Ablation of Idiopathic LV Fascicular VT Versus LV Papillary Muscle VT

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Introduction

- The prevalence, electrocardiographic and electrophysiological features and response to catheter ablation of idiopathic ventricular arrhythmias (VAs) have been increasingly established in the last decade.
- Several new syndromes and concepts of idiopathic VAs have been recently addressed.

PAM VT

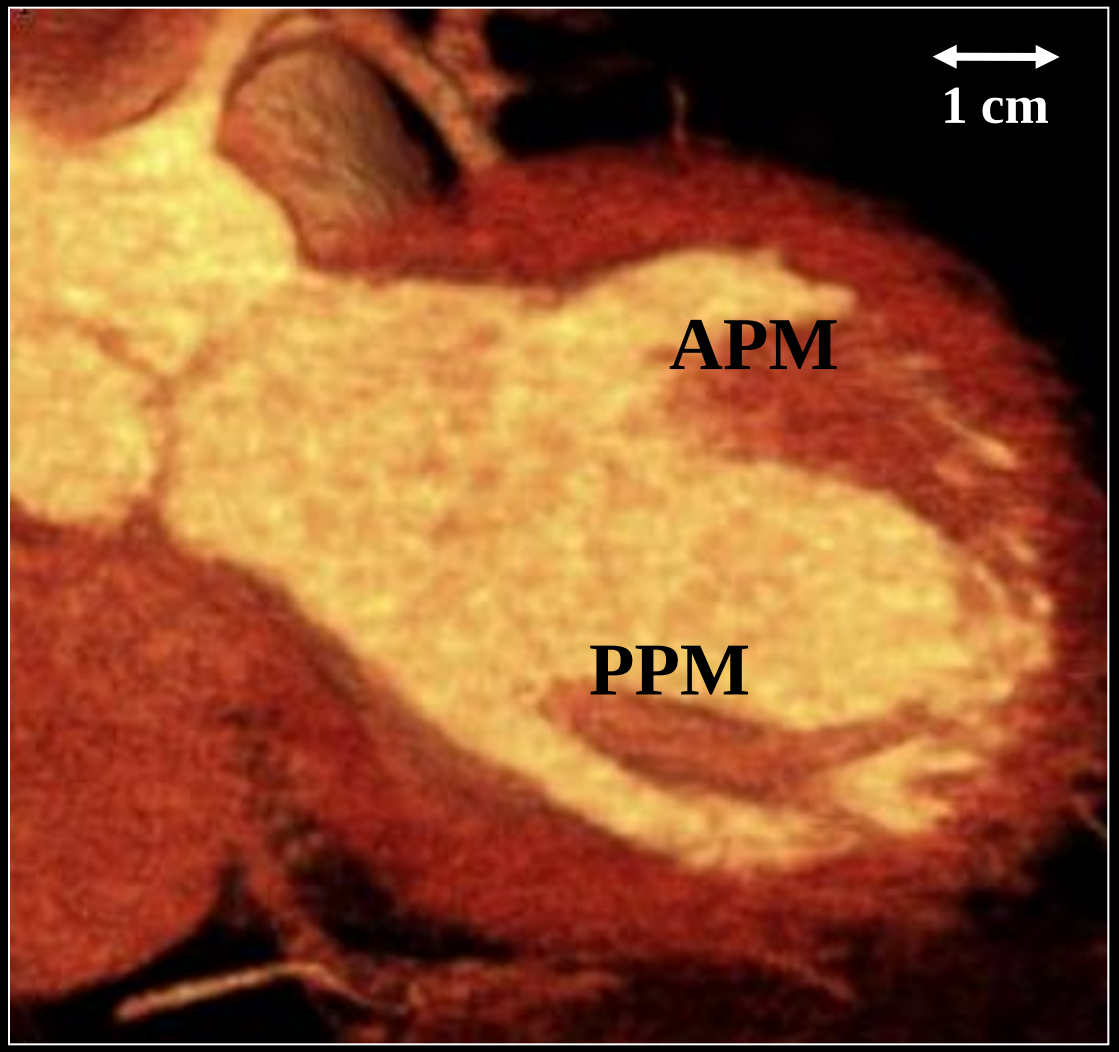
- Doppalapudi H, Yamada T, Kay GN, et al. Ventricular tachycardia originating from the posterior papillary muscle in the left ventricle - A novel clinical syndrome. Circ Arrhythmia Electrophysiol 2008;1:23-29.
- Good E, et al. Ventricular arrhythmias originating from a papillary muscle in patients without prior infarction: a comparison with fascicular arrhythmias. Heart Rhythm 2008;5:1530-1537.
- Yamada T, Kay GN et al. Idiopathic Focal Ventricular Arrhythmias Originating From the Anterior Papillary Muscle in the Left Ventricle. J Cardiovasc Electrophysiol 2009;20:866-872.
- Yamada T, Kay GN et al. Idiopathic ventricular arrhythmias originating from the papillary muscles in the left ventricle: prevalence, electrocardiographic and electrophysiological characteristics, and results of the radiofrequency catheter ablation. J Cardiovasc Electrophysiol. 2010;21:62-69.

Prevalence of PAM VTs

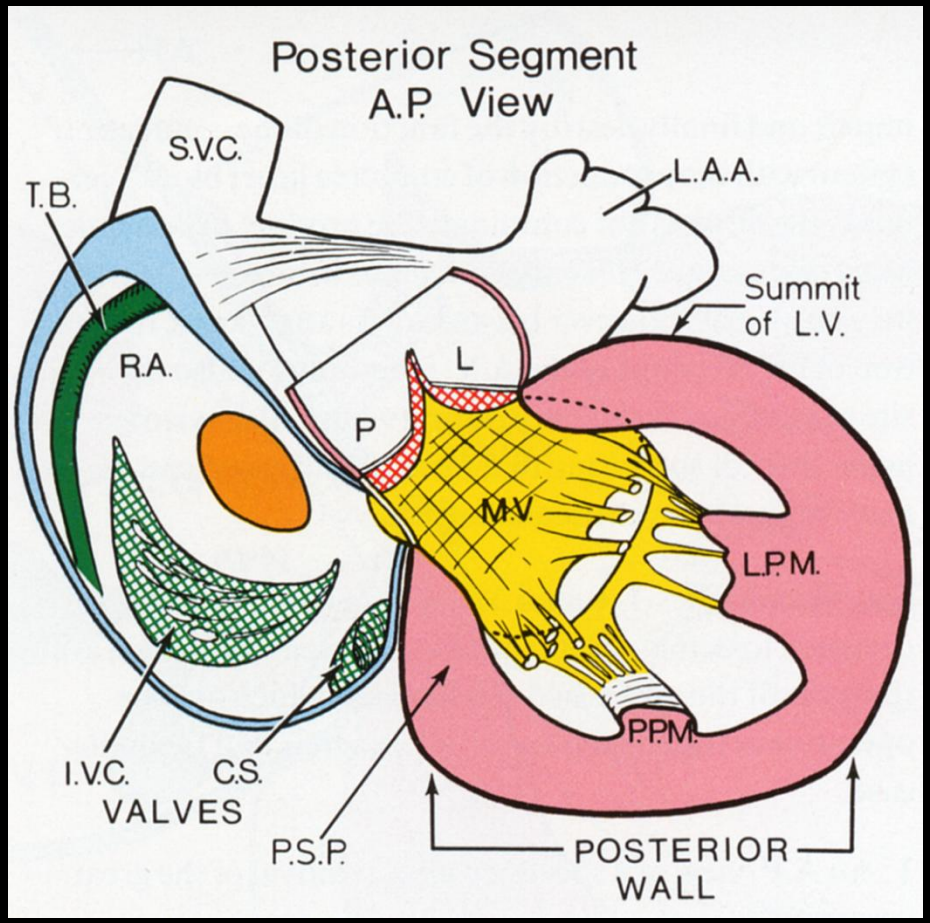
- 159 consecutive patients with idiopathic LV VAs
- 97 men, mean age 53±15 y.o.
- SVT (n=63), NSVT (n=26) and PVCs (n=70)
- Site of origin
  - ✓ Aortic root 47 (29.6%) patients
  - ✓ AMC 12 (7.5%)
  - ✓ epicardial surface 17 (10.7%)
  - ✓ mitral annulus 24 (15.1%)
  - ✓ fascicles of the LBB 38 (23.9%)
  - ✓ Anterior (Lateral) papillary muscle 7 (4.4%)
  - ✓ Posterior papillary muscle 12 (7.5%)
  - ✓ other sites 2 (1.3%)

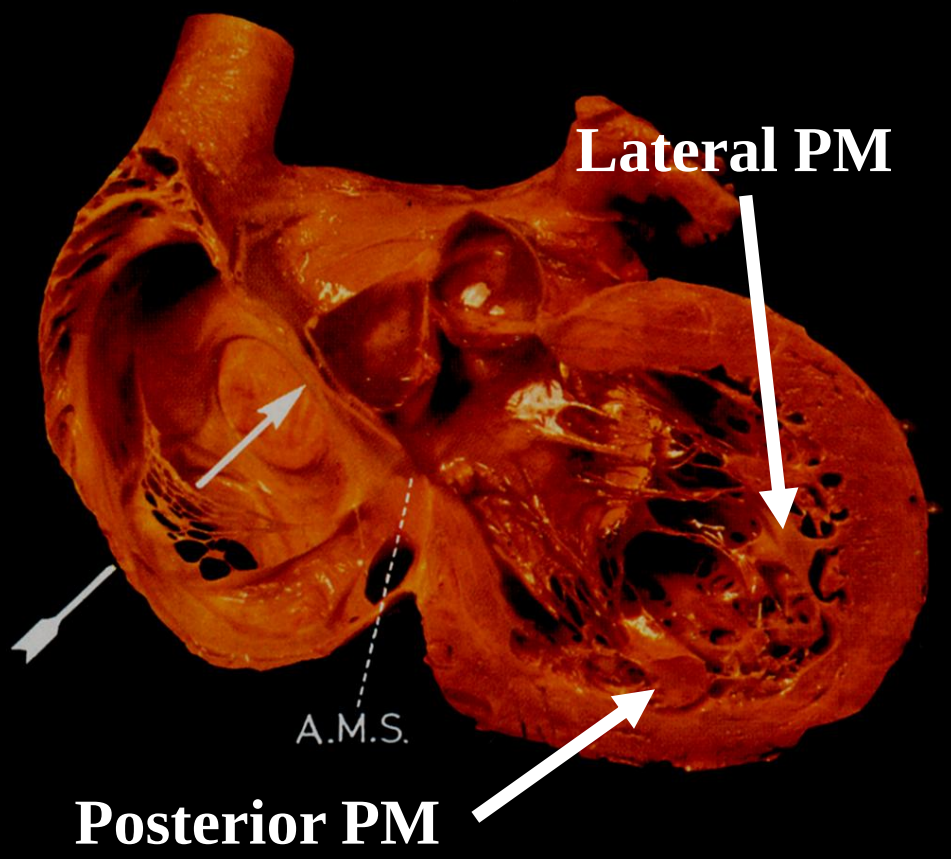
Anatomy

PAMs in a CT image



- ✓ Huge muscles
- ✓ Conical projections into the LV
- ✓ Myocardium covered by endocardium
- ✓ The PAMs originate from the middle to apical site of the ventral or inferior wall of the LV.





✓ **The basal end of the PAMs is attached to the mitral leaflets by multiple tendons.**

✓**The mitral annulus is located near the PAMs and Purkinje network is located on the surface of the PAMs.**

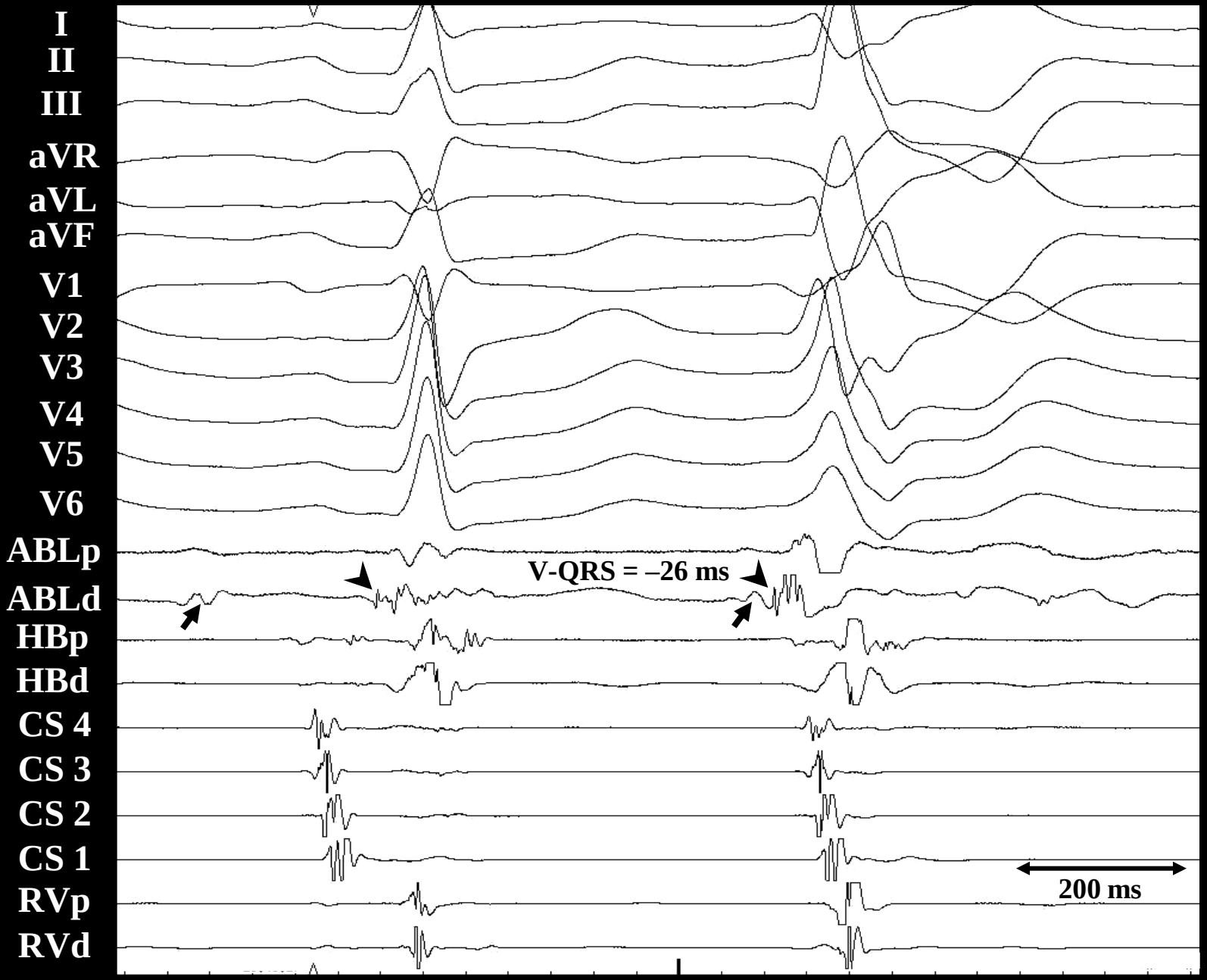
Differential Diagnosis Includes…

- PAM VT
- Mitral annular VT
- Fascicular VT

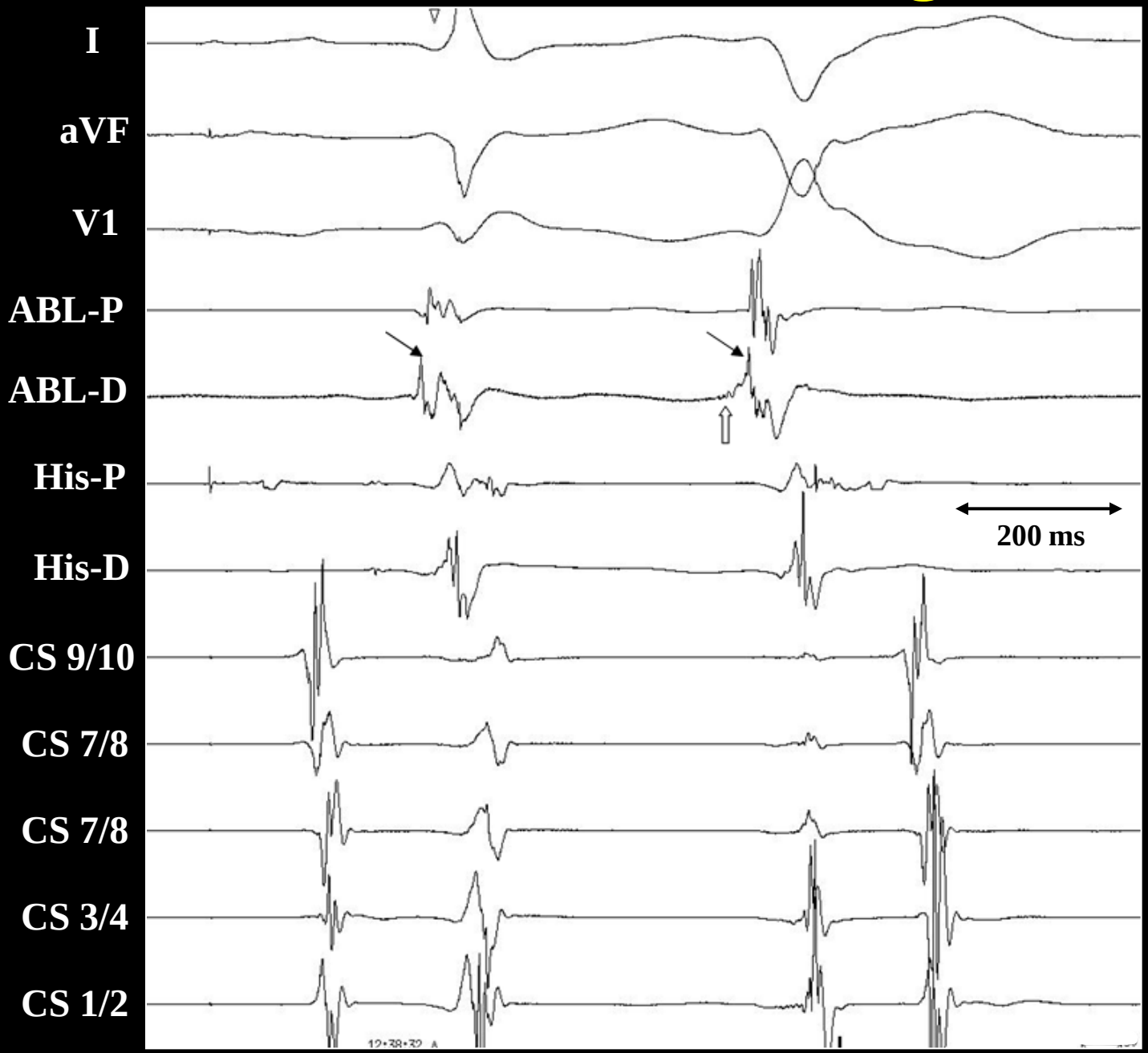
Definition of these VAs

- **Diagnosis of these VAs was made based on anatomical location of the successful ABL site and electrophysiological characteristics.**
  - PAM VT; No Purkinje potentials precede the QRS onset at the successful ABL site during the VAs.
  - Fascicular VT; Purkinje potentials always precede the QRS onset at the successful ABL site during the VAs.

PVCs originating from the left anterior fascicle

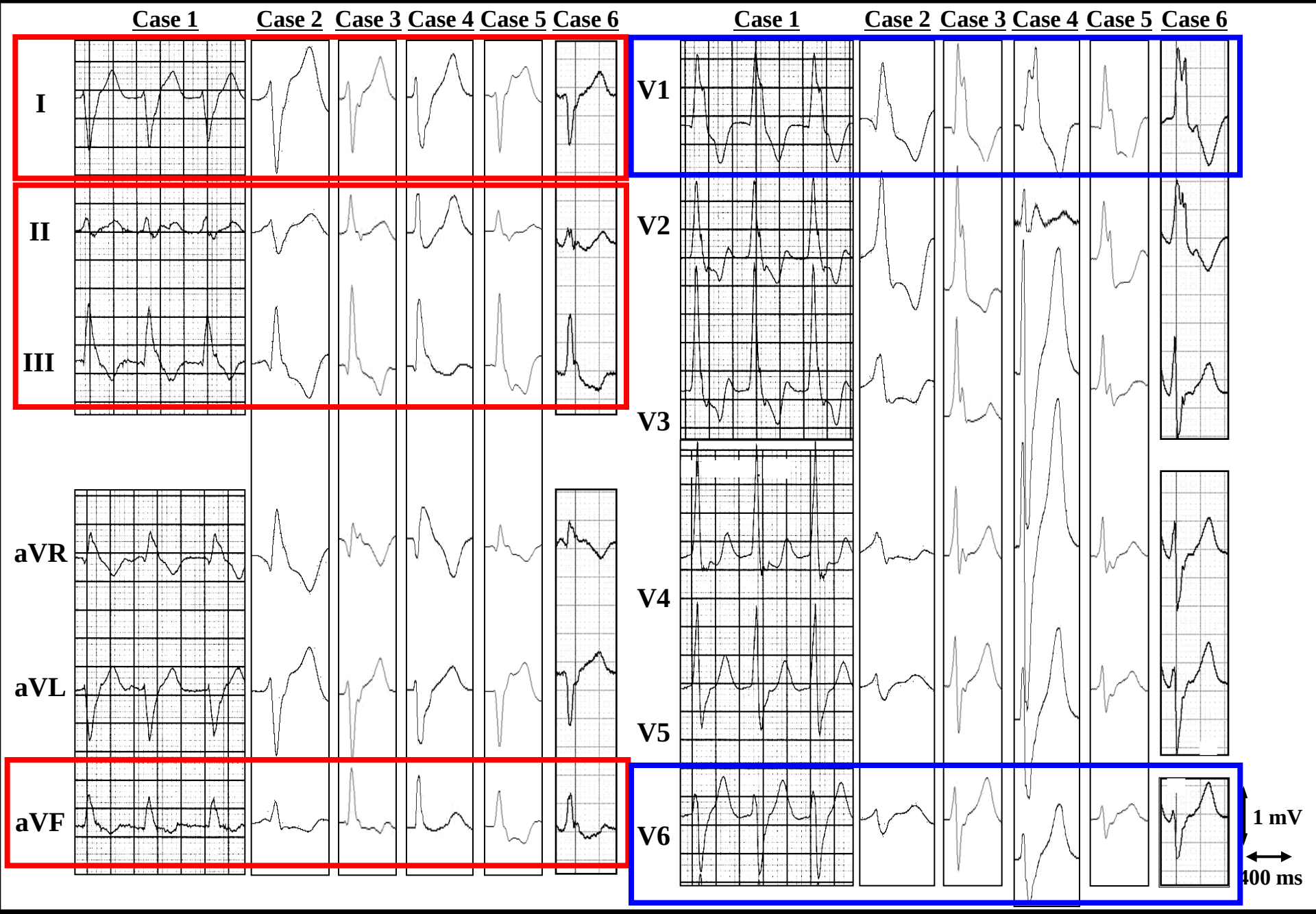


Evidence of Muscle Origin

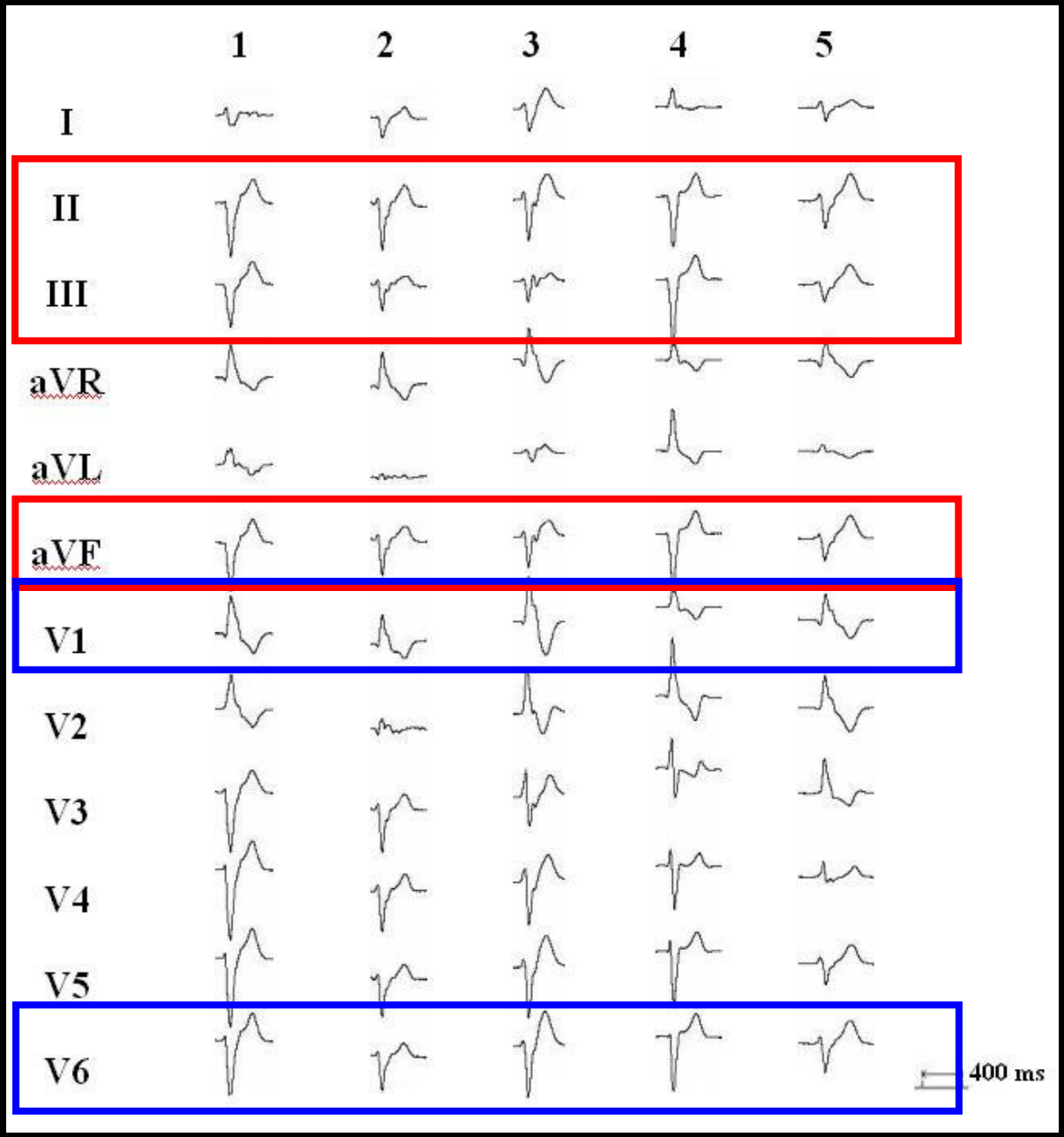


ECGs

ECGs of APM VTs

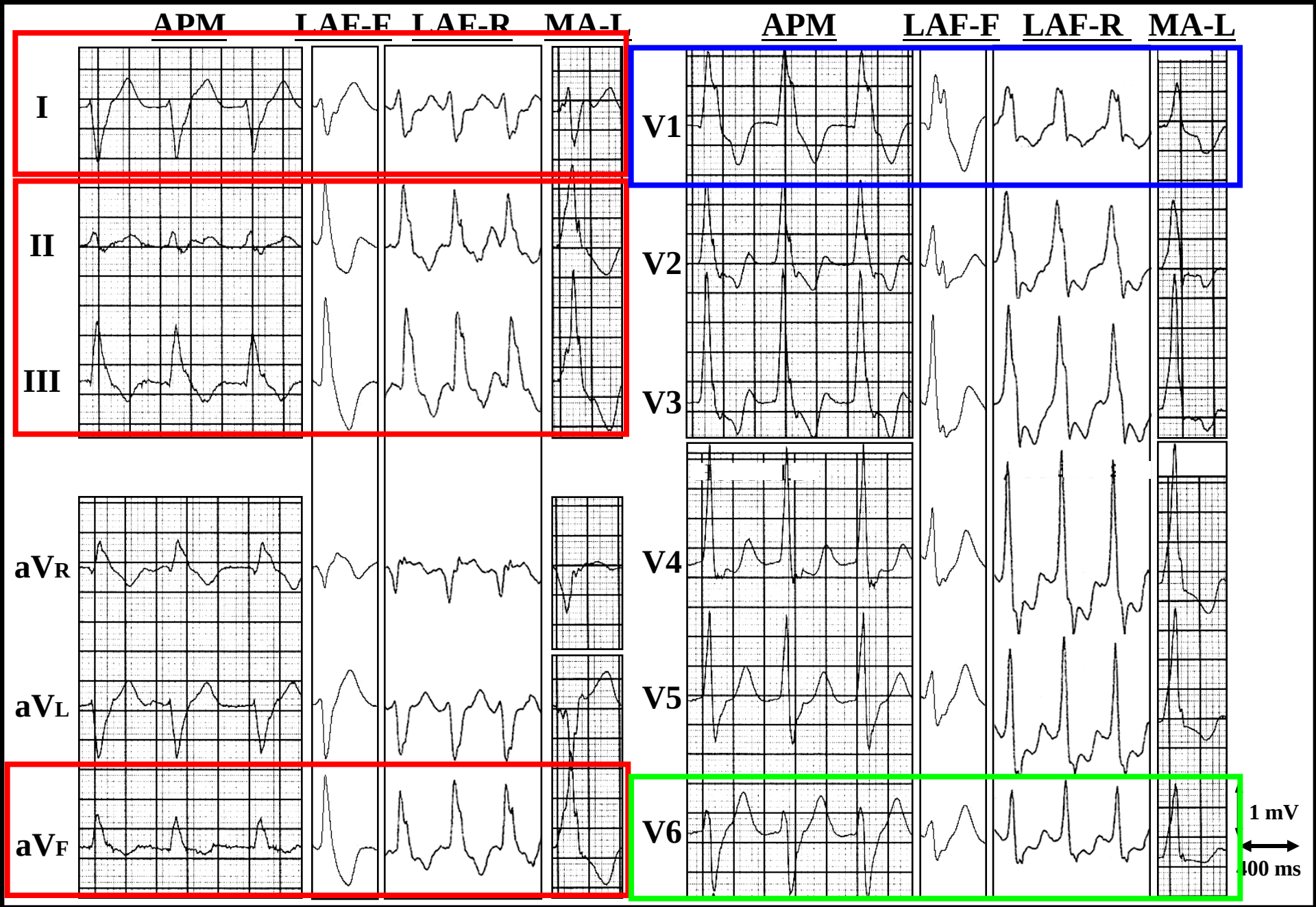


ECGs of PPM VTs

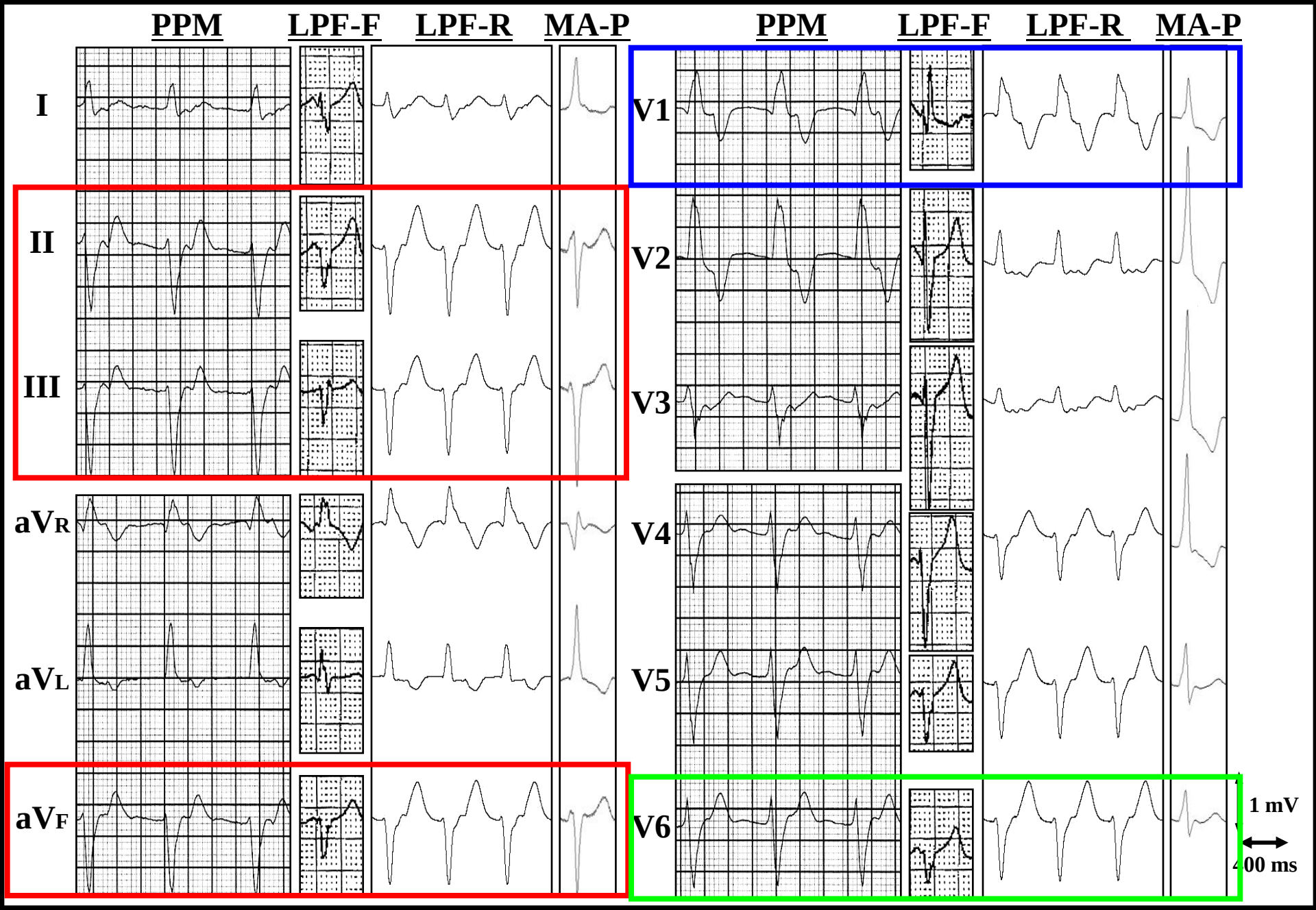


Comparison with MA VTs and Fascicular VTs

ECGs of VAs originating from the ant-lat LV



ECGs of VAs originating from the post-septal LV



Clinical, electrocardiographic and electrophysiological characteristics

Origin	Age	Gender (M/F)	Type (SVT/NSVT /PVC)	QRS						
				Duration (ms)	Morph.	Transition	Lead I	Lead aVR	Lead aVL	Q in V1
APM (n=7)	64±15	4 / 3	1/1/5 †	168±18 §	RBBB+ RIA; all	< V1; all	rS; 7 *	rS; 7 †	qR; 7 †	5 (71%) *
LAF (n=8)	52±19	6 / 2	7/1/0 †	155±13 † §	RBBB+ RIA; all	< V1; all	rS; 8 *	rS; 5 † QS; 3	qR; 6 † QS; 2	5 (63%) *
MA-AL, L (n=7)	60±11	4 / 3	0/1/6 †	179±10 †	RBBB+ RIA; all	< V1; all	rS; 3 * QS; 3 rsr'; 1	Qr; 1 † QS; 6	rS; 1 † QS; 6	0 (0%) *

APM=anterior papillary muscle; F=female; LAF=left anterior fascicular; M=male; MA-AL, L; antero-lateral and lateral portion of the mitral annulus; Morph.=morphology; NSVT=non-sustained ventricular tachycardia (VT); PVC=premature ventricular contraction; RBBB=right bundle branch block; RIA=right inferior axis; SVT=sustained VT. *; $p < 0.05$, †; $p < 0.005$, #; $p < 0.0001$, §; $p = 0.09$.

Clinical, electrocardiographic and electrophysiological characteristics

Origin	R amp. (mV) in inf. leads	III/II ratio	R/S ratio in V6	V-QRS (ms)	No. of RF lesions	ABL time (min)	Recurrence
APM (n=7)	1.5±0.5	3.4±1.4 *	0.5±0.2 *	-26±6	13±6 #	74±55 *†	5 (71%) *
LAF (n=8)	1.5±0.3	2.3±2.2	1.8±1.5 *	-36±17	4±2 #	27±13 *	2 (25%) *
MA-AL, L (n=7)	1.6±0.3	1.2±0.2 *	2.2±1.1 *	-24±7	2±1 #	14±8 †	0 (0%) *

ABL=ablation; inf.=inferior; R amp.=maximum R wave amplitude; RF=radiofrequency; R/S ratio=the amplitude ratio of the R and S waves; V-QRS=the local ventricular activation time relative to the QRS onset at the successful ablation site; III/II ratio=the R wave amplitude ratio in leads III and II.

Clinical, electrocardiographic and electrophysiological characteristics

Origin	Age	Gender (M/F)	Type (SVT/NSVT /PVC)	QRS						
				Duration (ms)	Morph.	Transition	Lead I	Lead aVR	Lead aVL	Q in V1
PPM (n=12)	# 55±13	9 / 3	† 4/4/4	# 173±9	RBBB+ RSA; 6 LSA; 6	< V1; all	# Rs; 6 rS; 6	rS; 2 R; 4 qR; 4 qrs; 2	# qR; 10 R; 2	† 10 (83%)
LPF (n=30)	# 30±13	20 / 10	† 26/2/2	# 141±8	RBBB+ RSA; 14 LSA; 16	< V1; all	# Rs; 14 rS; 14 R; 2	rS; 6 R; 4 qR; 10 qrs; 10	# qR; 28 R; 2	† 24 (80%)
MA-P, PS (n=7)	# 59±8	2 / 5	† 0/1/6	# 160±7	RBBB+ LSA; all	< V1; all	# rS; 2 R; 5	rS; 1 QS; 2 qR; 4	# Rs; 2 R; 5	† 0 (0%)

LPF=left posterior fascicular ; LSA=left superior axis; MA-P, PS; posterior and postero-septal portion of the mitral annulus; PPM=posterior papillary muscle; RSA=right superior axis. The other abbreviations are as in Table 1.

*; $p < 0.05$, †; $p < 0.005$, #; $p < 0.0001$.

Clinical, electrocardiographic and electrophysiological characteristics

Origin	S amp. (mV) in inf. leads	III/II ratio	R/S ratio in V6	V-QRS (ms)	No. of RF lesions	ABL time (min)	Recurrence
PPM (n=12)	1.4±0.5	1.1±0.3 #	0.4±0.3 #	-28±8	9±5 ¢ #	57±29 #	6 (50%) *
LPF (n=30)	1.6±0.6	1.2±0.2 #	0.4±0.3 #	-28±7	5±2 * ¢	23±11 #	4 (13%) *
MA-P, PS (n=7)	1.7±0.5	1.9±0.4 #	1.9±1.1 #	-30±10	1±1 * #	14±7 #	0 (0%) *

¢ ; p < 0.01.

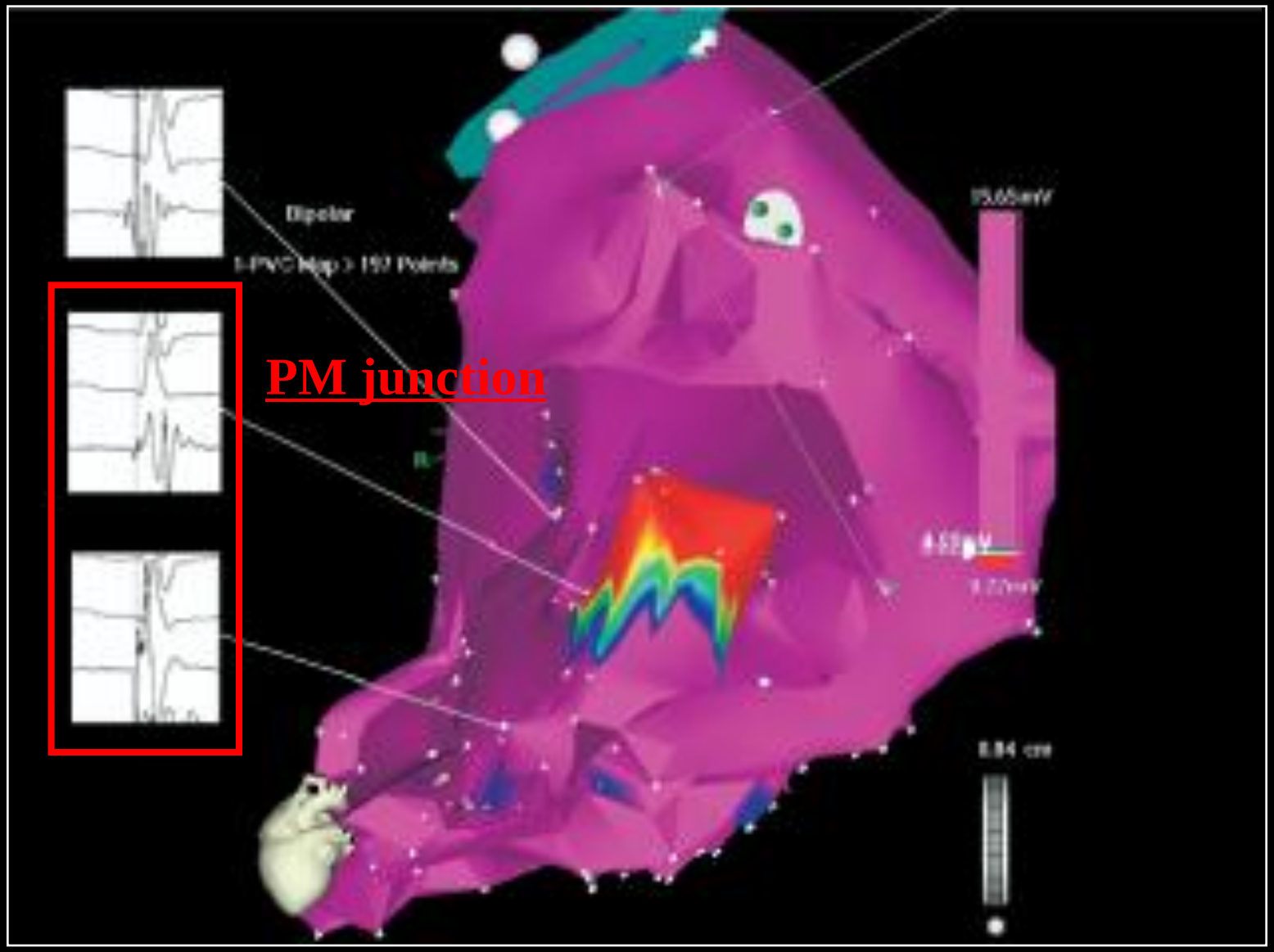
The sensitivity, specificity, and positive and negative predictive accuracies of the different QRS morphologies for a ventricular arrhythmia origin

QRS characteristics	Subjects	Site of prediction	Sensitivity	Specificity	PPV	NPV
Group-I (the antero-lateral region in the LV)						
rS in lead I	MA-AL,L & APM & LAF	APM & LAF	100%	57%	83%	100%
rS in lead aVR			80%	100%	100%	70%
qR in lead aVL			87%	100%	100%	78%
Q in lead V1			67%	100%	100%	58%
R/S ≤ 1 in V6	APM & LAF	APM	100%	63%	70%	100%
Group-II (the postero-septal region in the LV)						
Rs or rS in lead I	MA-P,PS & PPM & LPF	PPM & LPF	95%	71%	95%	71%
qR in lead aVL			90%	100%	100%	64%
Q in lead V1			81%	100%	100%	47%
III/II ratio < 1.5			95%	86%	98%	75%
R/S ratio ≤ 1 in V6			100%	71%	95%	100%
QRS duration > 160 ms	PPM & LPF	PPM	100%	100%	100%	100%

LV=left ventricle; NPV=negative predictive value; PPV=positive predictive value. The other abbreviations are as in the previous tables.

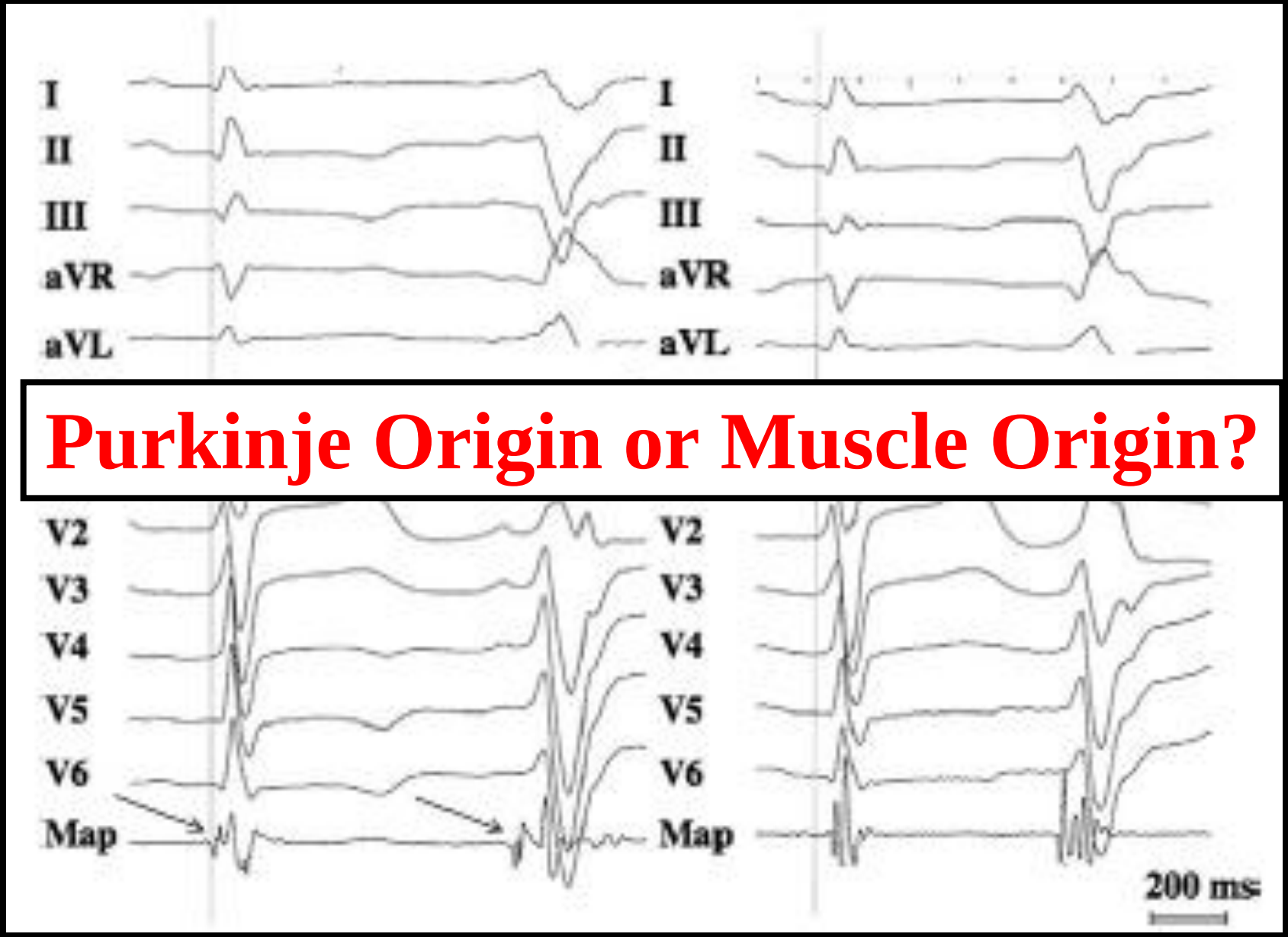
Mechanism of PAM VAs

Purkinje network on the PAMs



(Good et al. Heart Rhythm 2008;5:1530-7)

Two Different PAM VTs



Purkinje Origin or Muscle Origin?

(Good et al. Heart Rhythm 2008;5:1530-7)

Definition of PAM VAs is confusing.

- Anatomical definition (Broad definition)

  All the VAs that can be successfully ablated on the papillary muscles are defined as PAM VAs.

- Electrophysiological definition (True definition)

  No Purkinje potentials precede the QRS onset at the successful ABL site on the papillary muscle during VAs. These findings suggest that the VAs should originate from the papillary muscle itself.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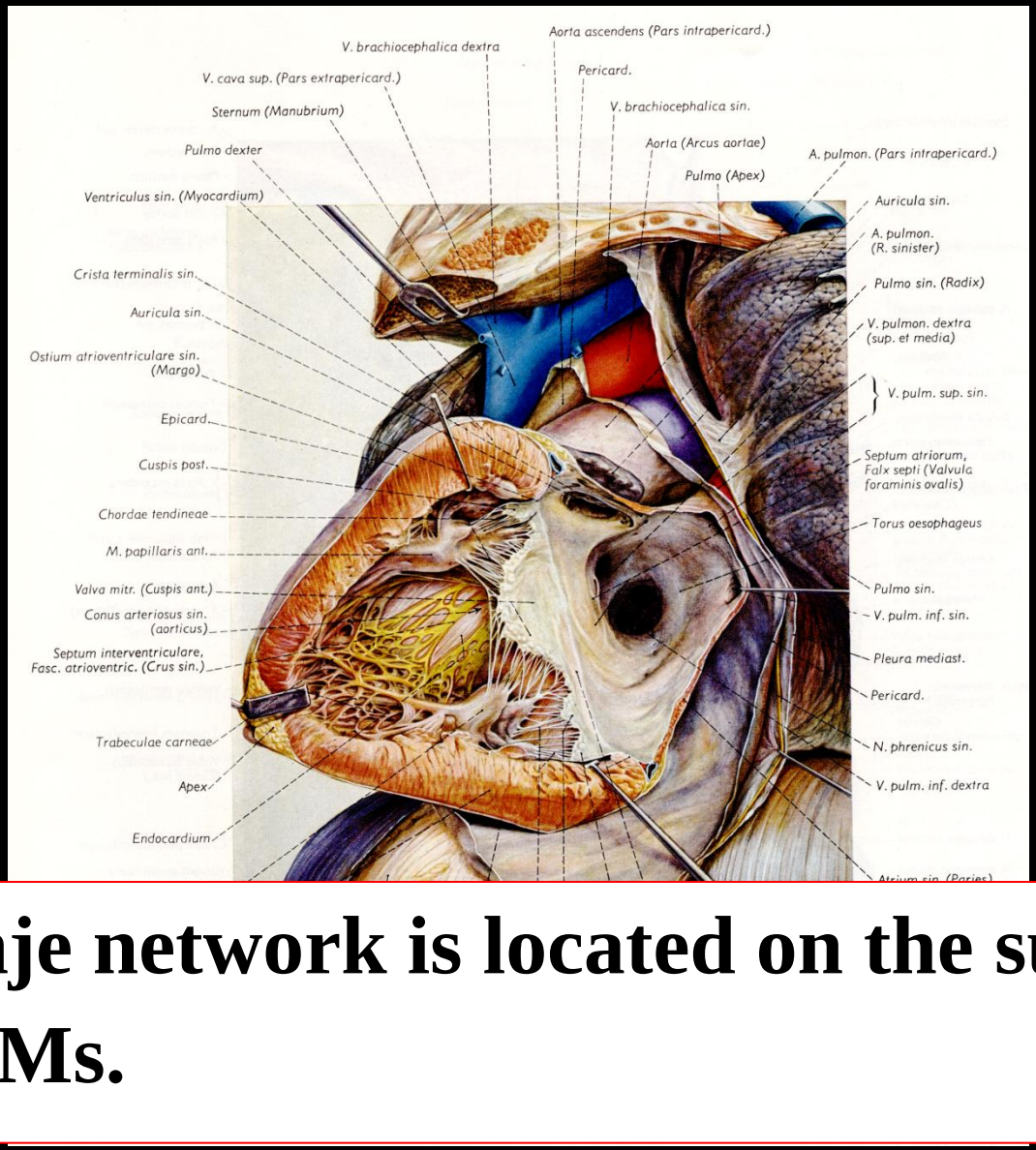
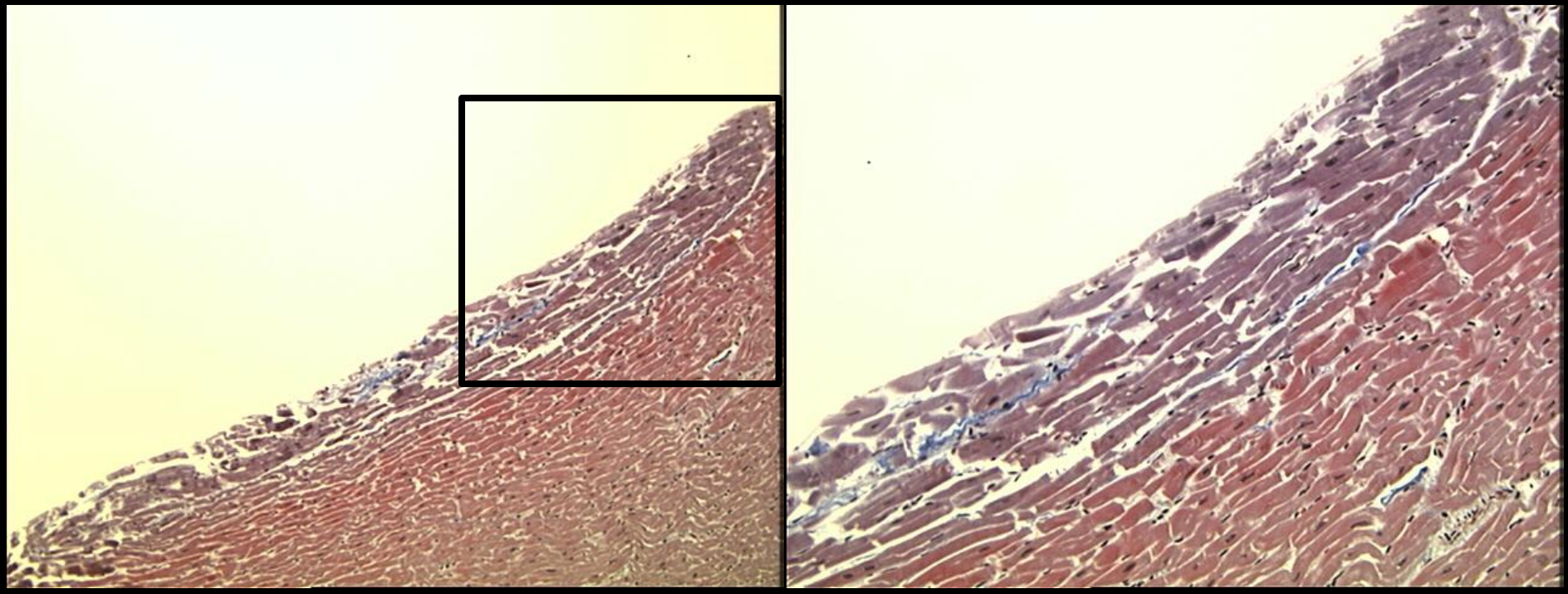
Anatomy of the PAM



- **Purkinje network is located on the surface of the PAMs.**

Histology of PAM



- **In human hearts, Purkinje cells are located only sub-endocardially.**

- Definition of PAM VAs is confusing.
  - ✓ Anatomical definition
  - ✓ Electrophysiological definition
- VAs originating from the PAM itself