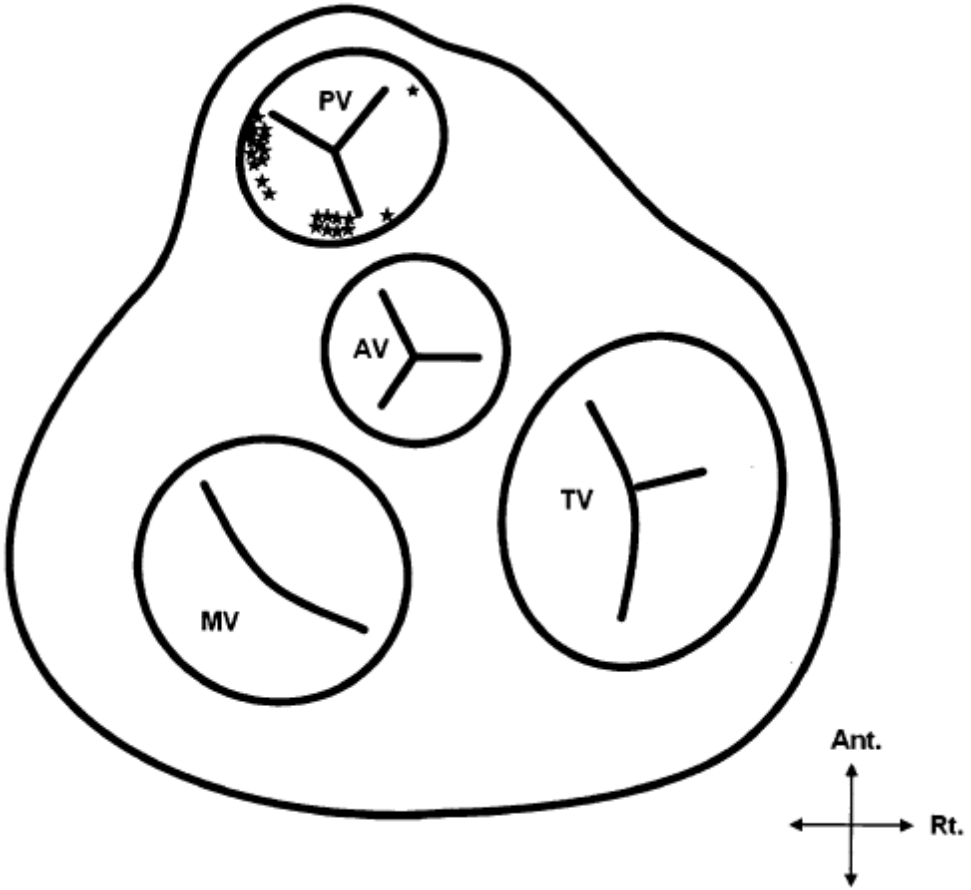


LAO

- Taller R in II, III, aVF
  1.89~1.92 mV vs 1.49~1.57 mV
  (PA VT vs RVOT VT)
- Larger R/S ratio in V2
  0.32 vs 0.17 (PA VT vs RVOT VT)
- aVL/aVR ratio of Q-wave amplitude >1 in the PA (1.11 vs 0.88 :RVOT VT)

Timmermans C, et al. Circulation. 2003;108:1960
Sekiguchi, et al. J Am Coll Cardiol 2005;45:887

Anatomic location of the successful ablation sites in the pulmonary artery group.



★ The successful ablation sites were located 1.18 ± 0.43 cm above the pulmonary valve and mostly along the septum.

Sekiguchi Y, et al. J Am Coll Cardiol 2005;45:887

VT with LBBB morphology and inferior axis

	RV OT	PA	LVOT	ASV	LV epi	CS	Total
Ito S	55(69%)		7(9%)	11(14%)	7(9%)		80
Tanner	20(61%)	1(3%)	5(15%)	2(6%)	2(6%)	3(9%)	33
Sekiguchi Y	92(72%)	24(19%)		11(9%)			148
Iwai S	100(82%)			22(18%)			122
	267(70%)	25(7%)	58(15%)		12(3%)		383 (100%)

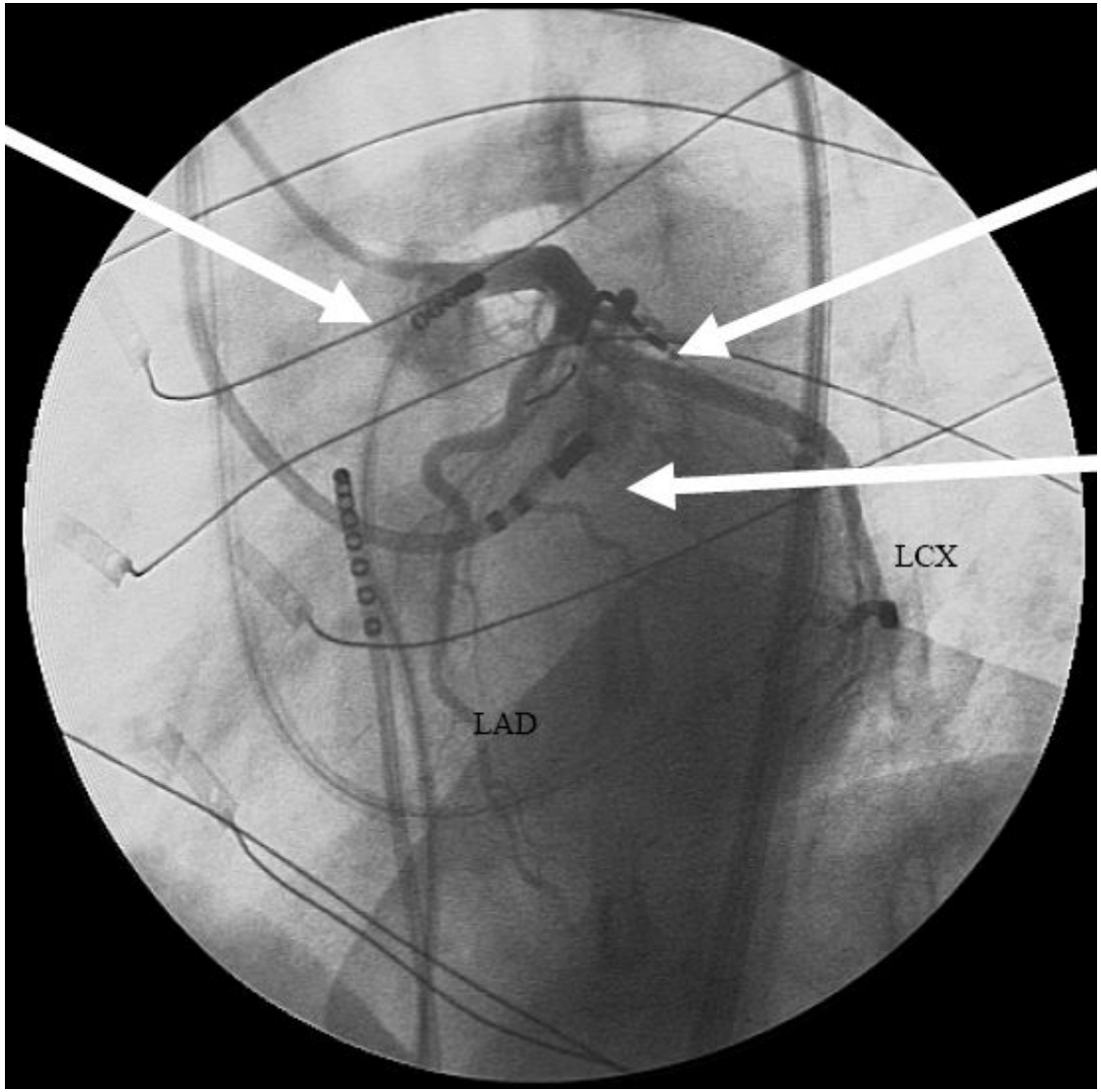
Ito S, et al. J Cardiovasc Electrophysiol. 2003;14:1280
Tanner H, et al. J Am Coll Cardiol 2005;45:418
Sekiguchi Y, et al. J Am Coll Cardiol 2005;45:887
Iwai S, et al. J Cardiovasc Electrophysiol, Vol. 2006;17:1

EPS

- PES
- Burst pacing of 200~400 msec
- Isoproterenol
  Epinephrine, phenylephrine, aminophylline, Atropine,
  Ca infusion, edrophonium
- Adenosine sensitivity
- Mapping: stepwise mapping

  RVOT, PA, CS, LVOT, ASV, and epicardial

RVOT



Cardiac vein

LVOT

LAO

Pace Mapping

- Single point mapping to obtain ≥ 11/12 morphologic match of the 12-lead ECG paced QRS complex to the tachycardia QRS complex.
- Successful ablation sites with identical/near identical matches
- However,

  Even a perfect pace match (12/12) defines a relatively broad area of interest of ~2 cm^2.

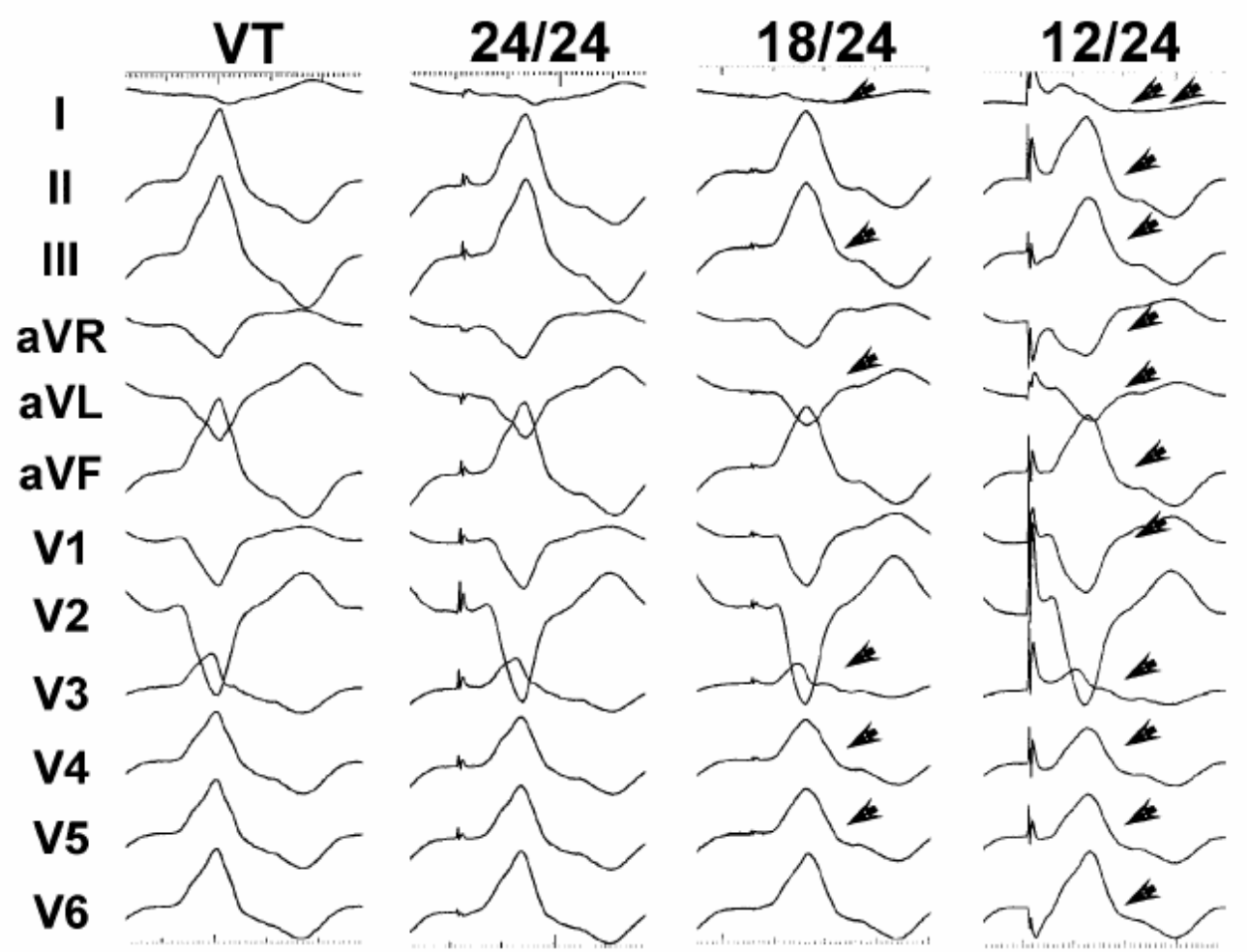
  QRS morphology may be similar over 15 mm separation.

  Sites within 5 mm may generate differences.

Kadish et al. JACC 1991, J Electrocardiol 1998

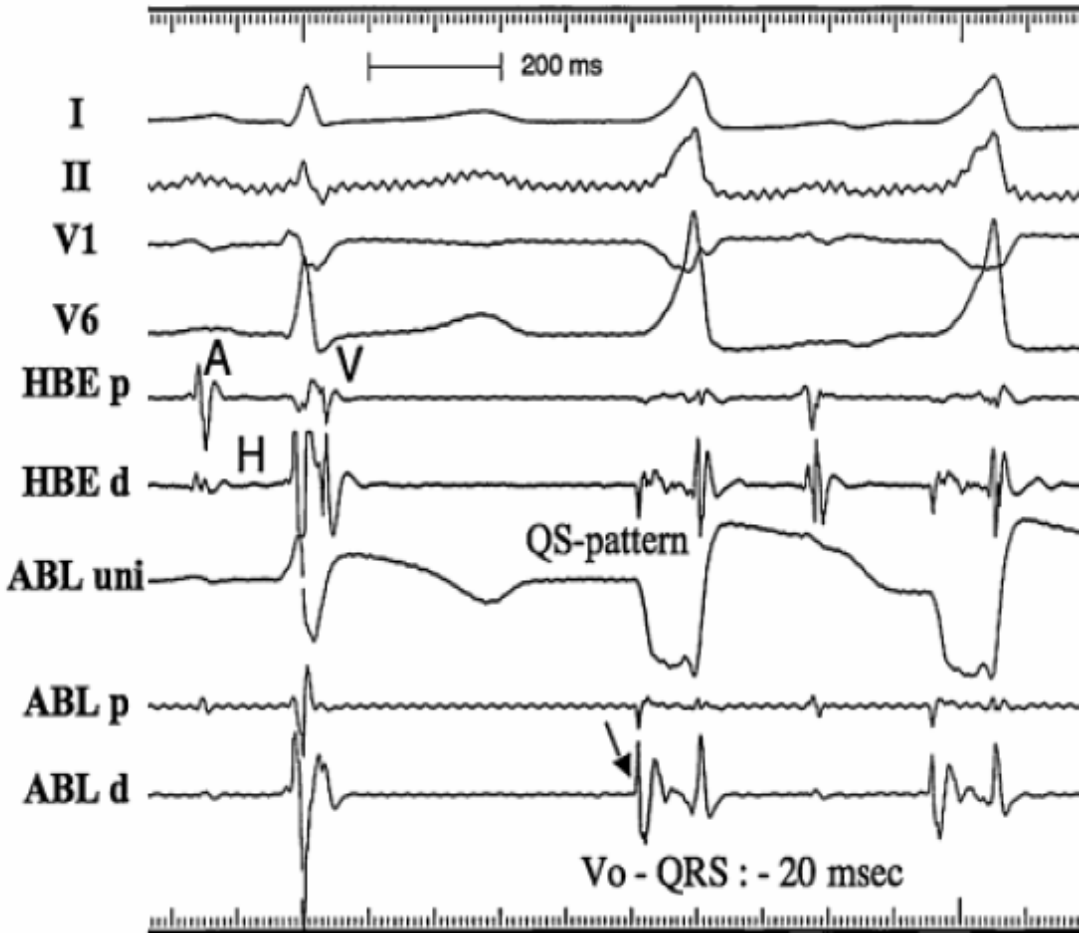
Clyne CA, et al. PACE 2007

Pace Mapping



Activation Mapping

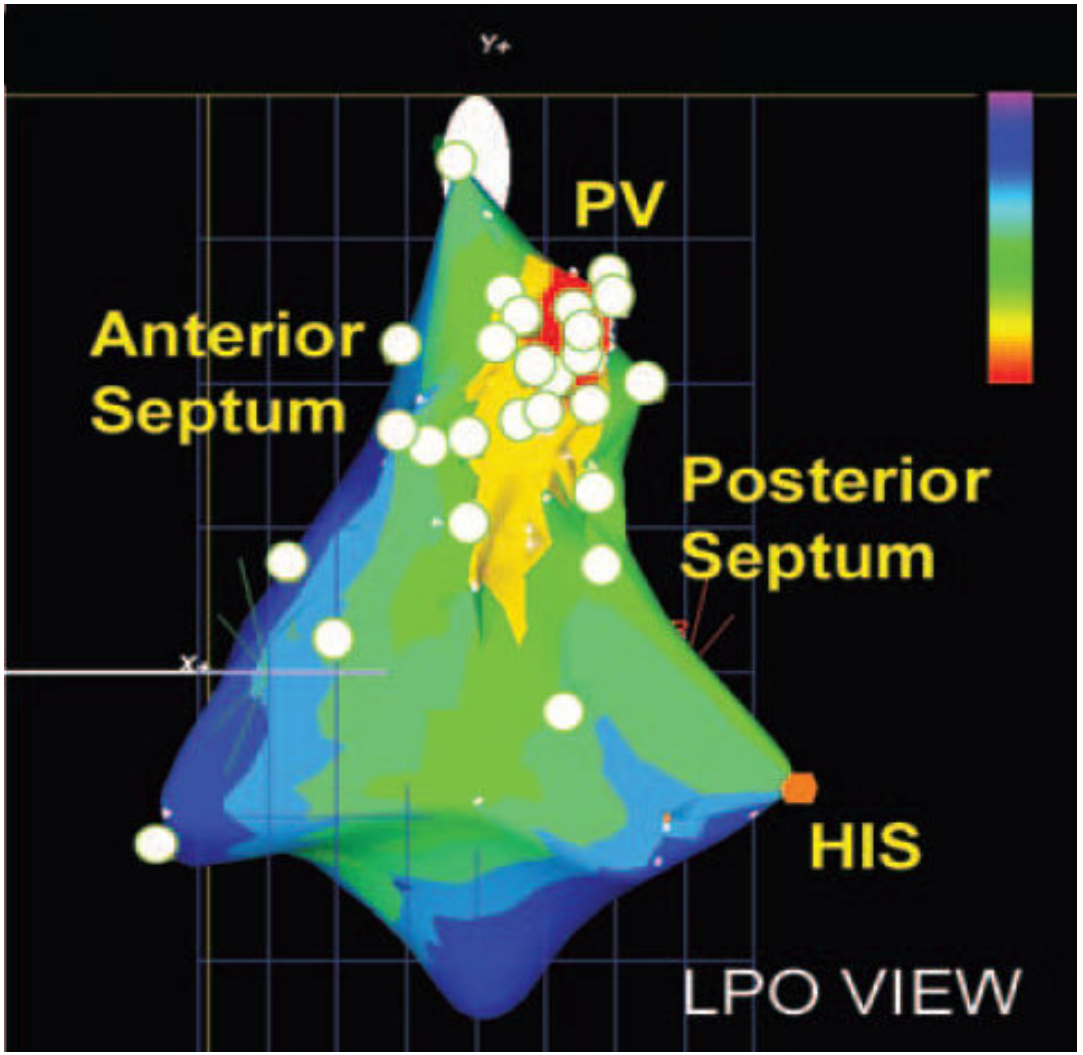
- Endocardial electrogram timing compared to the surface ECG.
- To detect the earliest endocardial activation time during tachycardia.
- 10~60 msec (mean 26~46 msec) prior to onset of the surface QRS



3D electroanatomical Mapping

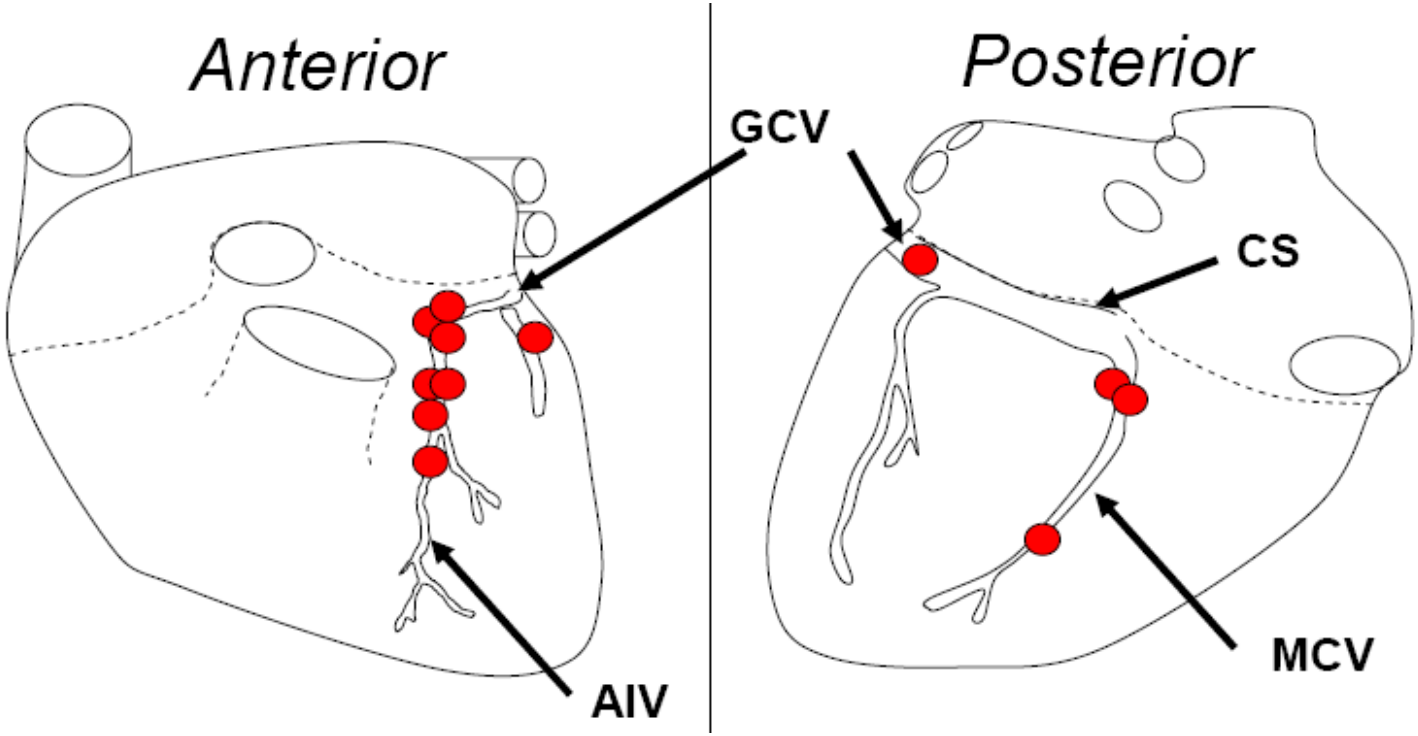
- The mean area of myocardium activated within the first 10 msec was 3.0 ± 1.6 cm^2 (1.3~6.4 cm^2).

Azegami K, et al. J Cardiovasc Electrophysiol 2005;16:823



Idiopathic Epicardial LV VT

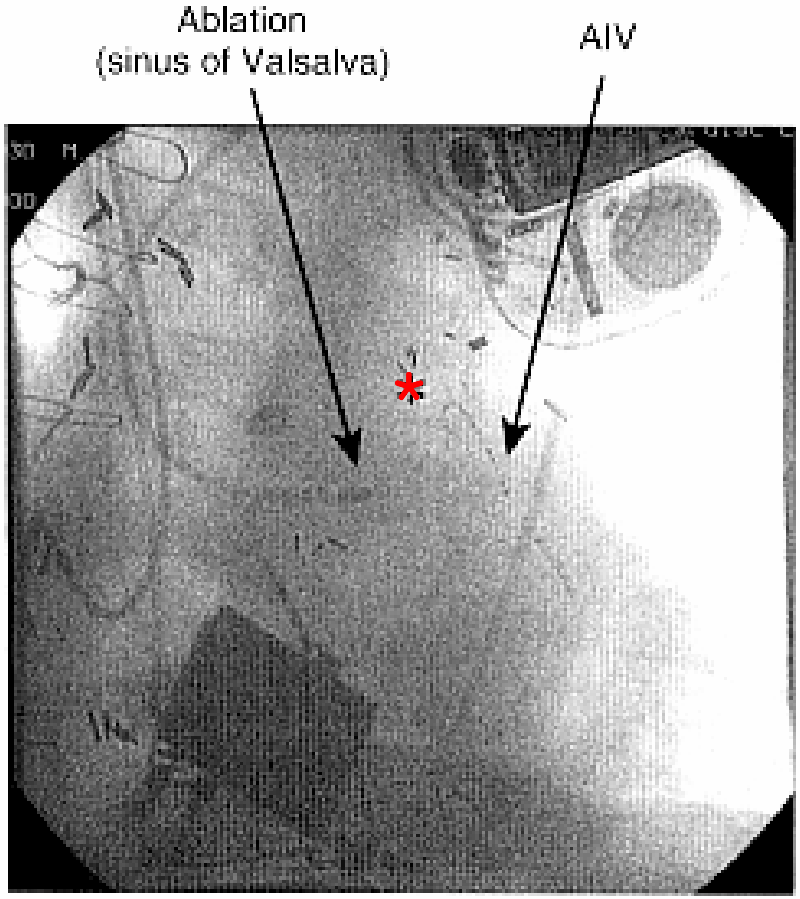
- Perivascular sites of origin
- Catecholamine enhanced, adenosine sensitive
- 5~10% of idiopathic VT

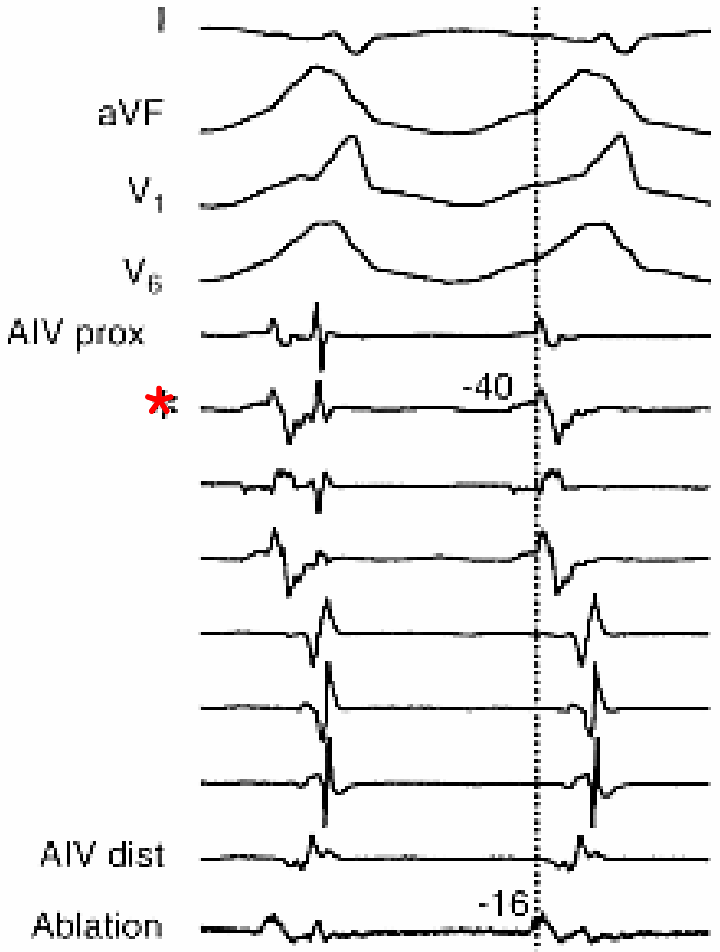


Daniels DV, et al. Circulation. 2006;113:1659

Epicardial origin of LV VT

Multipolar catheter in Ant. Interventricular Vein

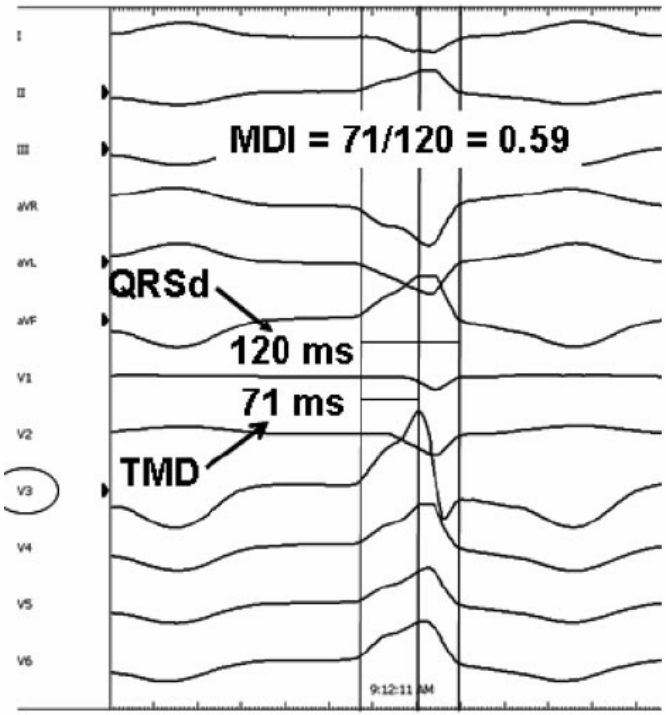


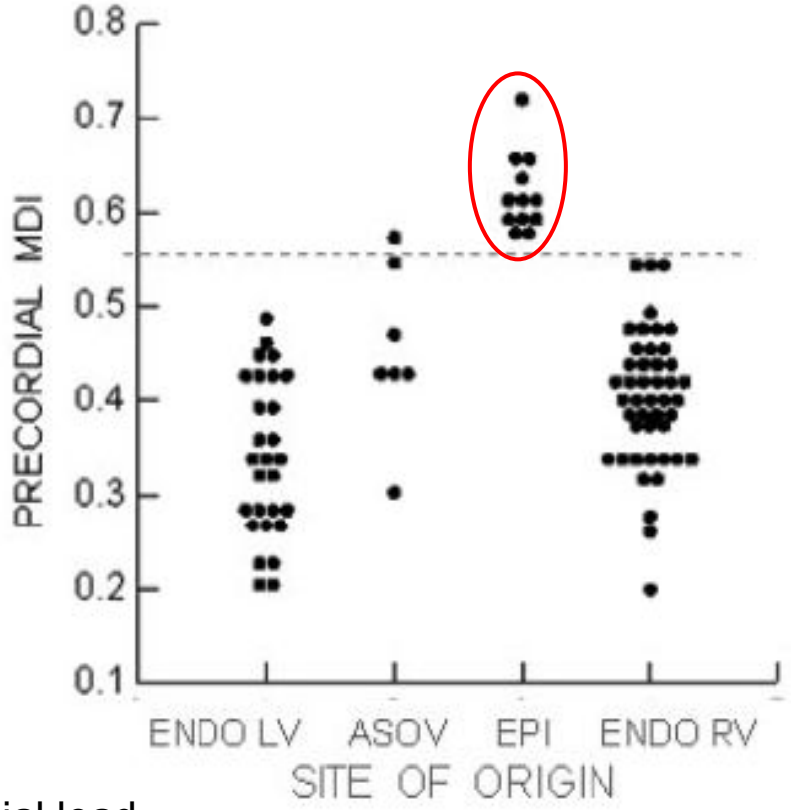


Zipes. Cardiac Electrophysiology. 4th ed. 2004.

ECG of Idiopathic Epicardial LV VT

- Precordial MDI >0.55 reliably identified EPI VT.





MDI : the maximum deflection index
TMD: time to maximum deflection in precordial lead

Daniels DV, et al. Circulation. 2006;113:1659

RF ablation

- Ablation with power settings of ≤ 50 W, a target temperature of 55~70◦C and duration of 30~60 seconds.
- No change in the arrhythmia after 15 seconds of power delivery, it should be stopped and catheter contact and stability reassessed.
- Nonspecific response :

  Acceleration/gradual slowing

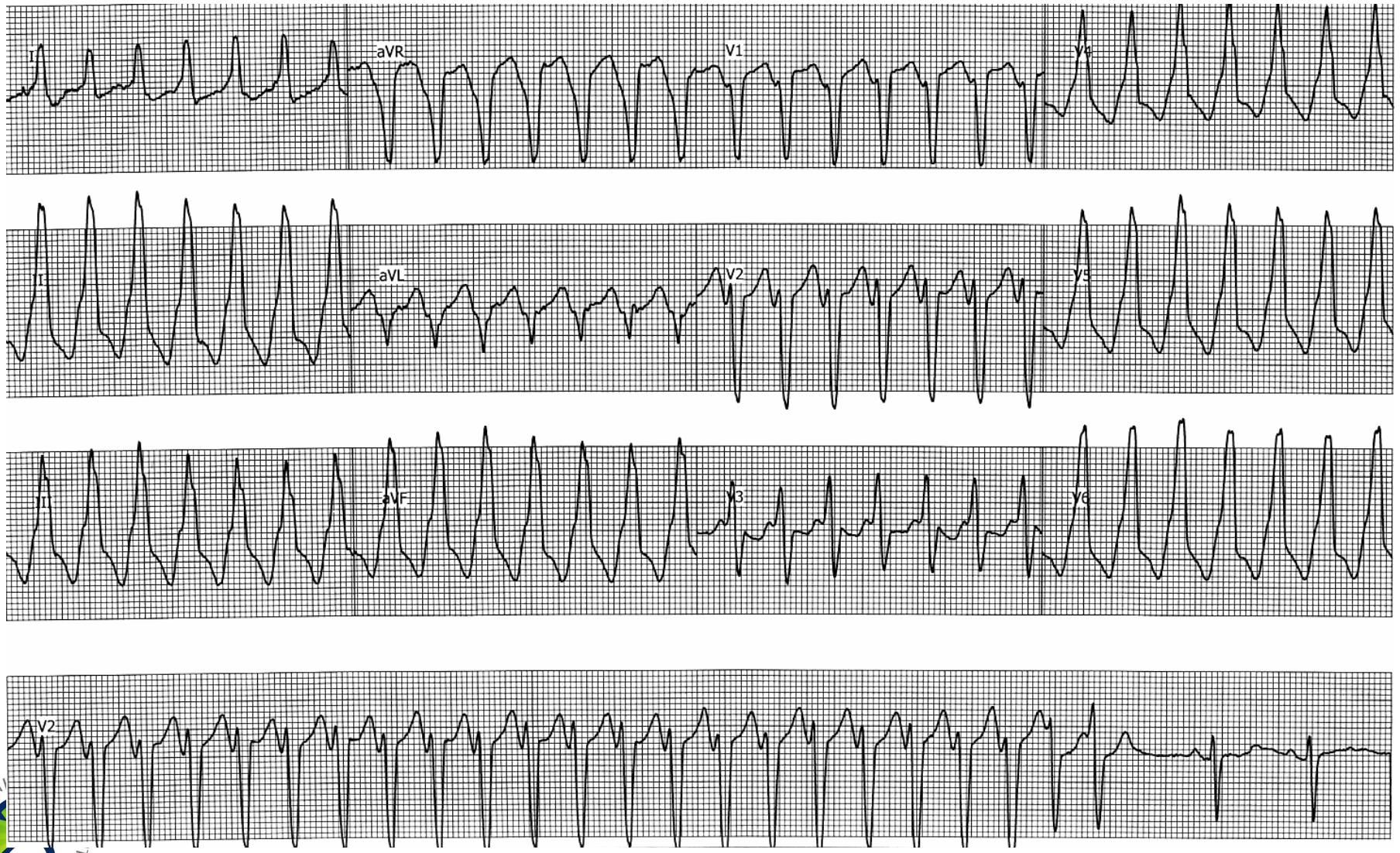
  Repetitive response

Complication

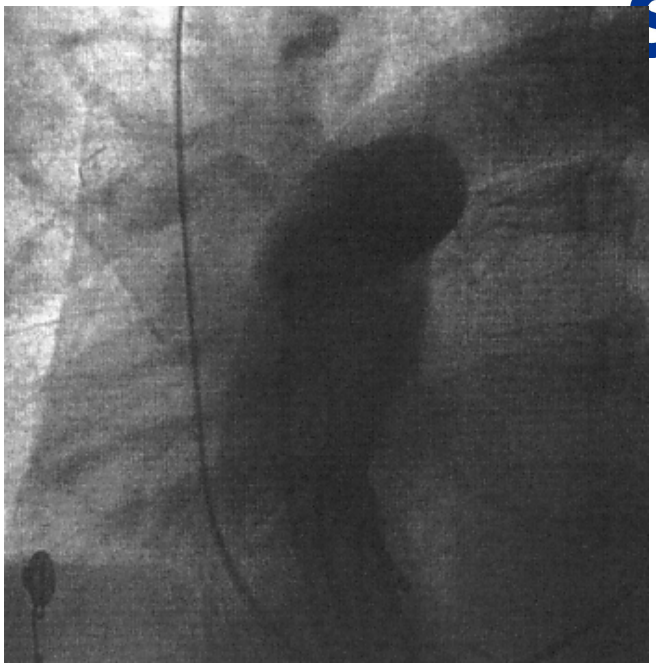
- Myocardial perforation with cardiac tamponade
- Heart block due to inadvertent slippage of the catheter toward the His bundle
- Injury to the LAD or left main coronary arteries
- Death, rare

Case

F/51

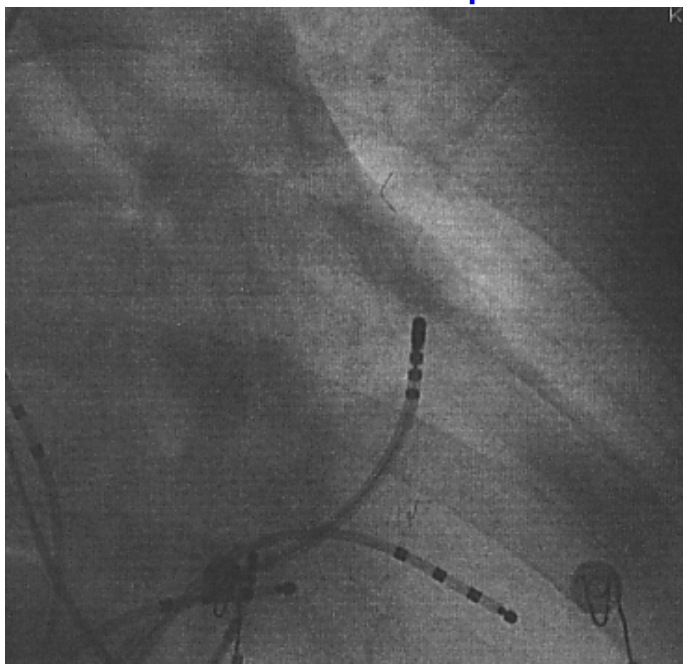


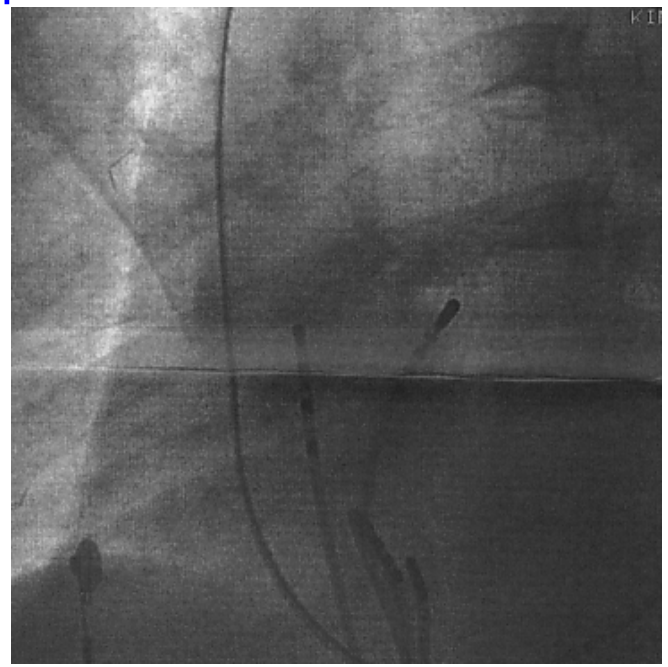
RAO



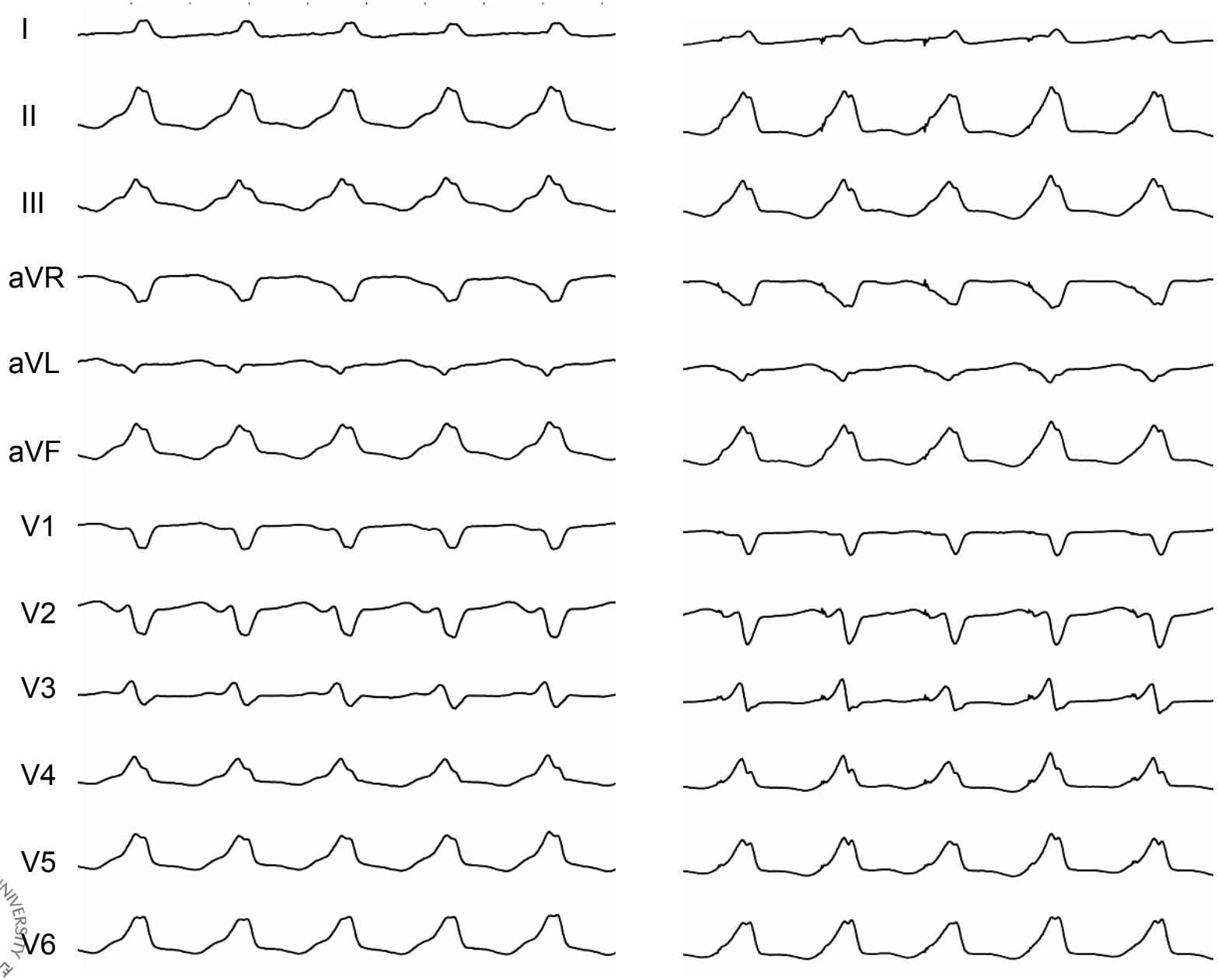
LAO

Superior anteroseptum of RVOT

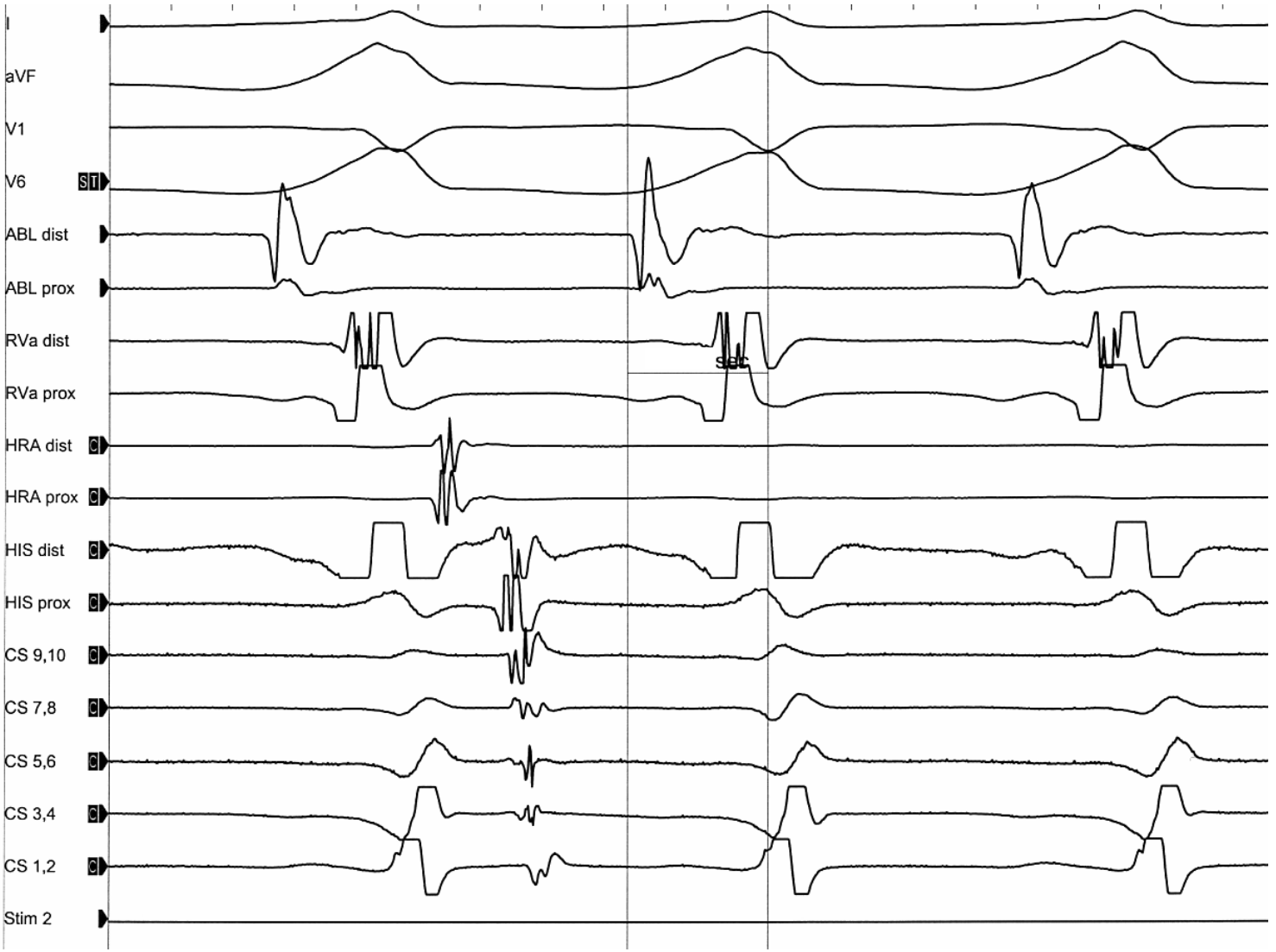




Pace Mapping

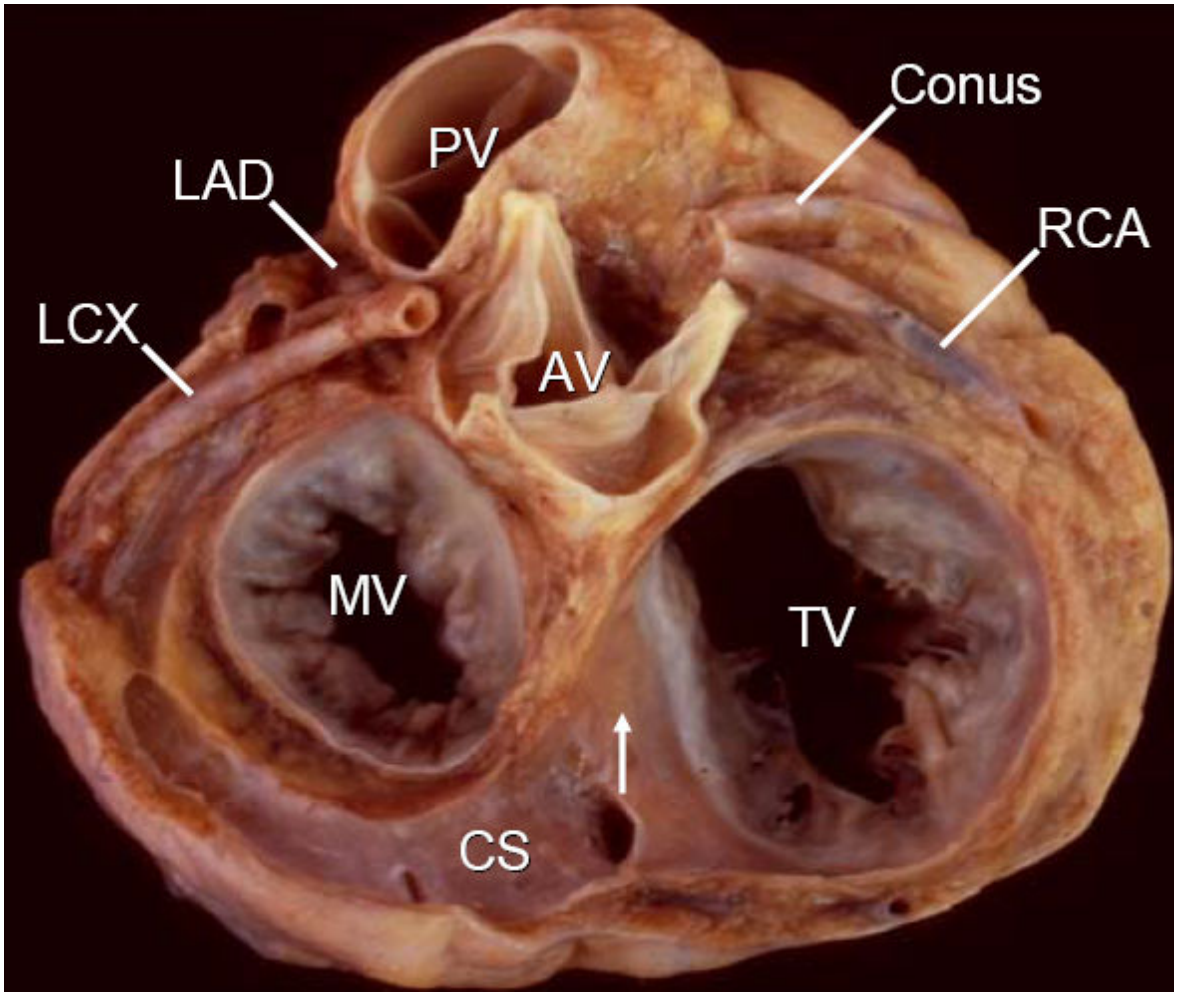


Activation Mapping

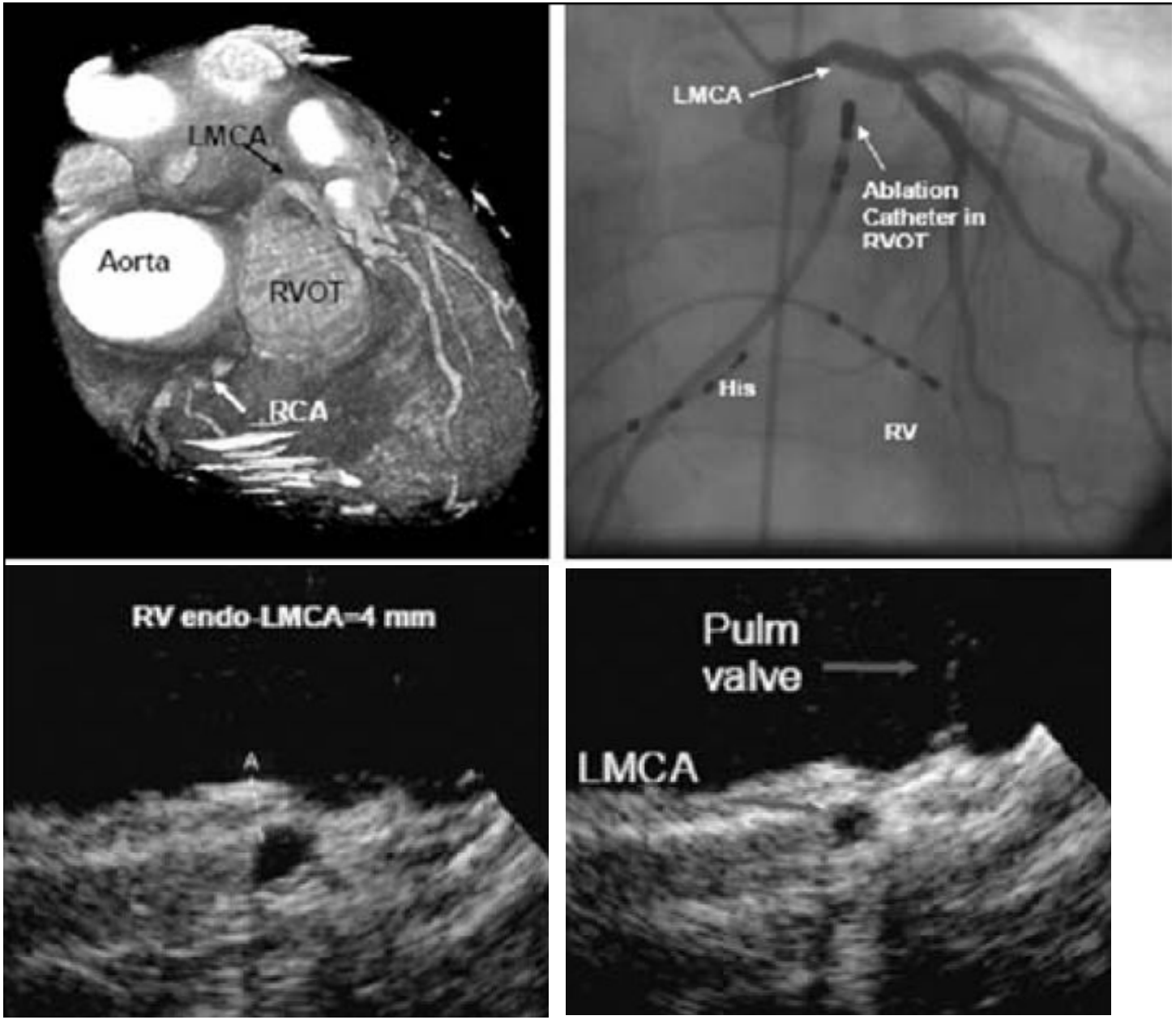


Normal Heart

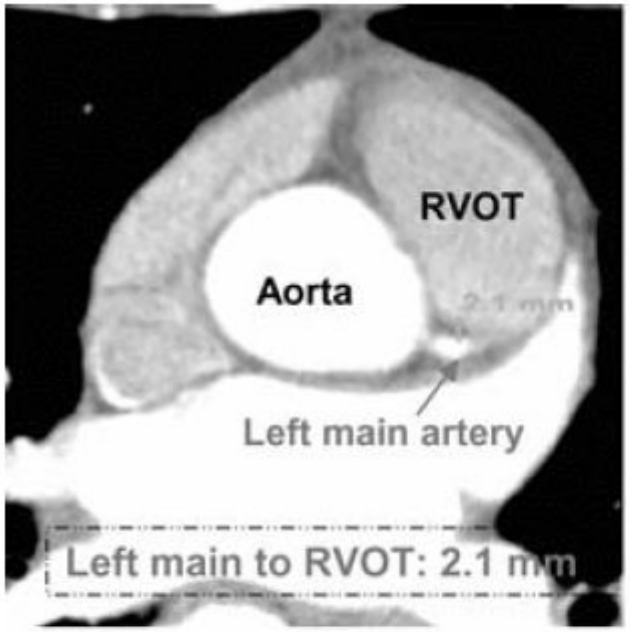
Valves and Coronary arteries

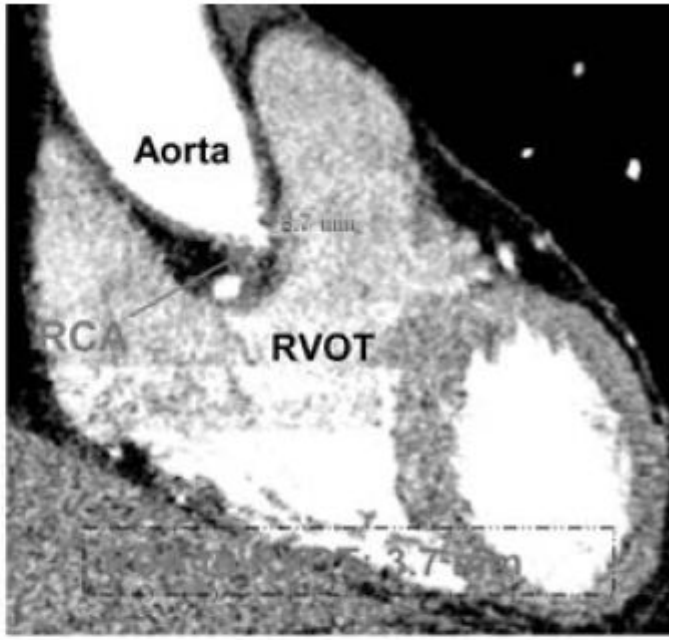


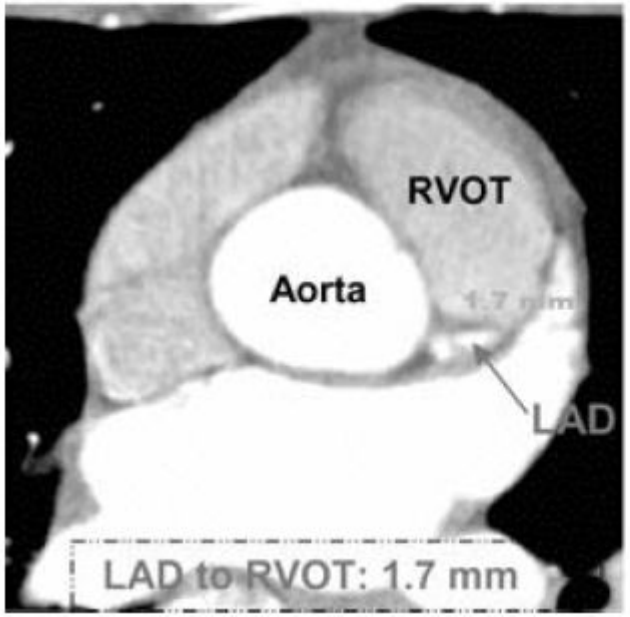
Major coronary arteries lie in close proximity to the RVOT.



Vaseghi M, et al. J Cardiovasc Electrophysiol, 2006;17:632







Coronary artery	Distance to RVOT (avg±SD)
Left main	4.1±1.9 mm
RCA	4.3±1.9 mm
LAD	2.0±0.6 mm

Vaseghi M, et al. J Cardiovasc Electrophysiol, 2006;17:632

Outcome of RFCA in Patients with Idiopathic RVOT Tachycardia

	Year	N	Acute Success	Mean Follow-up (mo)	Recurrence[#]
Calkins et al.[34]	1993	10	10/10	8	0/10
Coggins et al.[36]	1994	20	17/20	10	1/17
Mandrola et al.[35]	1995	35	35/35*	24	0/35
Movsowitz et al.[38]	1996	18	16/18	12	5/16
Gumbrielle et al.[33]	1997	10	10/10	16	0/10
Chinushi et al.[32]	1997	13	13/13	28	1/13
Rodriguez et al.[39]	1997	35	29/35	30	4/28
Almendral et al.[37]	1998	15	13/15*	21	1/13
Wen et al.[48]	1998	44	39/44	41	4/39
Aiba et al.[44]	2001	50	47/50	NA	NA
Lee et al.[63]	2002	35	30/35	NA	NA
Freidman et al.[41]	2002	10	9/10	11	2/9
O'Donnell et al.[22]	2003	33	32/33	56	1/32
Ribbing et al.[43]	2003	33	27/33	54	1/27
Ito et al.[53]	2003	109	106/109	21	0/106
Current article	2005	72	71/72	51	2/71
Total		542	504/542 (93%)		22/426 (5%)

Joshi et al, JCE 2005;16suppl:S52

Idiopathic Left Ventricular Tachycardia

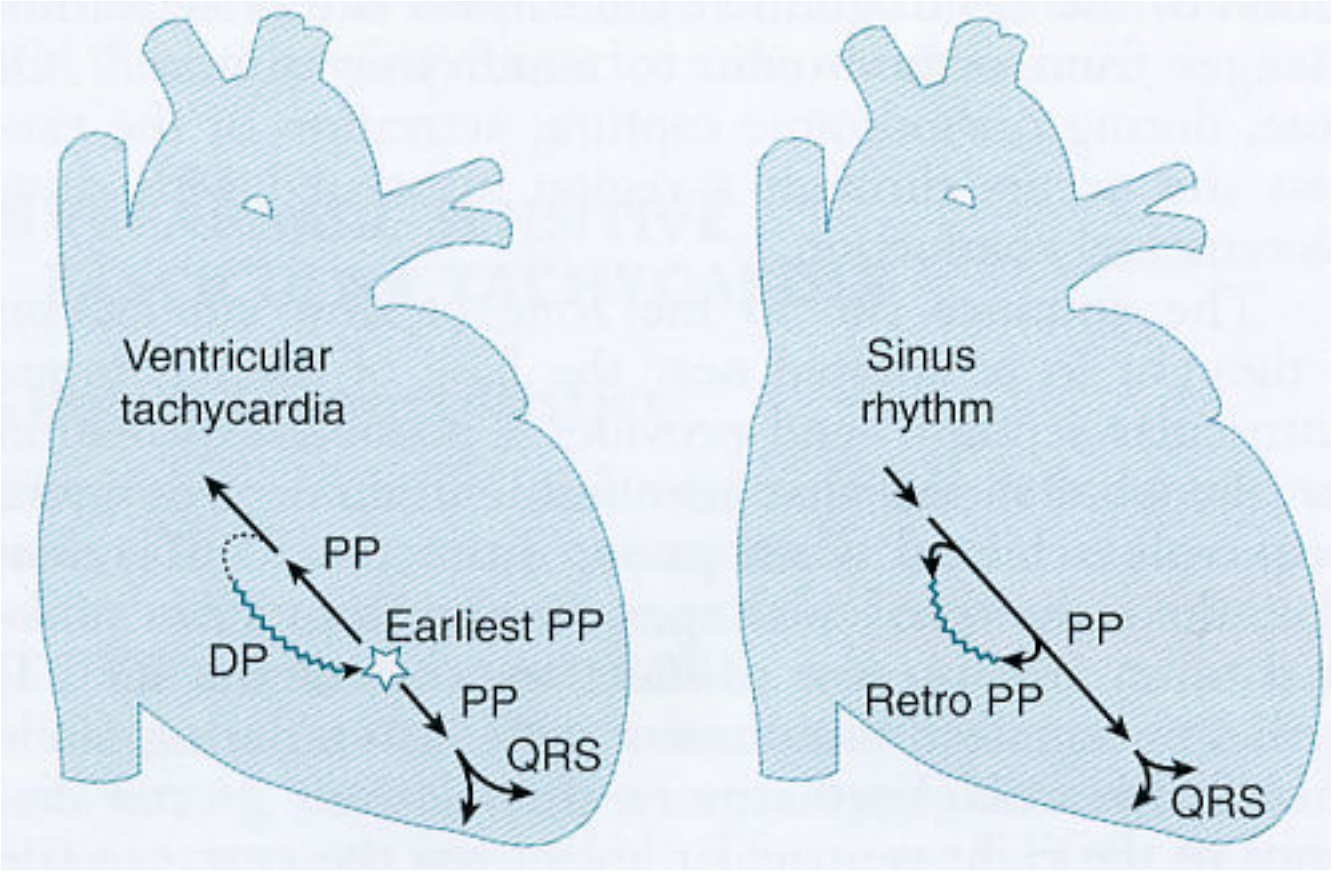
- Fascicular Tachycardia (52%)
  - Posterior fascicular reentry
  - Anterior fascicular reentry
  - Fascicular automaticity
- ASOV Tachycardia (10%)
- LV Endocardial Tachycardia (20%)
  - Aortic root, basal septum (LVOT)
  - Mitral annular Tachycardia
- Epicardial Tachycardia (15%)
  - Anterior interventricular vein
  - Middle cardiac vein
  - Great cardiac vein
- Bundle Branch reentry (3%)

LV Fascicular Tachycardia

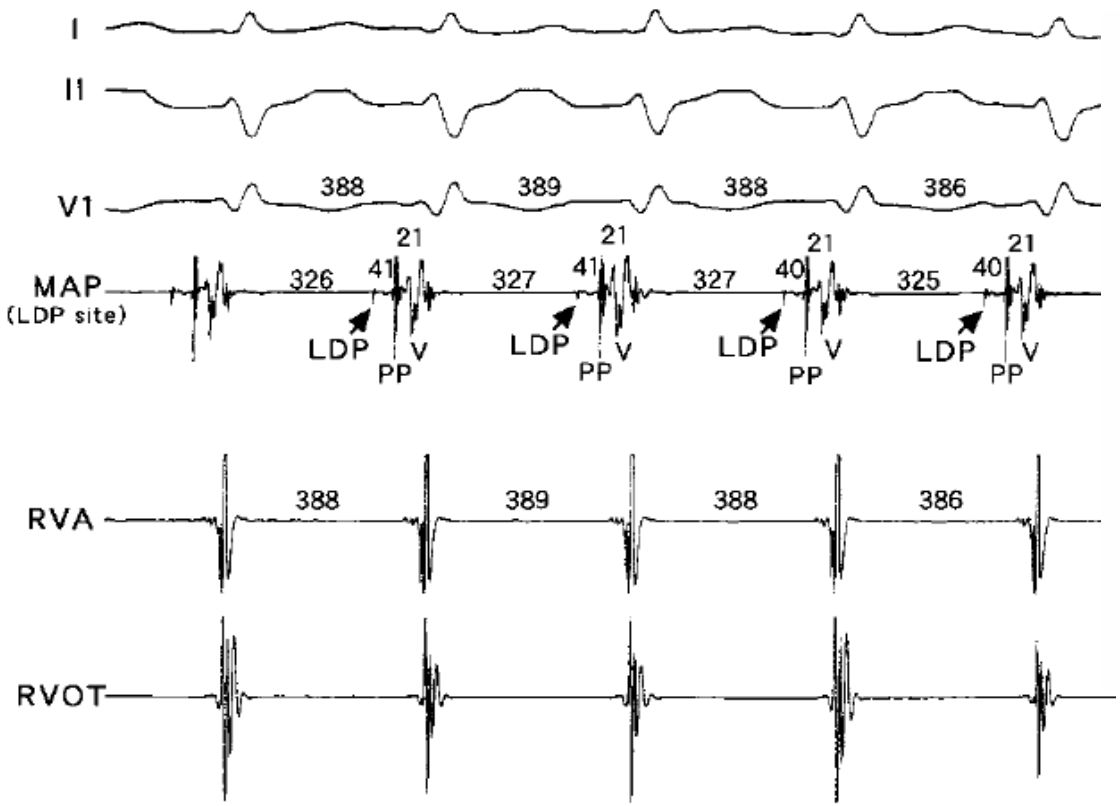
- ages of 15~40 yrs
- More frequent in men
- RBBB with left superior axis: Lt posterior fascicle (90~95%)
  inferoposterior LV septum
- RBBB with right inferior axis: Lt anterior fascicle
  anterosuperior LV septum
- Arrhythmia episodes

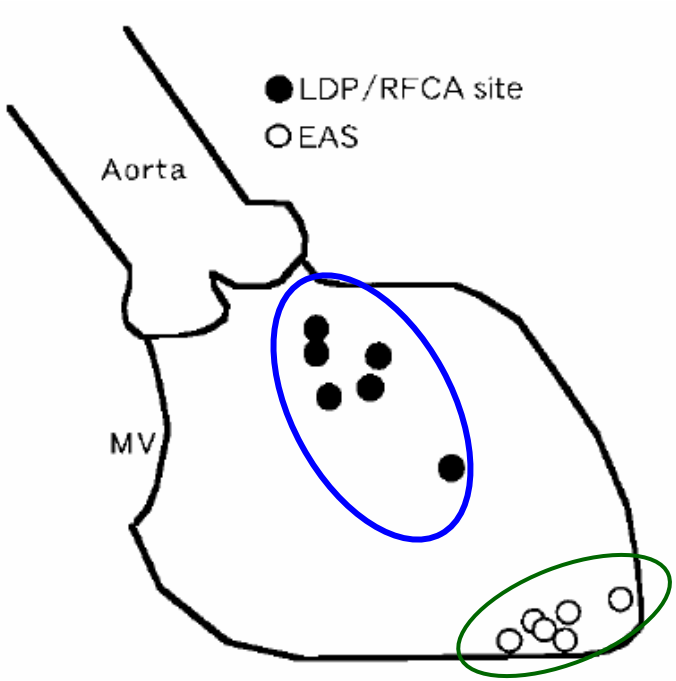
  ; sensitive to catecholamines(exercise or postexercise) or emotional stress

- ILVT reentry may be a small macroreentrant circuit.
- Anterograde limb: abnormal Purkinje tissue, slow decremental conduction, verapamil-sensitive diastolic potential along the midseptum
- Retrograde limb : Purkinje tissue from the left posterior fascicle, Purkinje potential



Late Diastolic Potential Preceding Purkinje Potential in Idiopathic LV Tachycardia

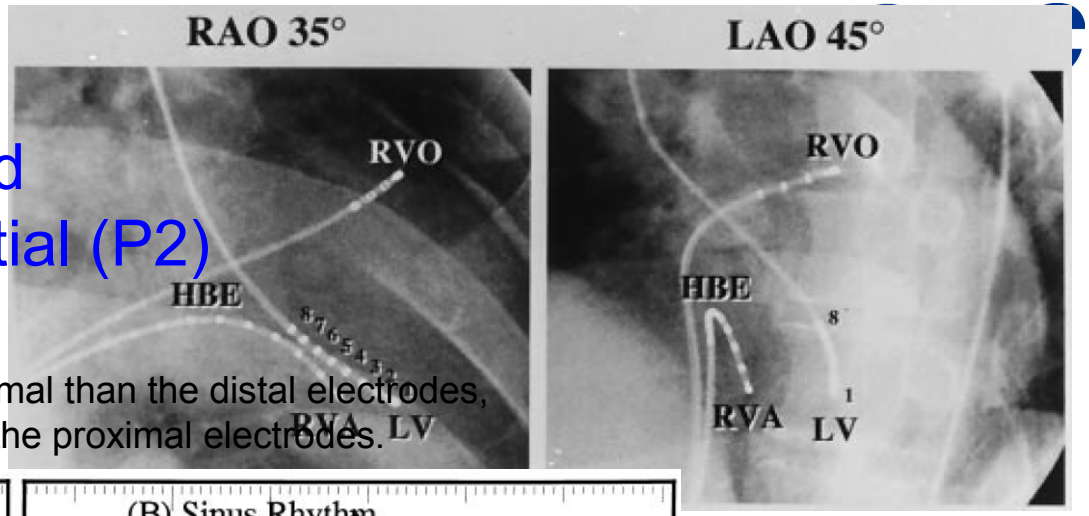




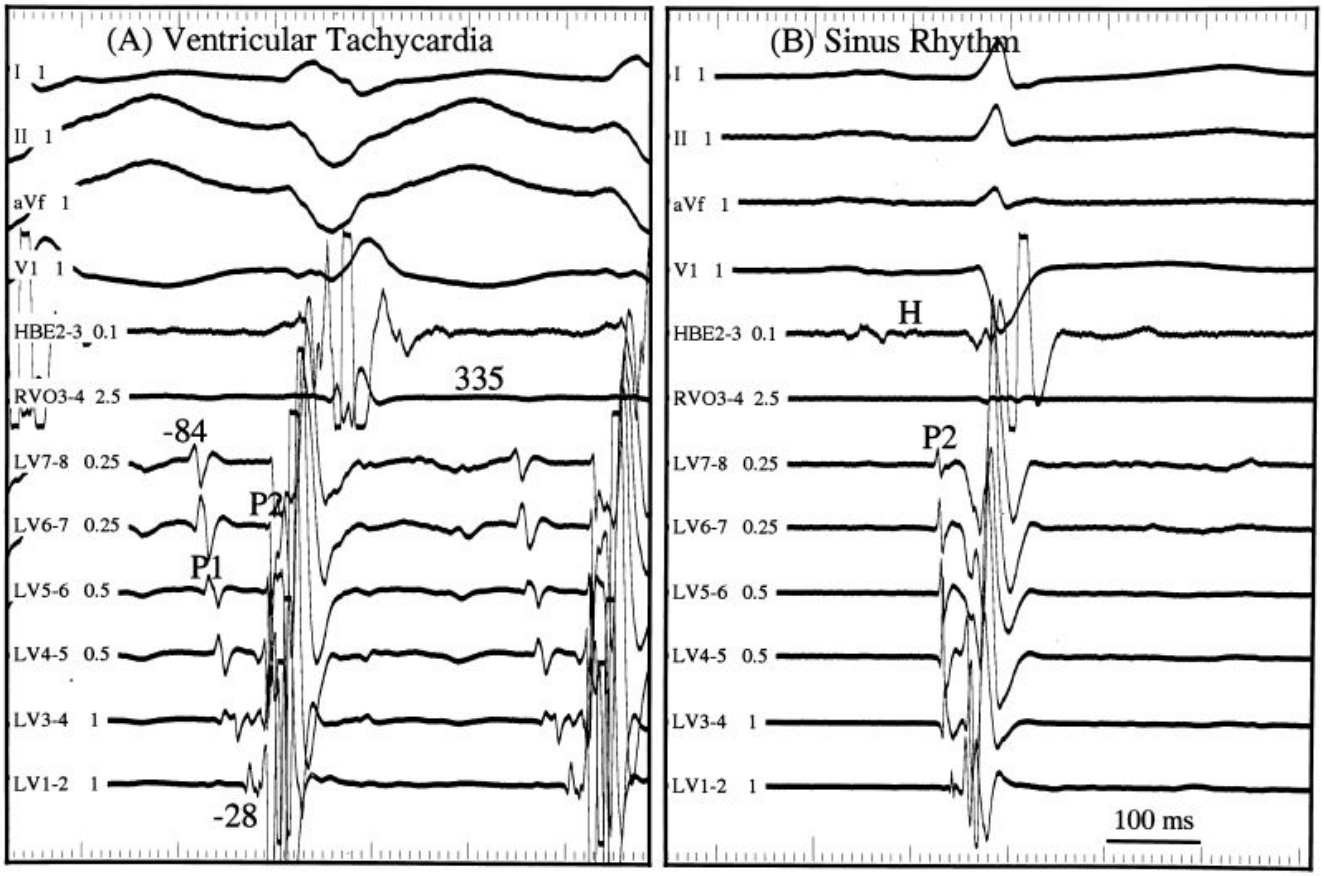
LDP recording sites and earliest ventricular activation sites (EAS)

Tsuchiya T, et al. Circulation. 1999;99:2408

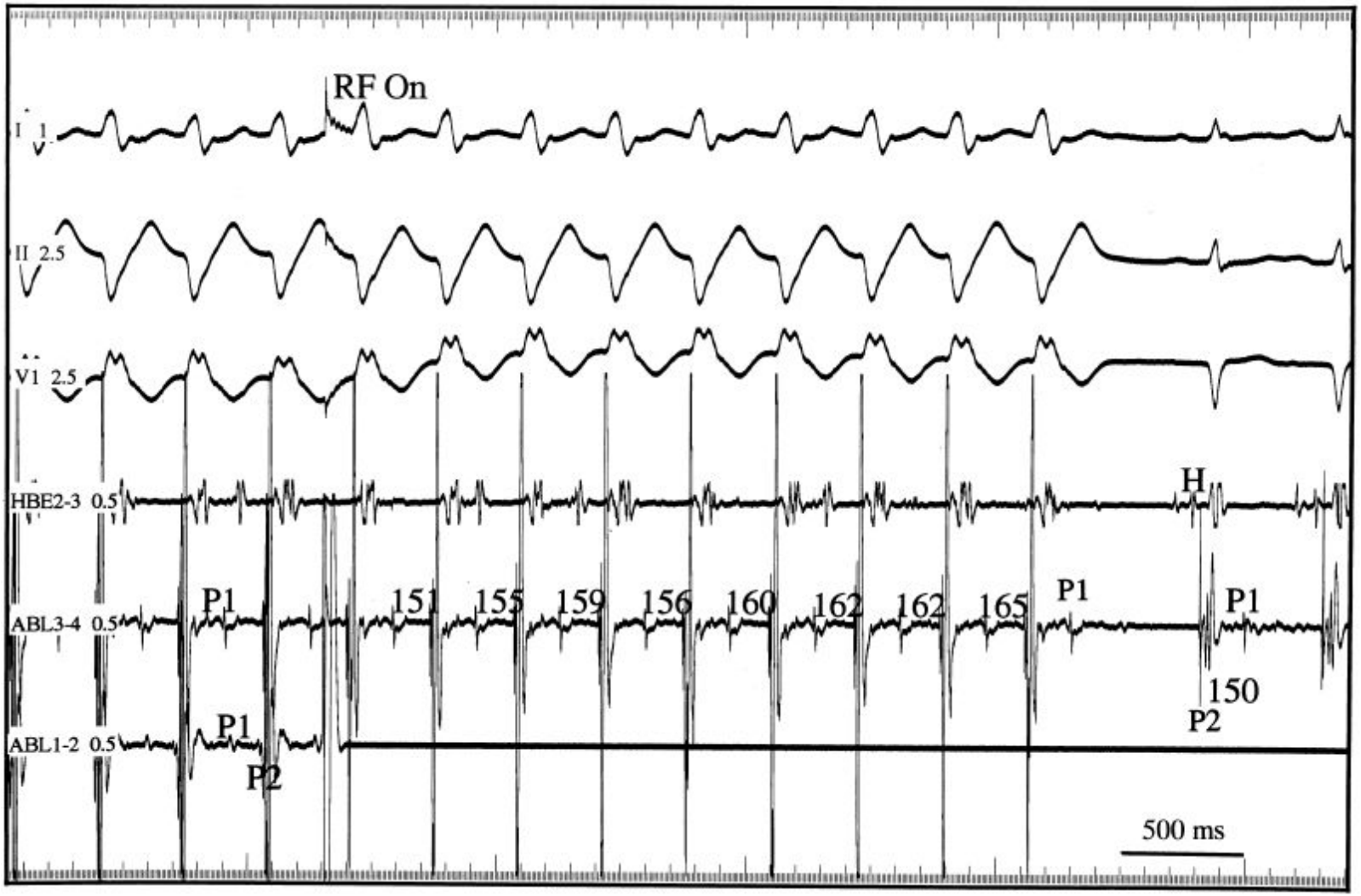
Diastolic potential (P1) and presystolic Purkinje potential (P2)



While P1 was recorded earlier from the proximal than the distal electrodes, P2 was recorded earlier from the distal than the proximal electrodes.

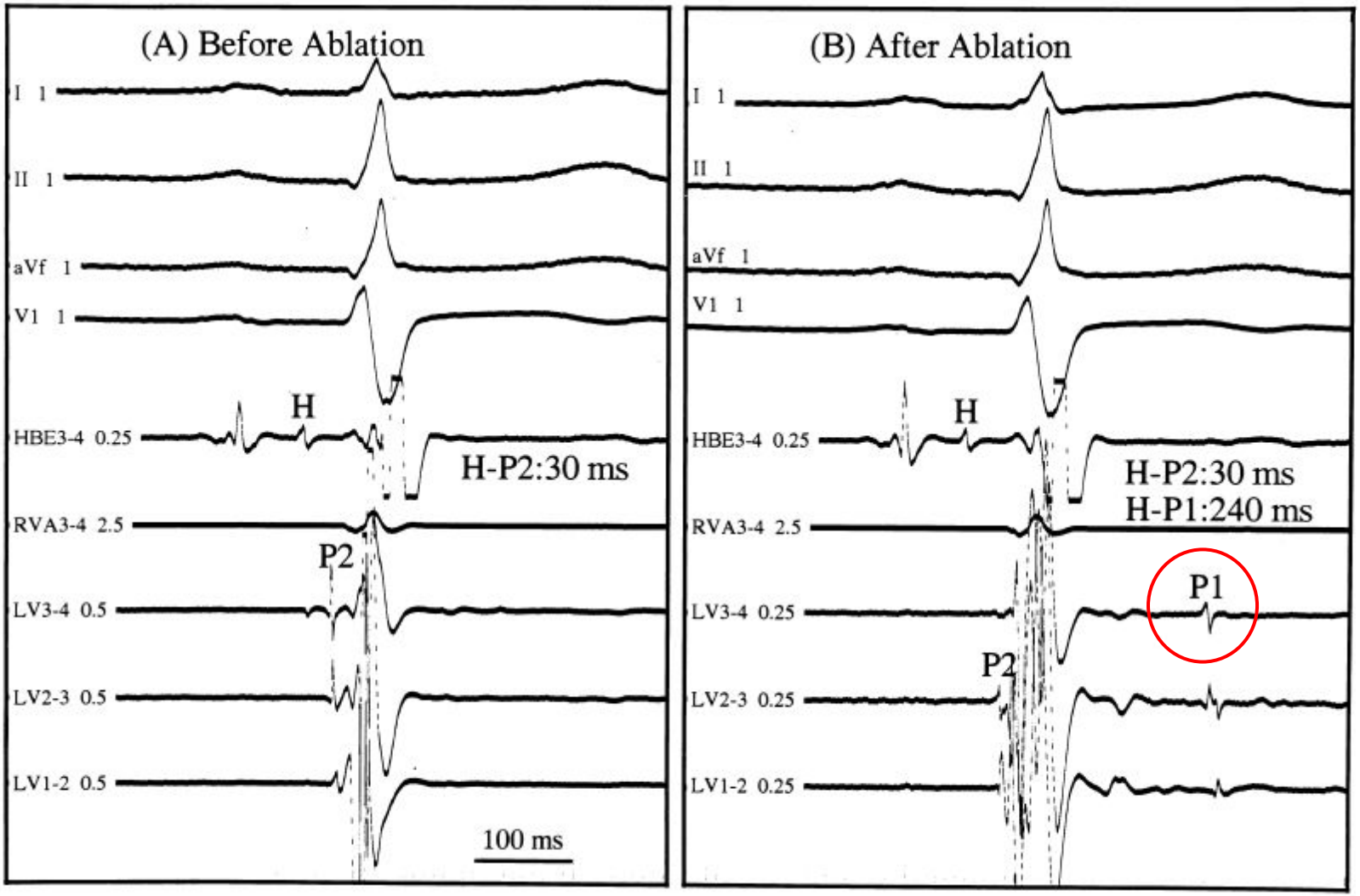


Nogami A, et al. J Am Coll Cardiol 2000;36:811



P1-P2 interval was gradually prolonged, and VT was terminated by block between P1 and P2. After ablation the P1 occurred after the QRS complex during sinus rhythm.

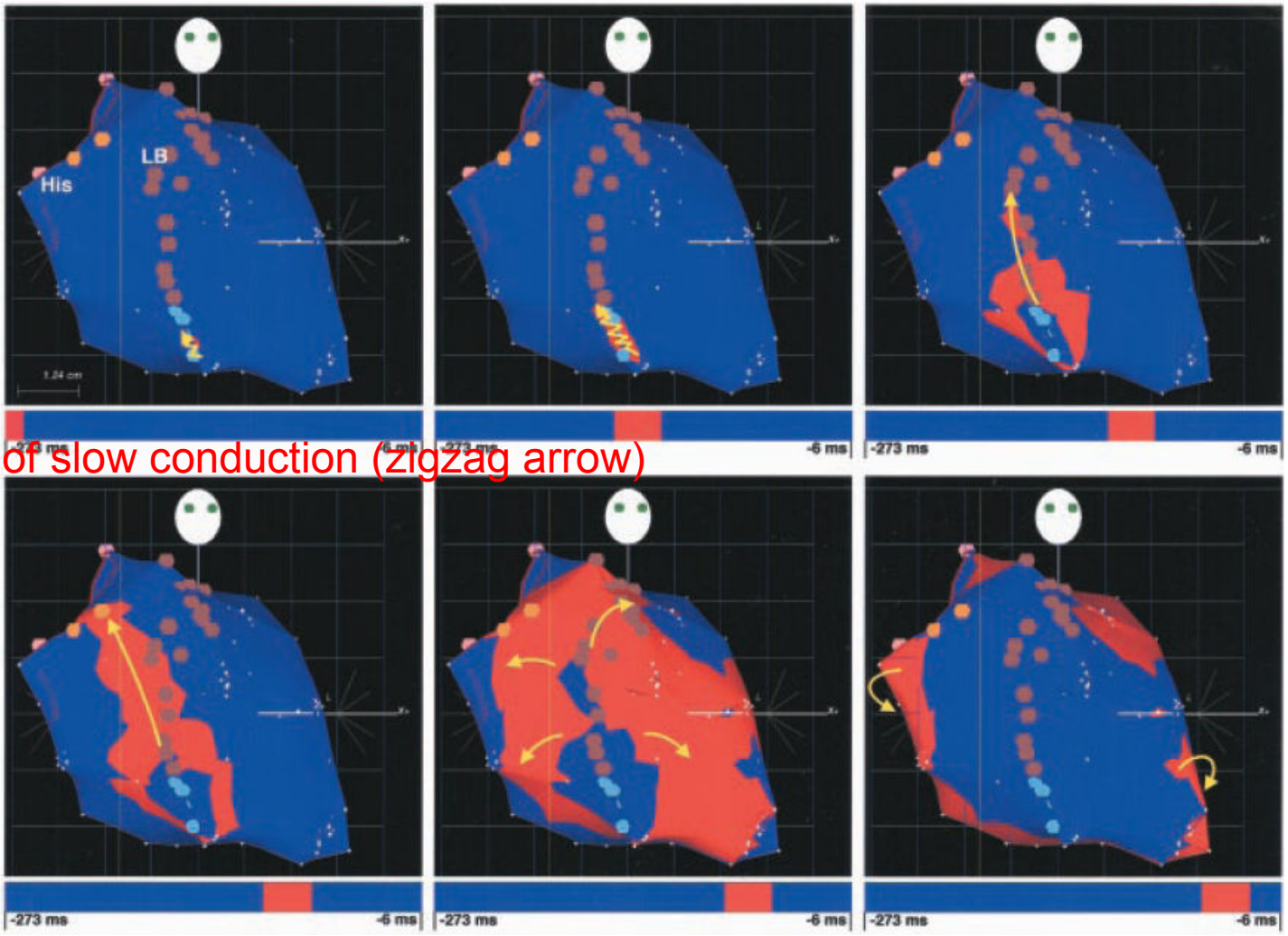
Nogami A, et al. J Am Coll Cardiol 2000;36:811



Before ablation. Diastolic potential was not observed during sinus rhythm.
After ablation, the P1 occurred after the QRS complex.

Nogami A, et al. J Am Coll Cardiol 2000;36:811

During tachycardia the LV was initially activated at the sites with DPs, then at the posterior fascicle, then at the His bundle region, and progressively at the anterior fascicle before the entire left ventricle is finally activated.



Area of slow conduction (zigzag arrow)

Ouyang F, et al. Circulation. 2002;105:462

- Optimal site for catheter ablation of verapamil-sensitive ILVT

1. When diastolic potential and presystolic Purkinje potential are recorded from the midseptal area during VT, this site should be targeted.

2. If such a diastolic potential cannot be detected, the application of RF current to the earliest ventricular activation with a fused Purkinje potential may be carried out.

3. The appearance of diastolic potential after the QRS complex during sinus rhythm appeared to be a useful marker for the effective RF application.

Case

36세 남자

CC; palpitation

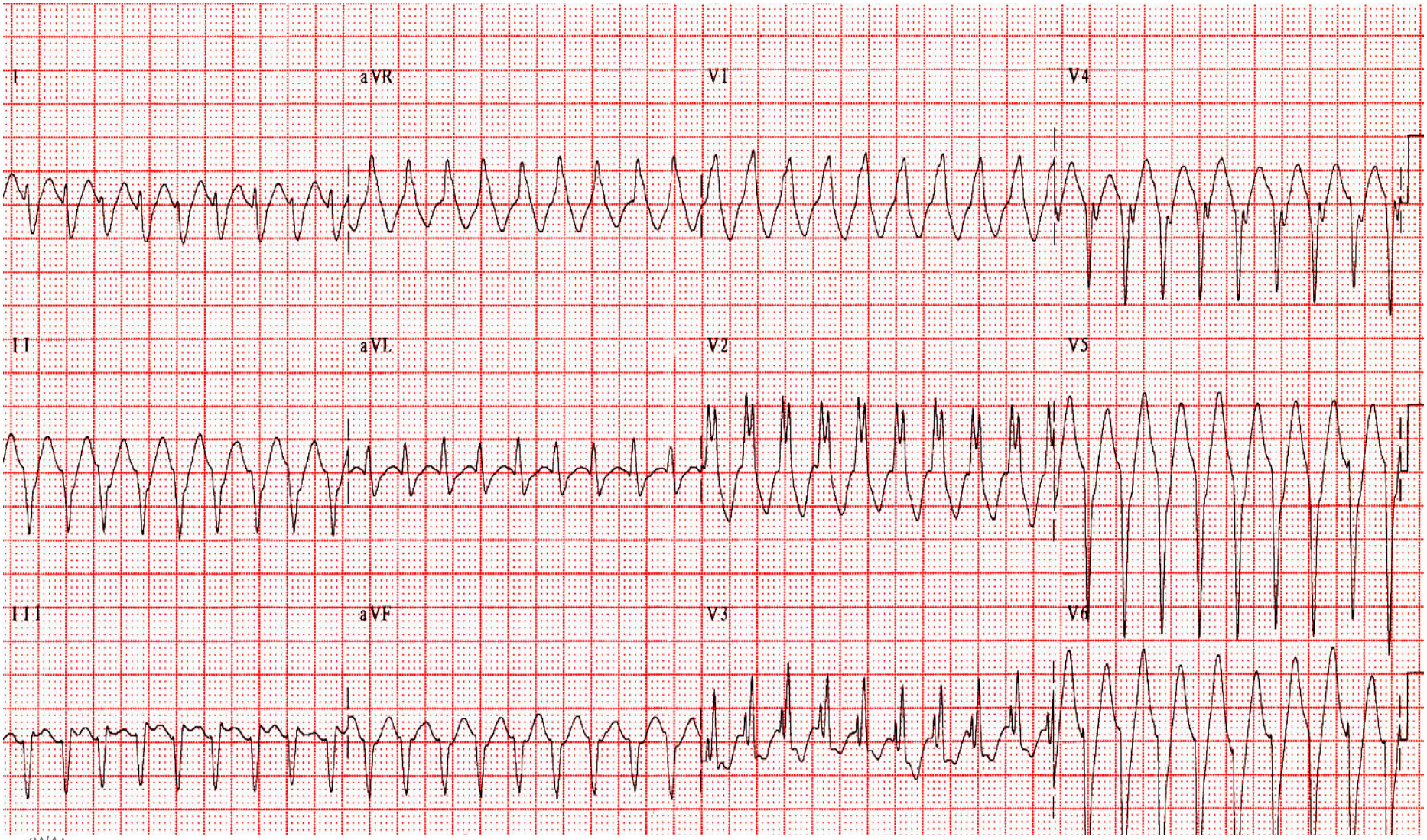
PI; 2005년 6월 등산 직후 palpitation 발생 30분 지속

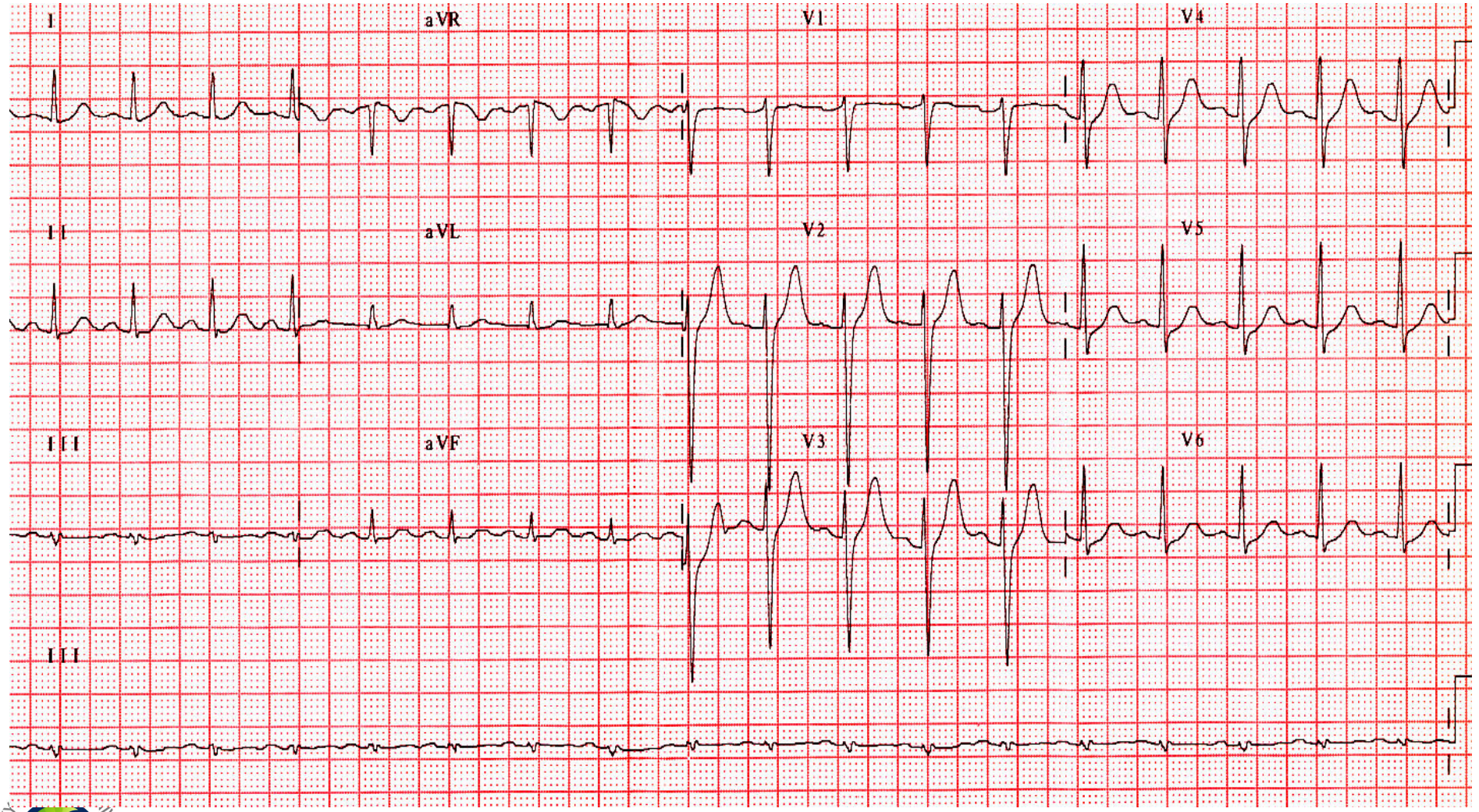
2005년 9월 25일 등산 중 palpitation 발생 1시간 지속

2006년 6월 28일 샤워 후 palpitation 발생 1시간 지속

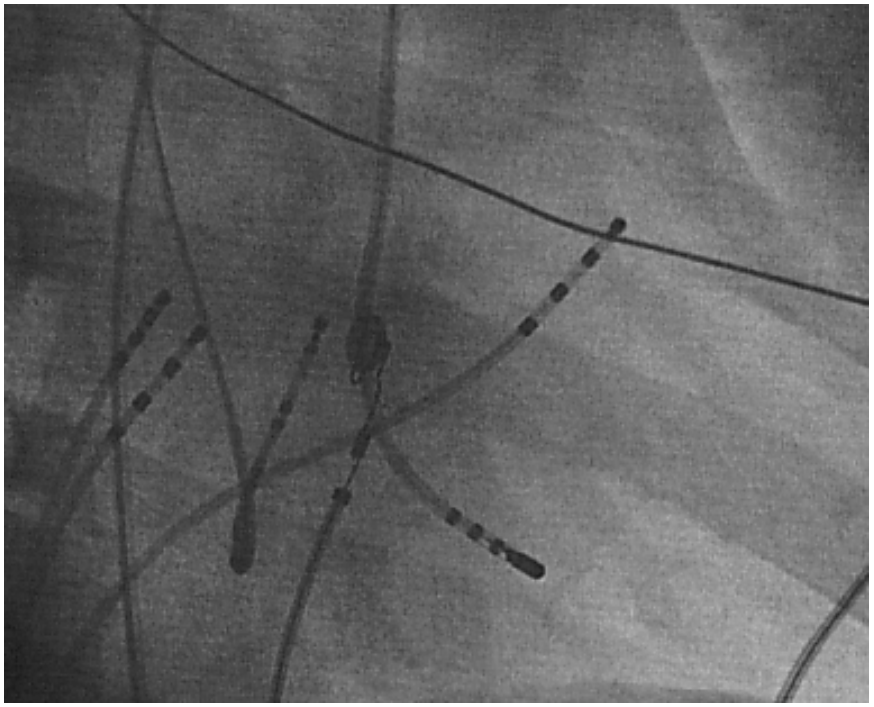
응급실 방문

가족력; 없음.

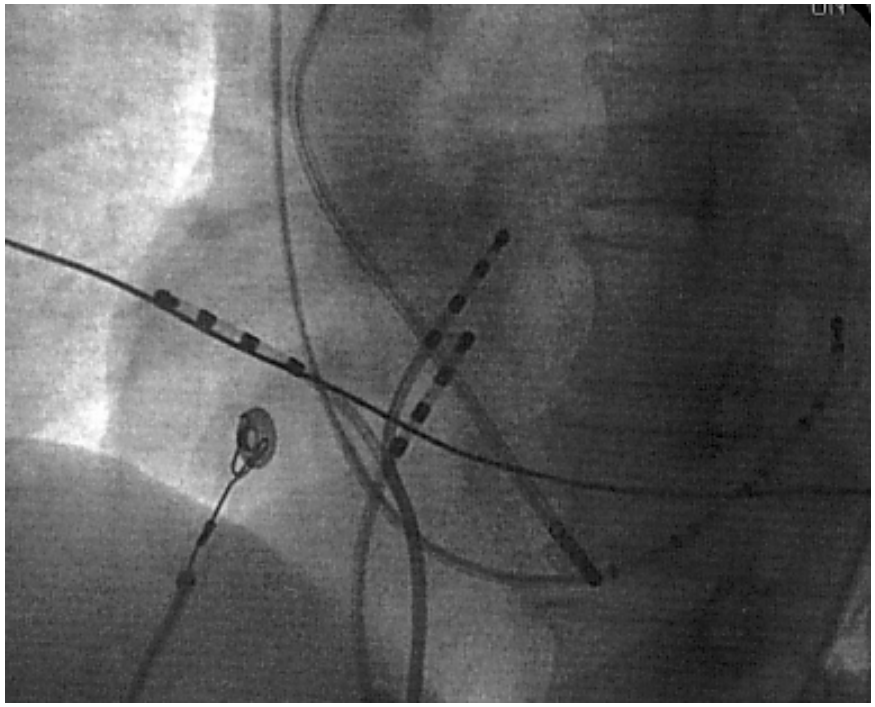

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6


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

Inferoapical septum



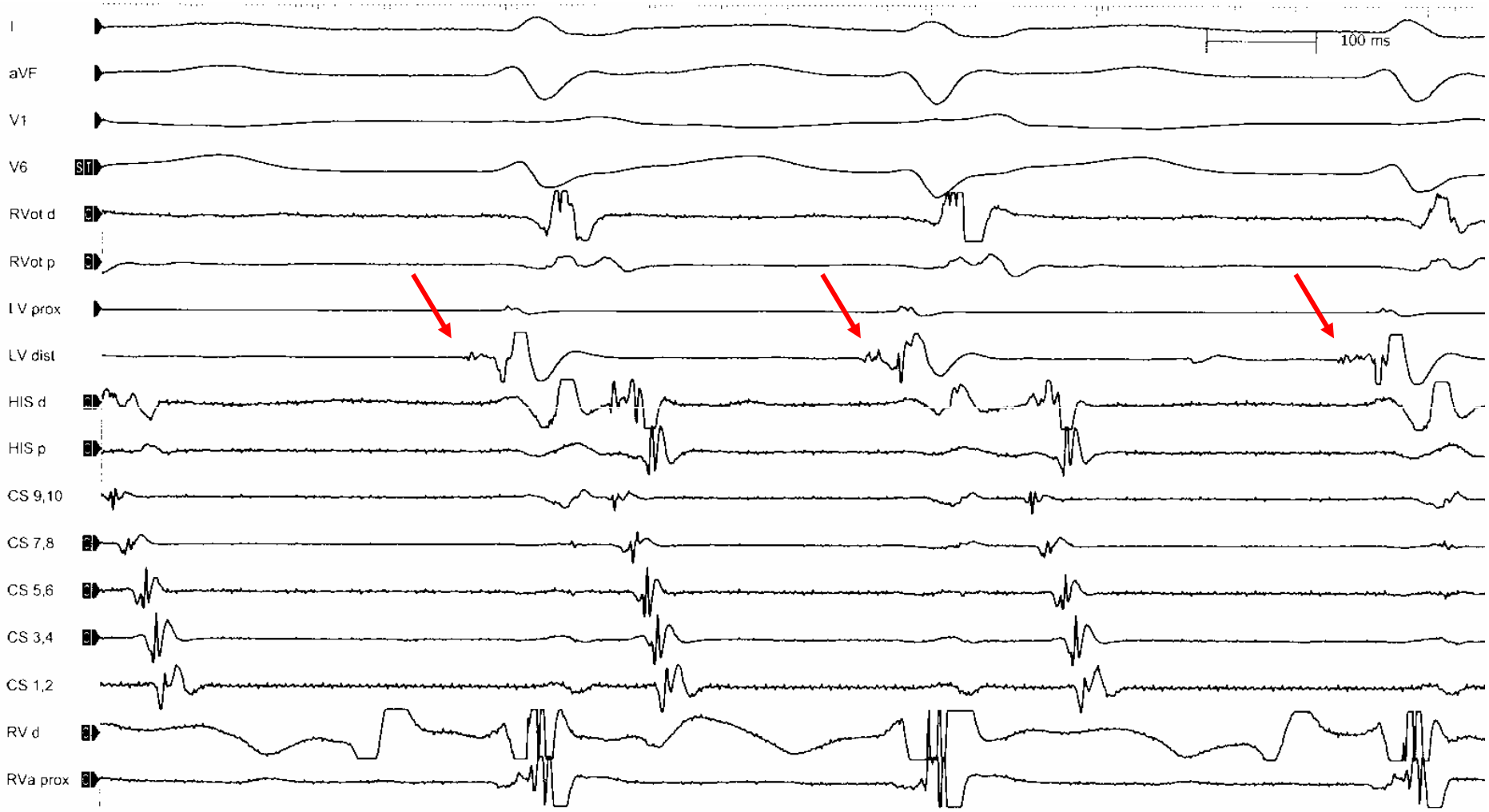
RAO



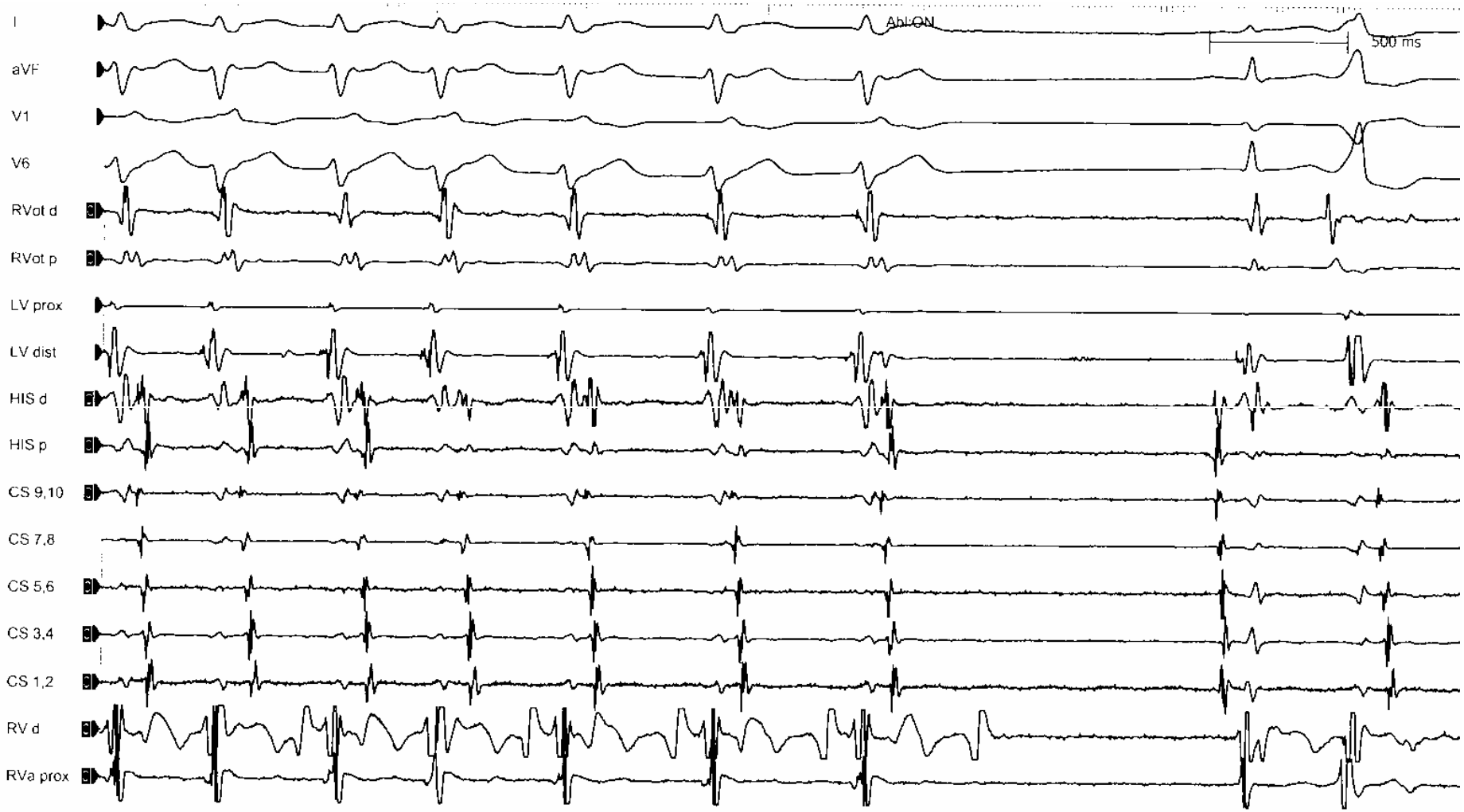
LAO

EPS

P-potential



RFCA


I
aVF
V1
V6
RVot d
RVot p
LV prox
LV dist
HIS d
HIS p
CS 9,10
CS 7,8
CS 5,6
CS 3,4
CS 1,2
RV d
RVa prox
Abl ON
500 ms

Approach to ILVT

- Narrow QRS(≤ 140 msec), RBBB with superior axis
  - Probable fascicular tachycardia
  - Activation mapping during tachycardia
  - Earliest diastolic potentials (pacemap may be poor.)
  - Fused double potentials

    (earliest P-potential, pacemap may be good.)

Approach to ILVT

- Wider QRS (>140 msec), inferior axis
  - Atypical LB more likely on septum, aortic root or aortic SOV.
  - Monophasic R in V1 with late or no transition, more likely mitral annulus
  - Consider epicardial origin If :

    delayed MDI(>0.55) in precordial leads

    short presystolic endocardial activation times

    poor endocardial pacemap matches at all sites

    failed ablation at best endocardial target site.

Summary

- Classification of Idiopathic Monomorphic VT
  - Adenosine-sensitive (RVOT/LVOT)
  - Verapamil-sensitive (*Fascicular reentry)*
  - Propranolol-sensitive (*Automaticity)*
- Ventricular Outflow Tract Tachycardia
  - Evaluation of RVOT tachycardia
  - Localization of RVOT tachycardia by ECG
  - Anatomy of RVOT and LVOT
  - Pace mapping, Activation mapping, 3D mapping
- LV Fascicular Tachycardia
  - Purkinje Potential, Late Diastolic Potential
  - Fascicular reentry
- Approach to ILVT