VT symposium in Korea 2017

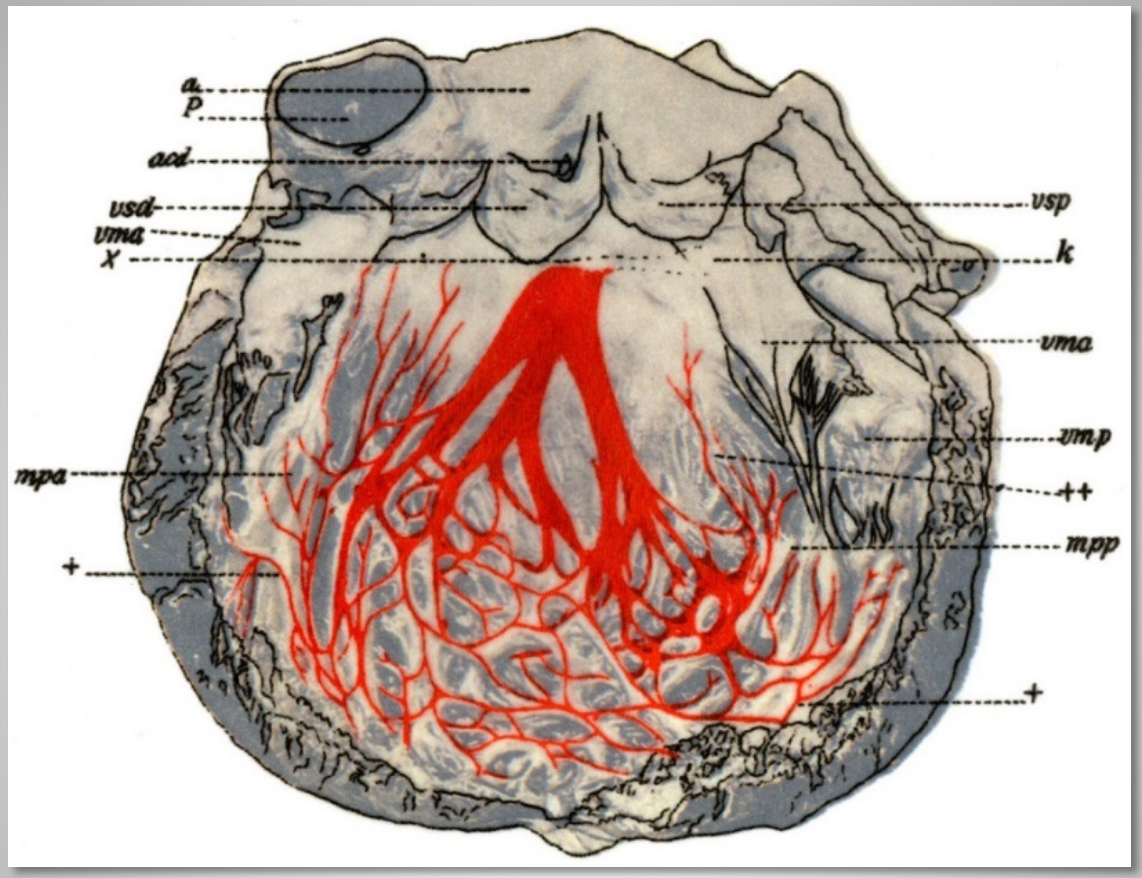
昭和大学
SHOWA University

How to differentiate the Ventricular Tachycardia Originating from Papillary Muscles, Purkinje Network and Cardiac Crux.

vision of Cardiology, Showa University School of Medicine
Mitsuharu Kawamura

4 November 2017

Distribution of Purkinje Fiber and Left Bundle Branch in LV

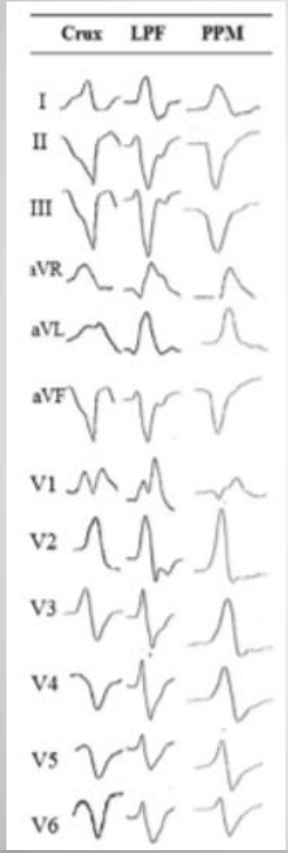


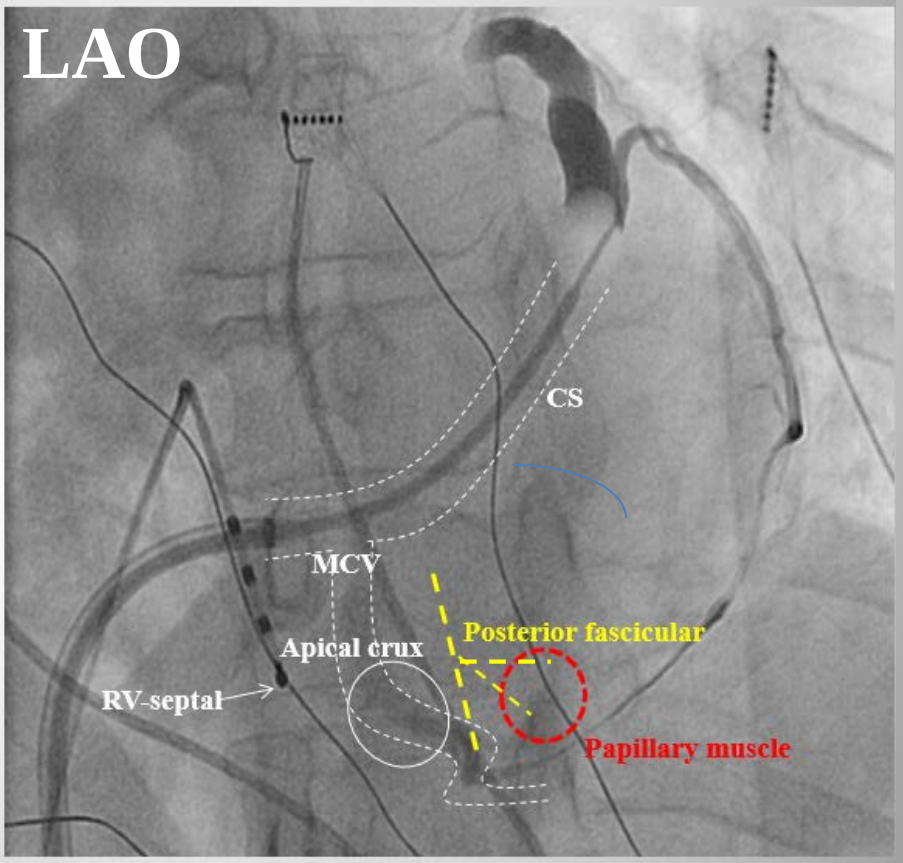
The Purkinje fibers cover the endocardial surface of the ventricles and largely distribute at the midventricular area and around the complex arrangements of the papillary muscles.

Tawara S: 1906.

The ECG morphology with RBBB and superior axis is common in patients with VAs originating from LV-posterior fascicle (LPF), LV-posterior papillary muscles (PPM) and apical crux area.
Therefore, it is challenging to distinguish these VAs due to similar ECG morphology and vicinity of area.

VA-ECG





Kawamura M et al. Heart Rhythm 2015; 12 1137-1144.

What is the Cardiac Crux VT?

Idiopathic Ventricular Arrhythmia Originating From the Cardiac Crux or Inferior Septum

Epicardial Idiopathic Ventricular Arrhythmia

Mitsuharu Kawamura, MD; Edward P. Gerstenfeld, MD; Vasanth Vedantham, MD, PhD; Derek M. Rodrigues, MD; J. David Burkhardt, MD; Youichi Kobayashi, MD; Henry H. Hsia, MD; Gregory M. Marcus, MD, MAS; Francis E. Marchlinski, MD; Melvin M. Scheinman, MD; Nitish Badhwar, MD

Study population

Among 1021 patients with idiopathic VA referred for ablation, 18 patients (mean age; 53 years old) were identified with crux-VA. All patients had a symptomatic idiopathic VA and 3 patients had an ICD implantation because of hemodynamic collapse associated with rapid VT.

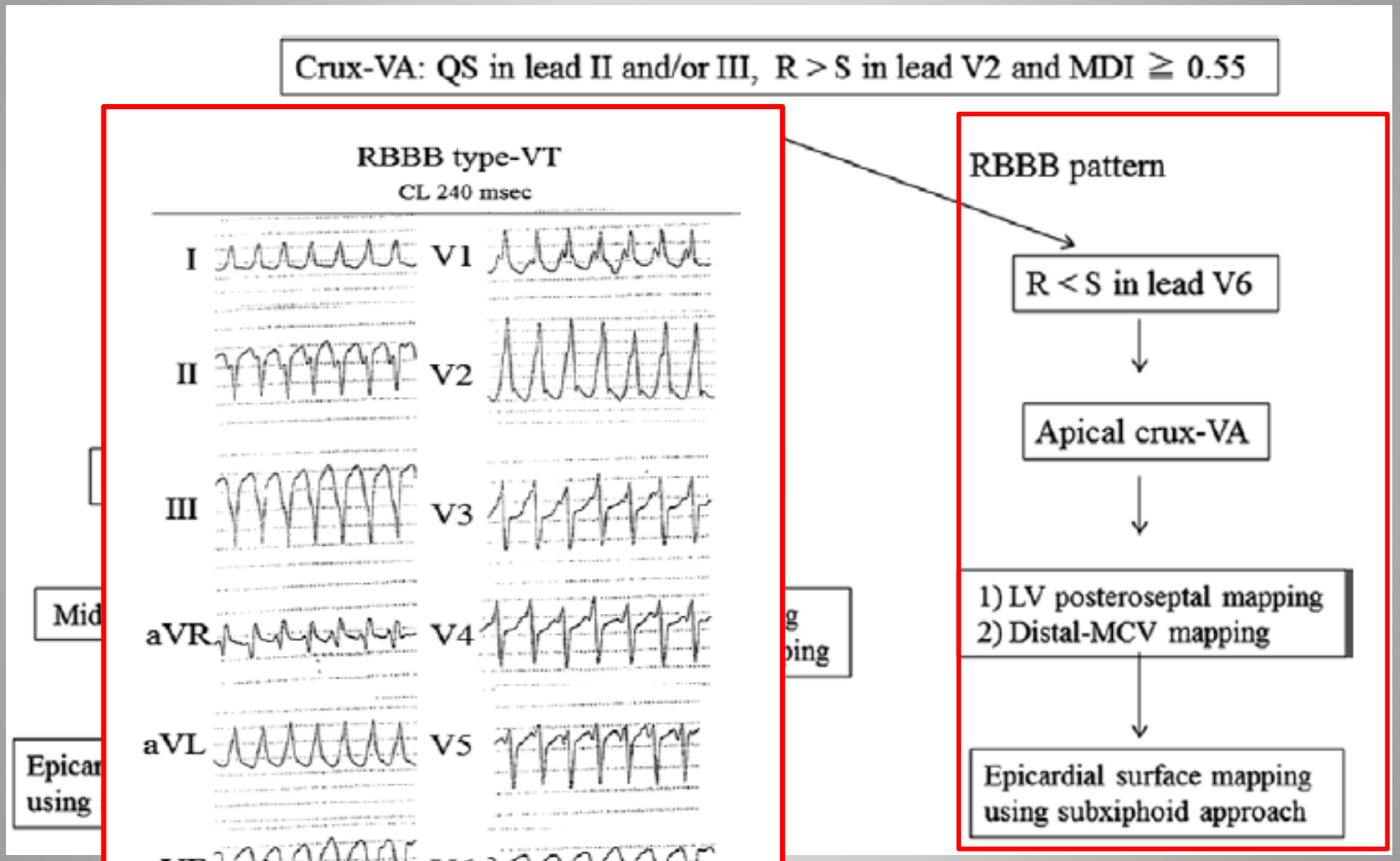
All patients had a normal ejection fraction with no evidence of significant coronary artery disease.

often requires a subxiphoid epicardial approach. (*Circ Arrhythm Electrophysiol.* 2014;7:1152-1158.)

Key Words: catheter ablation ■ epicardial mapping ■ tachycardia, ventricular

Kawamura M, et al. Circulation AE. 2014;7:1152-8.

Mapping and ablation algorithm for crux-VA.



Similar ECG of PPM-VA and PF-VA

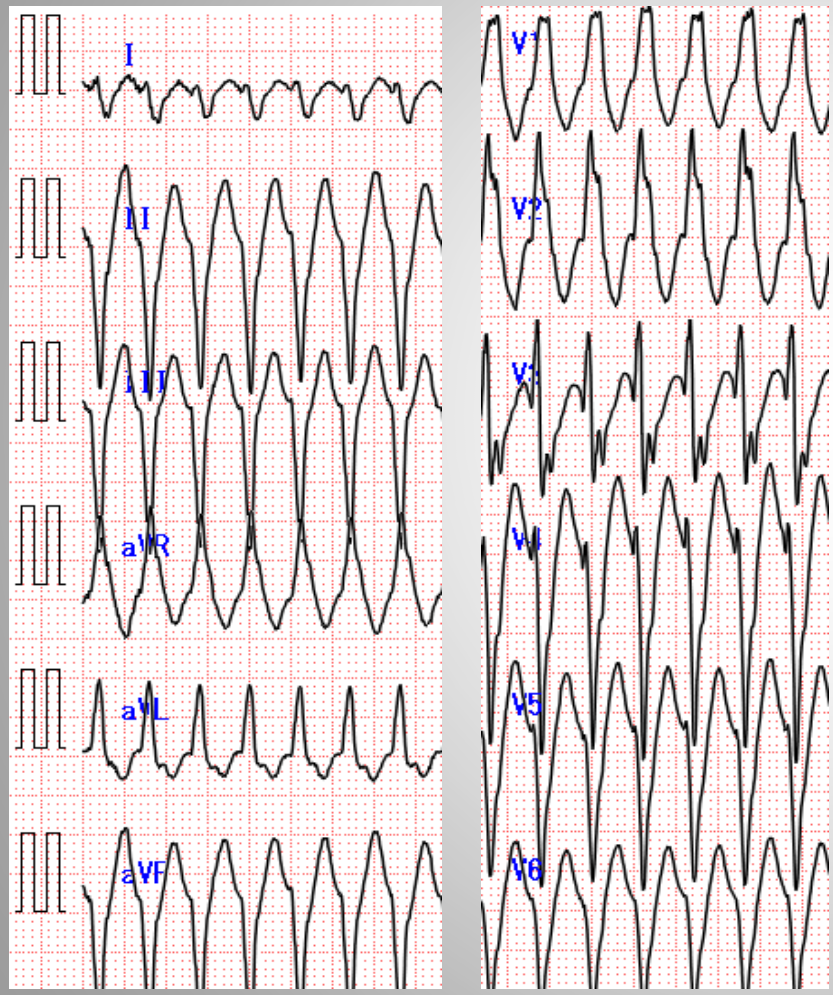
Kawamura M, et al. Circulation AE. 2014;7:1152-8.

Case 1
Fascicular VT

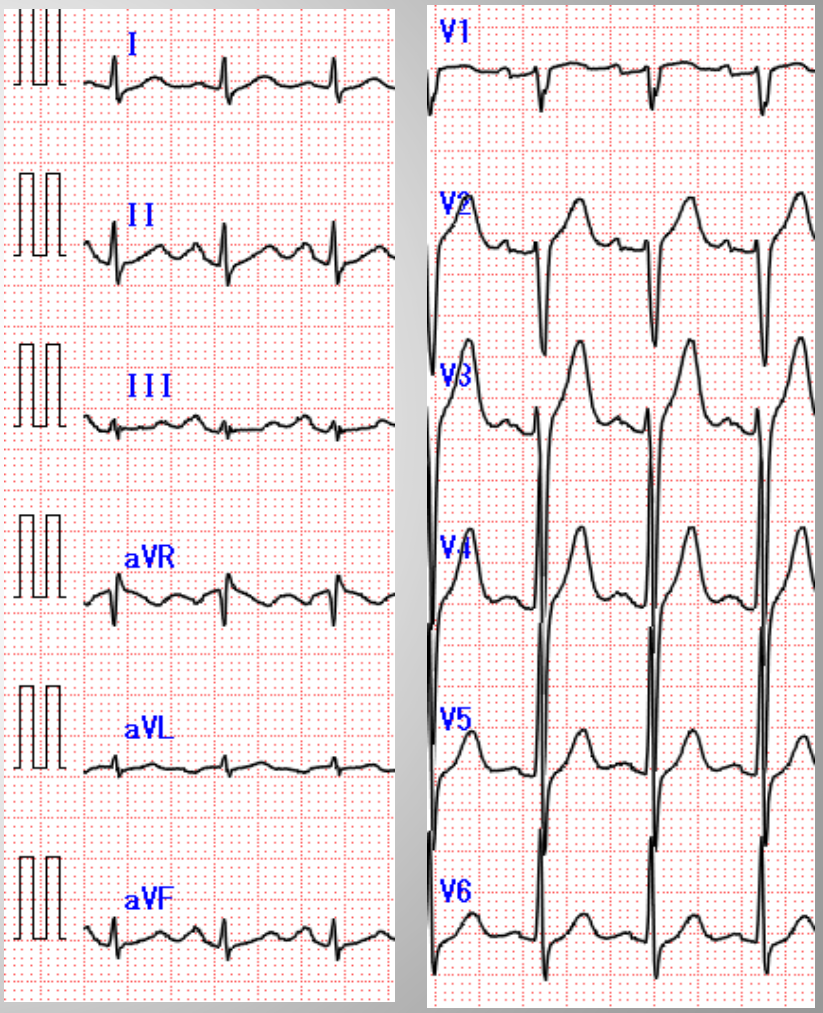
35 years old, male.
He had palpitation and had VT.
He had no structural heart disease.

ECG

Ventricular tachycardia

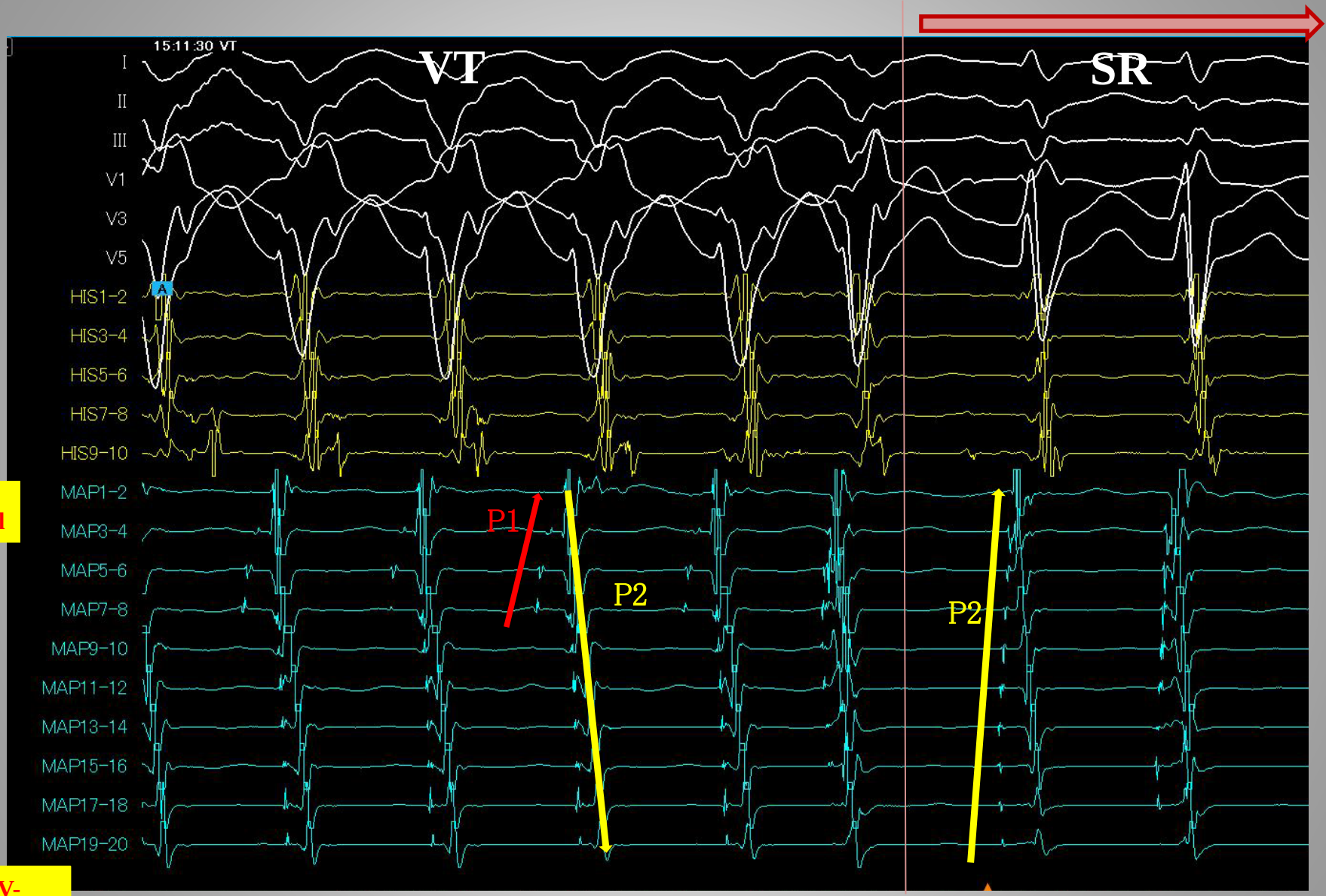


Sinus rhythm



HR 248 /bpm, CRBBB+superior axis, QRS 120 msec

VT termination

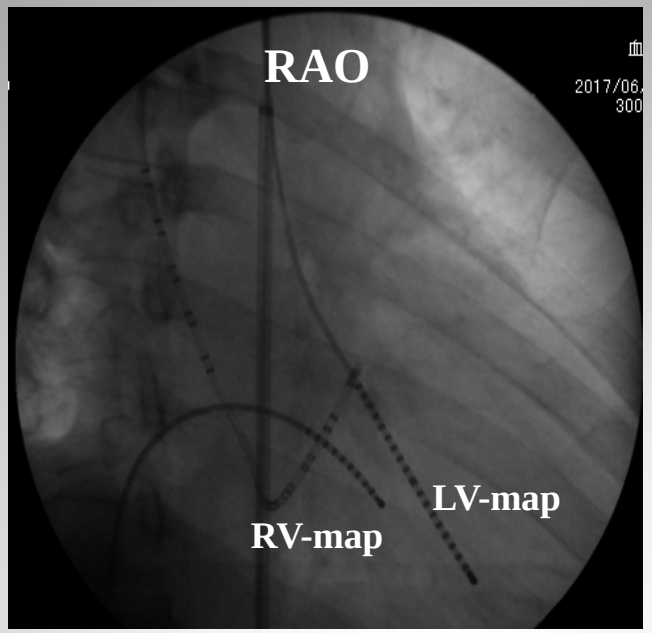


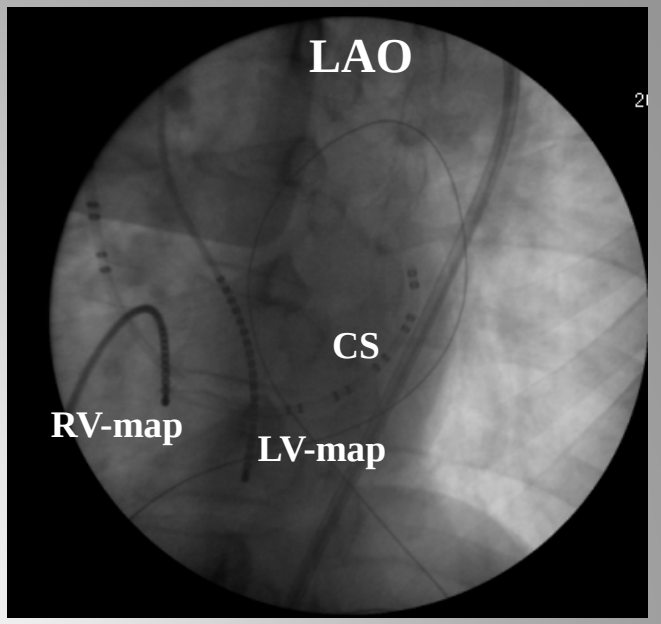
(100mm/sec)

P1: diastolic potential

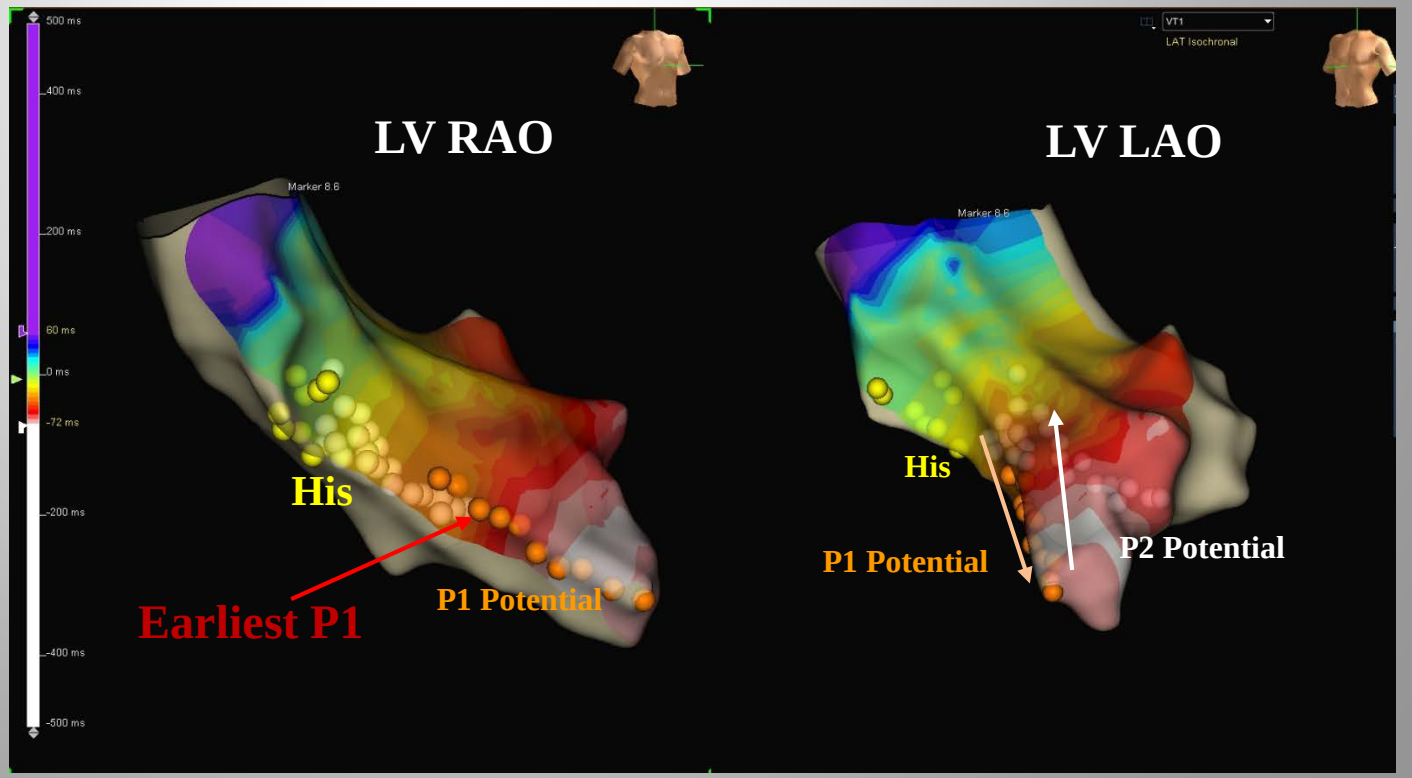
P2: presystolic purkinje potential

Catheter position



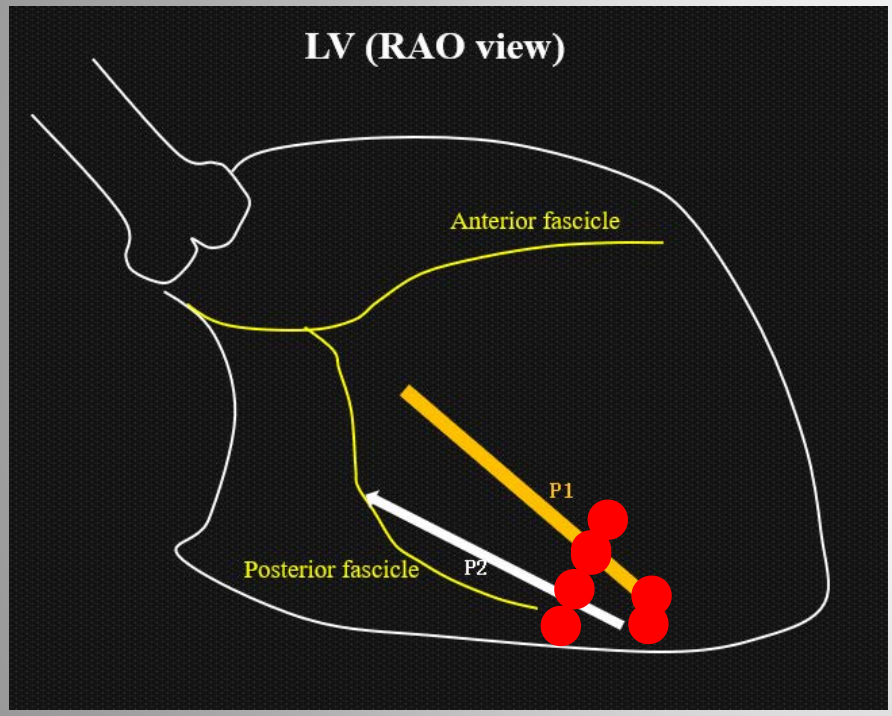


VT Activation Map



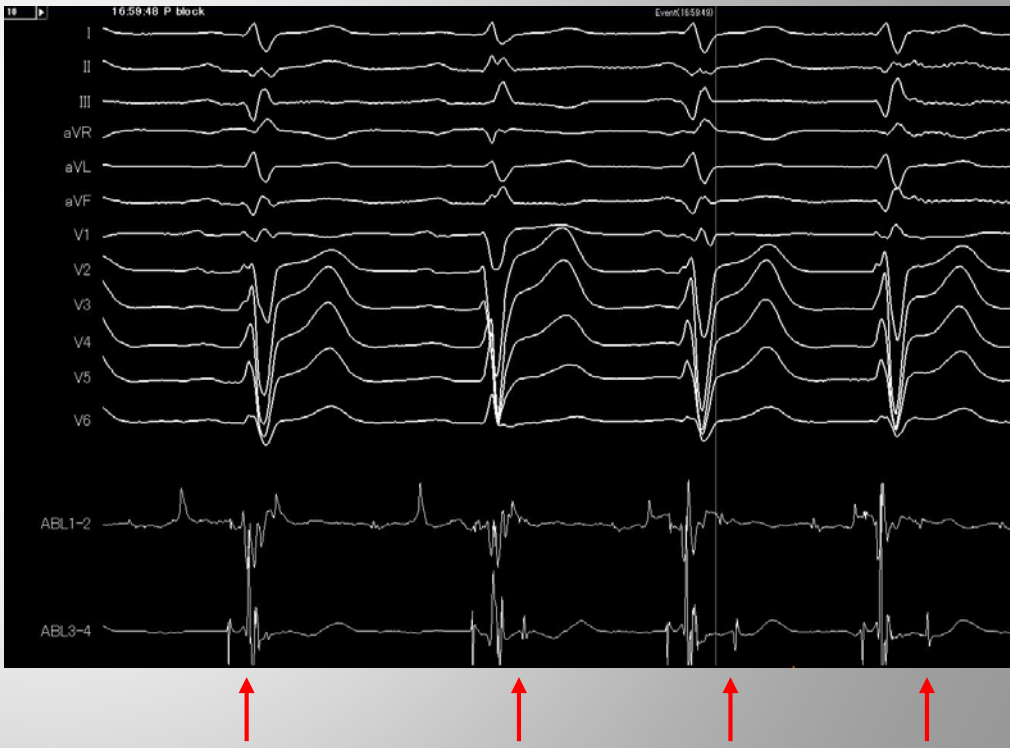
Schema of the ablation point and Intracardiac ECG

Ablation point



- liner ablation to transect the involved middle to distal left fascicular tract
- point ablation at the earliest ventricular activation with a fused P2.

P1 Block



P1-P2 interval was gradually prolonged during ablation. After P1 block, VT wasn't induced.

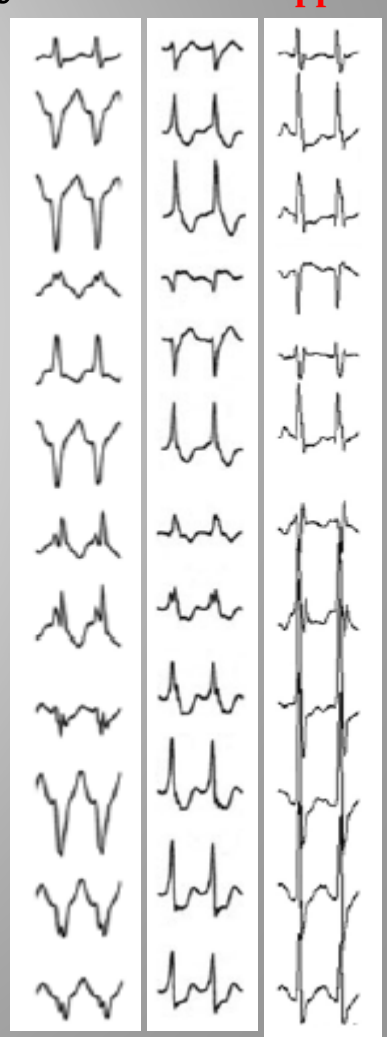
Mapping and ablation of Fascicular VT

Mapping

LV septal mapping using a multipolar electrode catheter is useful. Activation mapping is not typically required, however the ability to tag catheter positions of interest is often helpful.

The diastolic potential (P1) and Purkinje potential (P2) can be recorded during VT from the mid- septum.

Because P1 has been proved a critical potential in the VT circuit, this potential can be targeted to cure the tachycardia.



Ablation

P1 is the antegrade limb of the VT circuit.

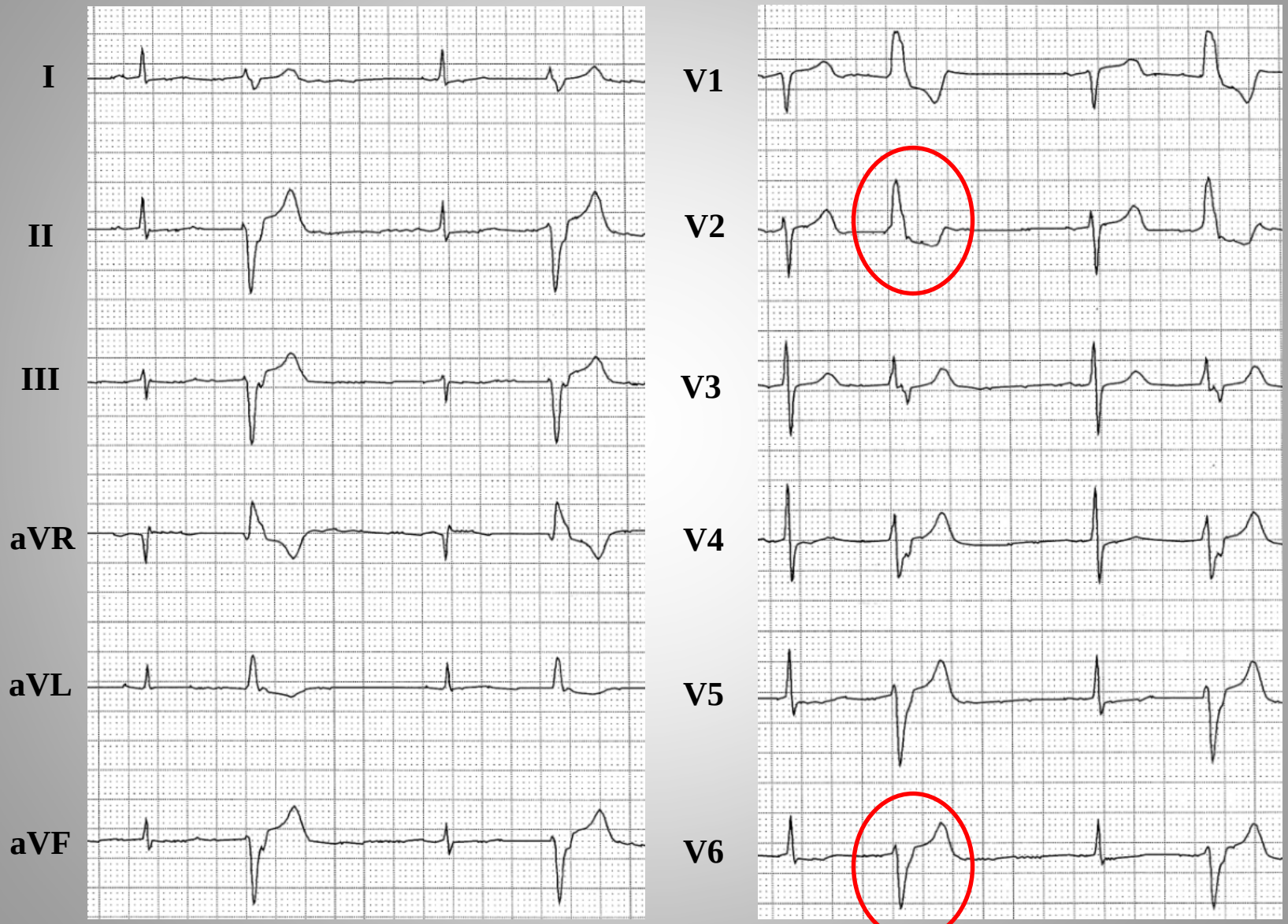
The earliest P1 is not need.

The distal third of P1 potential is usually targeted to avoid LBBB or AV block. If FVT isn't induced, we perform an anatomic liner ablation to transect the involved middle to distal left fascicular tract.

Case 2
Papillary muscle PVC

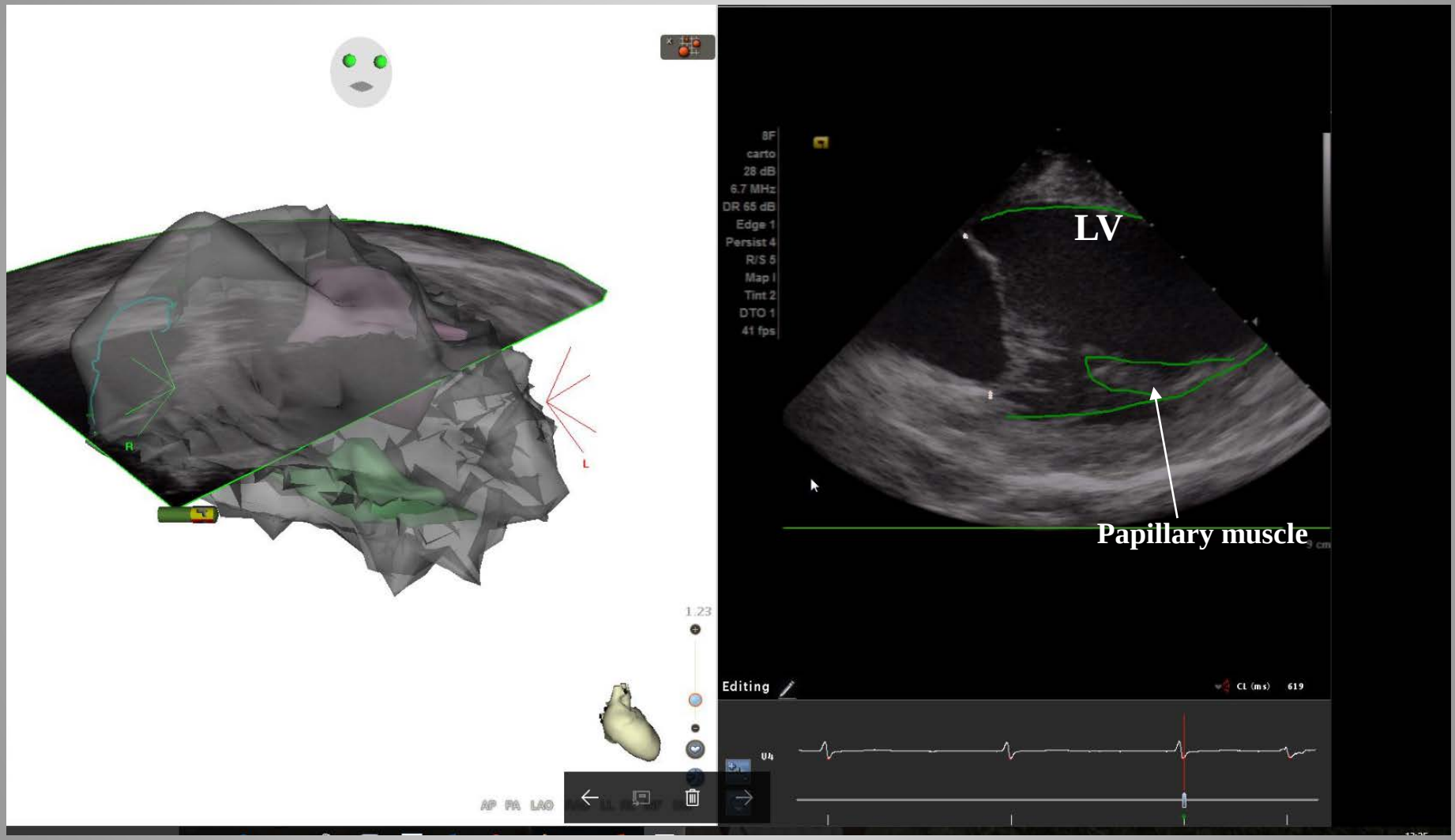
56 years old, male.
He had palpitation and had PVC.
He had no structural heart disease.

Surface ECG during appearance of PVC



PVC: CRBBB+superior axis, QRS 162 msec

Real time integration of ICE and 3D electroanatomic mapping



CARTOSOUND

Intracardiac echocardiography (ICE)

Successful ablation site

(A)

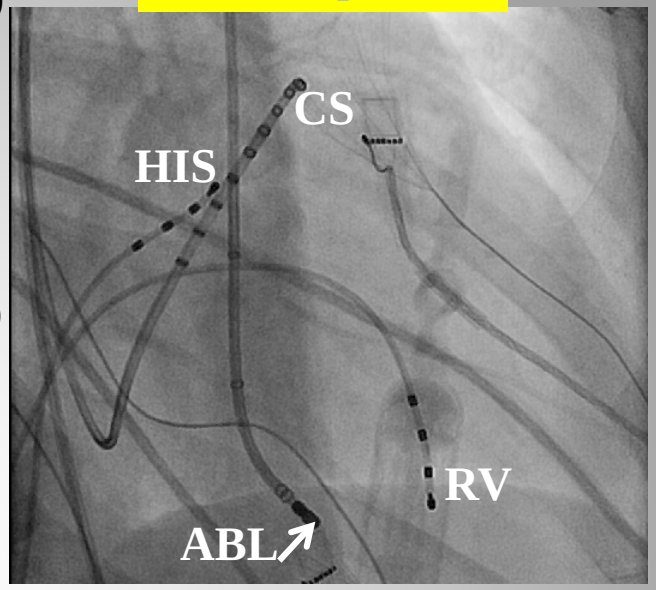
Intracardiac ECG

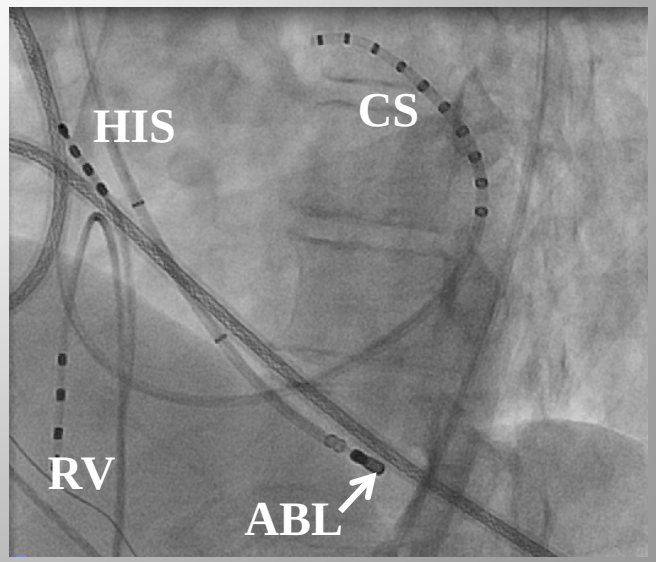
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ABL-d
ABL-p
HIS-p
HIS-m
HIS-d
CS-p
CS 7-8
CS 5-6
CS 3-4
CS-d
RV-p
RV-d

V-QRS = - 48 msec

(B)

Fluoroscopic view

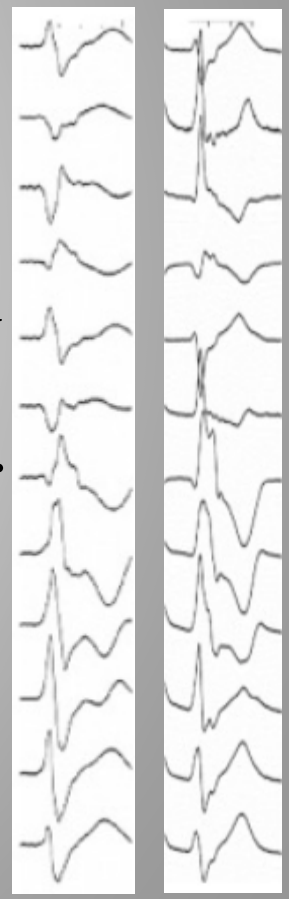




Mapping and ablation method of Papillary muscle VA

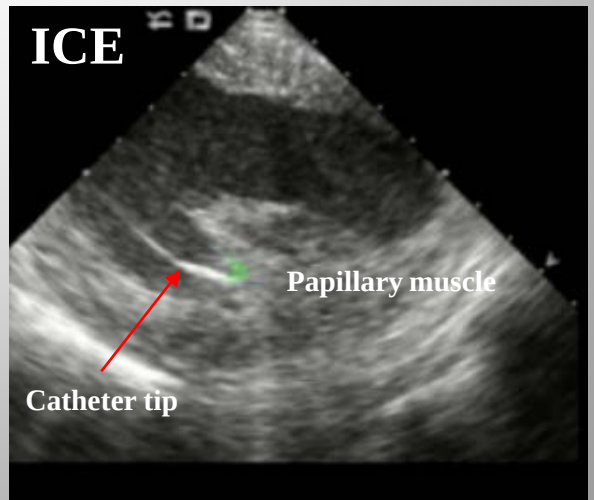
- **Mapping**

Intracardiac echocardiography(ICE) is essential to ensure adequate catheter-tissue contact and correct orientation of the catheter tip. We use a Carto system and the CartoSound module allows integration of the anatomic shell based on the echo images with real-time integration of the ICE views.



- **Ablation**

Ablation is challenging as compared to those with other VAs probably because of the deep location of the origin and the difficulty in maintaining stable contact of the catheter tip at the papillary muscles. Targets for ablation include sites with earliest ventricular activation and a QS in the local unipolar recording. These sites usually exhibit an excellent pace map.



How to differentiate VT Originating from

- Posterior Papillary Muscles
- Posterior Fascicular
- Apical Crux. ? ?

Clinical and electrocardiographic characteristics of idiopathic ventricular arrhythmias with right bundle branch block and superior axis: Comparison of apical crux area and posterior septal left ventricle

Mitsuharu Kawamura, MD,* Jonathan C. Hsu, MD, MAS,† Vasanth Vedantham, MD, PhD,* Gregory M. Marcus, MD, MAS,* Henry H. Hsia, MD,* Edward P. Gerstenfeld, MD,* Melvin M. Scheinman, MD,* Nitish Badhwar, MD*

We studied 40 patients who underwent successful catheter ablation of idiopathic VA from
Posterior papillary muscle (PPM, n=15),
LV posterior fascicle (LPF, n=18),
Apical cardiac crux (crux, n=7).

superior axis.

METHODS We studied 40 patients who underwent successful catheter ablation of idiopathic VAs originating from the LPF (n = 18), LV PPM (n = 15), and apical crux (n = 7). We investigated clinical and ECG characteristics, including maximum deflection index and QRS morphology in leads aVR and V_6.

RESULTS Syncope was more frequently seen in apical crux VA compared with other VAs (57% vs 6%, $P < .001$). Patients with apical crux VA more frequently had an maximum deflection index ≥0.55 compared with LPF VA and PPM VA ($P = .02$). A monophasic R wave in aVR and QS or r/S ratio <0.15 in V_6 ($P < .001$) could distinguish apical crux VA from other VAs with high accuracy. All patients with VA underwent attempted ablation in the endocardium an ablation strategy.

KEYWORDS Ventricular tachycardia; Catheter ablation; Epicardial approach; Cardiac crux; Right bundle branch block

ABBREVIATIONS **CS** = coronary sinus; **ECG** = electrocardiography; **LBBB** = left bundle branch block; **LPF** = left posterior fascicle; **LV** = left ventricle; **MCV** = middle cardiac vein; **MDI** = maximum deflection index; **NPV** = negative predictive value; **PPM** = posterior papillary muscle; **PPV** = positive predictive value; **RBBB** = right bundle branch block; **RV** = right ventricle; **VA** = ventricular arrhythmia; **VT** = ventricular tachycardia

(Heart Rhythm 2015;12:1137–1144)

Kawamura M et al. Heart Rhythm 2015; 12 1137-1144.

Baseline characteristics

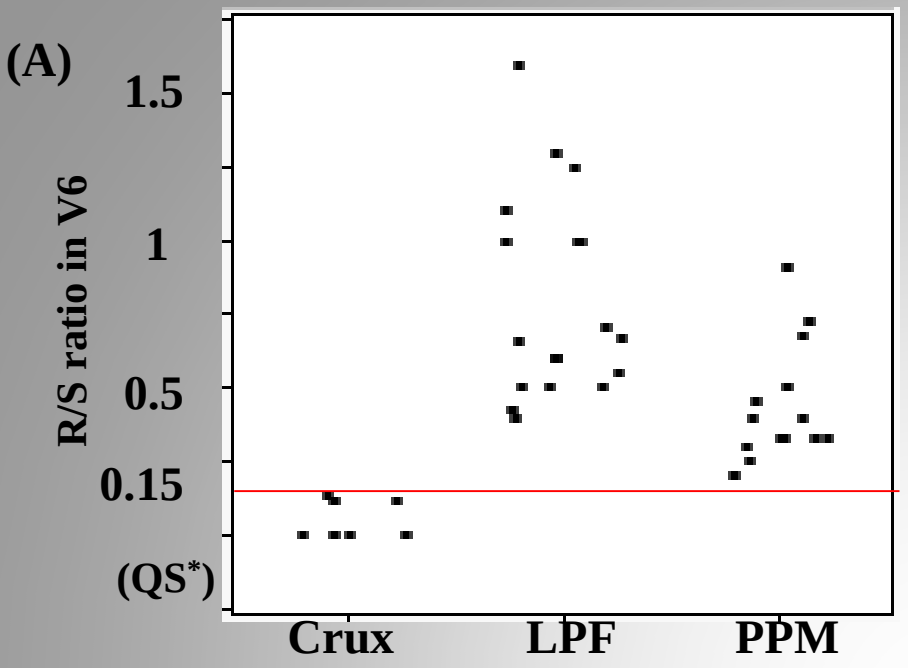
Table 1 Patients characteristics

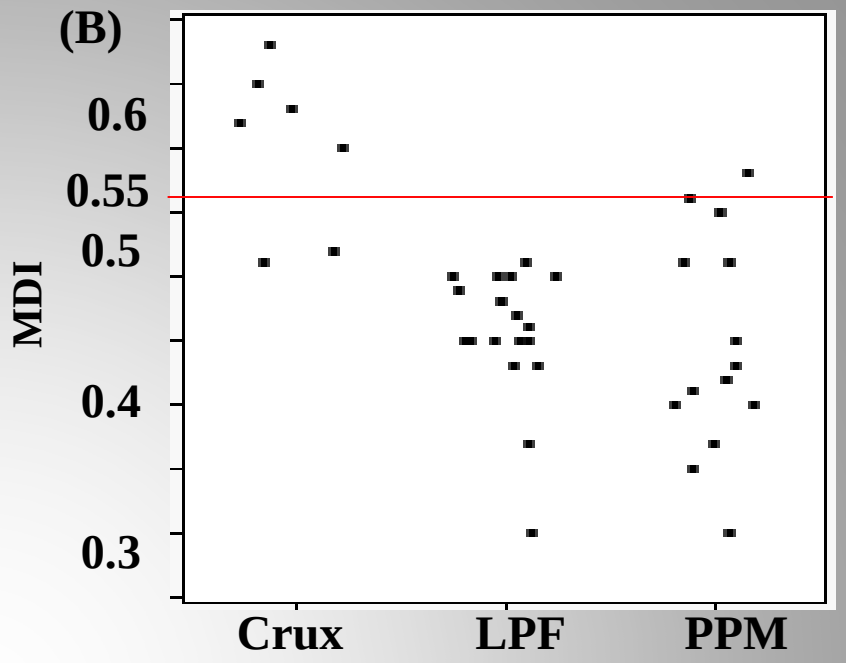
	All patients	LPF	LV PPM	Apical crux
No. of patients	40	18	15	7
Age (years)	49 ± 10	41 ± 12†	52 ± 11†	57 ± 9†
Gender, male	21 (52%)	10 (56%)	8 (53%)	3 (43%)
Ejection fraction (%)	58 ± 8	57 ± 12	60 ± 5	62 ± 3
History of ventricular tachycardia	22 (55%)	12 (67%)	4 (27%)*	6 (86%)†
History of syncope/cardiac arrest	6 (15%)	1 (6%)†	1 (7%)†	4 (57%)†
Successful ablation				
Endocardium	29 (73%)	16 (89%)*	12 (80%)*	1 (14%)†
Epicardium	2 (5%)	N/A	N/A	2 (29%)
Medical therapy [n (%)]				
Amiodarone/sotalol	5 (13%)	3 (17%)	2 (13%)	0 (0%)
Flecainide	2 (5%)	0 (0%)	1 (7%)	1 (14%)
Beta-blocker	12 (30%)	4 (22%)*	4 (27%)	4 (57%)*
Calcium blocker	14 (35%)	10 (56%)	3 (20%)	0 (0%)
Electrocardiography				
QRS duration (ms)	141 ± 18	124 ± 15†	142 ± 13†	155 ± 22†
MDI >0.55	7 (17%)	0 (0%)†	2 (13%)*	5 (71%)†
QS in II	18 (45%)	6 (33%)	5 (33%)	7 (100%)
Monophasic R in aVR	9 (23%)	2 (11%)†	1 (7%)†	6 (86%)†
qR in V_1	13 (32%)	3 (17%)	9 (60%)	1 (14%)
QS or r/S <0.15 in V_6	9 (23%)	1 (5%)†	1 (7%)†	7 (100%)†

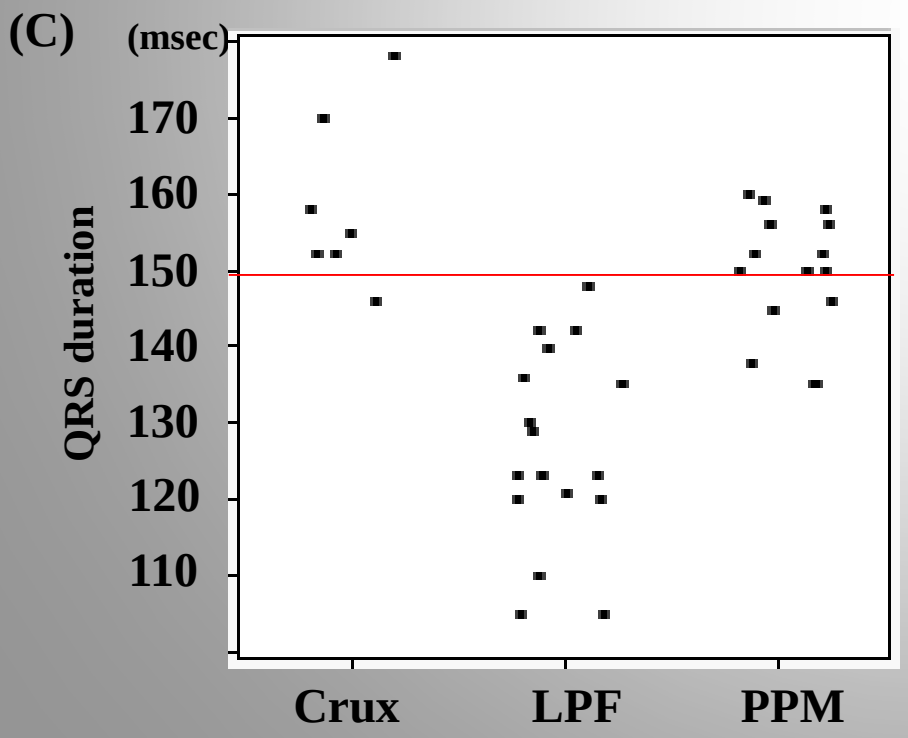
LPF = left ventricular posterior fascicle; LV PPM = left ventricular posterior papillary muscle; MDI = precordial maximal deflection index; N/A = not applicable.

*P <.05

Kawamura M et al. Heart Rhythm 2015; 12 1137-1144.







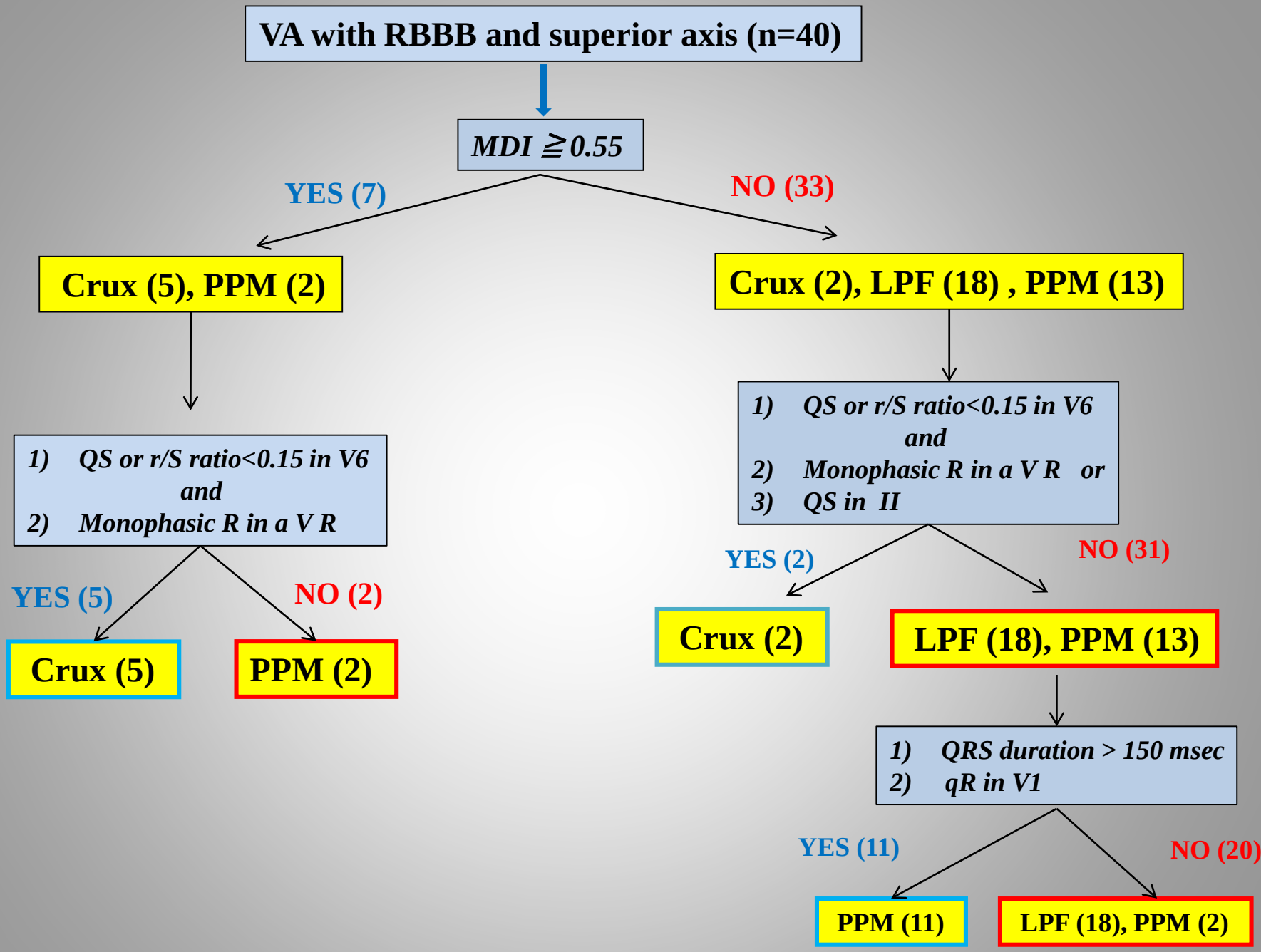
Panel A shows that the R/S ratio in V_6 was significantly lower in patients with apical crux VA compared to those with other VAs.

The R/S ratio also tended to be lower in patients with PPM VA compared to those with LPF VA (*P* = .06).

MDI was significantly higher in patients with apical crux VA compared to those with other VAs (B).

Furthermore, QRS durations in patients with LPF VA were significantly narrower compared to other VAs.

Kawamura M et al. Heart Rhythm 2015; 12 1137-1144.



Kawamura M et al. Heart Rhythm 2015; 12 1137-1144.

Original Article

Fascicular Ventricular Tachycardia Originating From Papillary Muscles

Purkinje Network Involvement in the Reentrant Circuit

Yuki Komatsu, MD; Akihiko Nogami, MD; Kenji Kurosaki, MD; Itsuro Morishima, MD; Keita Masuda, MD; Tomoya Ozawa, MD; Takashi Kaneshiro, MD; Yuichi Hanaki, MD;

This study investigated 13 patients in whom fascicular VT (FVT) was successfully eliminated by ablation at the posterior PM (PPM-FVT, n=8) and anterior PM (APM-FVT, n=5). All patients had no evidence of structural heart disease. The exact location of mapping/ablation catheter was confirmed by real-time intracardiac ultrasound image.

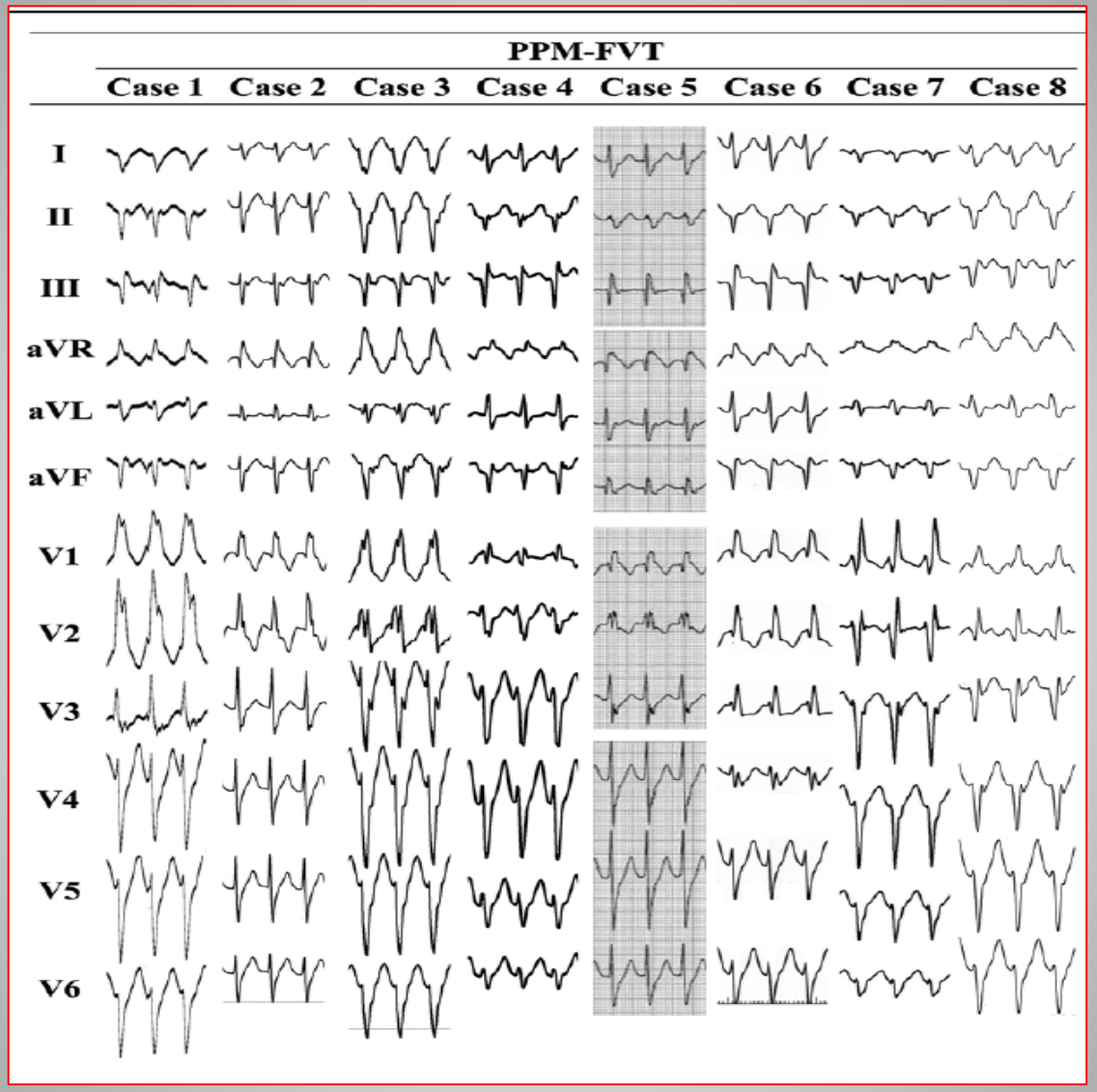
exhibited right bundle branch block and superior right axis (extreme right axis) or horizontal axis deviation. APM-FVT exhibited right bundle branch block configuration and right axis deviation with deep S wave in leads I, V_5, and V_6. VT was reproducibly induced by programmed atrial or ventricular stimulation. His-ventricular interval during VT was shorter than that during sinus rhythm. Ablation at the left posterior or anterior fascicular regions often changed the QRS morphology but did not completely eliminate it. Mid-diastolic Purkinje potentials were recorded during VT around the PMs, where ablation successfully eliminated the tachycardia. All patients have been free from recurrent VT after ablation.

Conclusions—Reentrant circuit of verapamil-sensitive FVT can involve the Purkinje network lying around the PMs. PM-FVT is a distinct entity that is characterized by distinctive electrocardiographic characteristics and less sensitivity to verapamil administration compared with common type FVT. Ablation targeting the mid-diastolic Purkinje potentials around the PMs during tachycardia can be effective in suppressing this arrhythmia. (***Circ Arrhythm Electrophysiol.* 2016;10:e004549. DOI: 10.1161/CIRCEP.116.004549.)**

Key Words: catheter ablation ■ fascicular ventricular tachycardia ■ papillary muscles

Komatsu Y et al. Circ Arrhythm Electrophysiol 2016; 10: e004549.

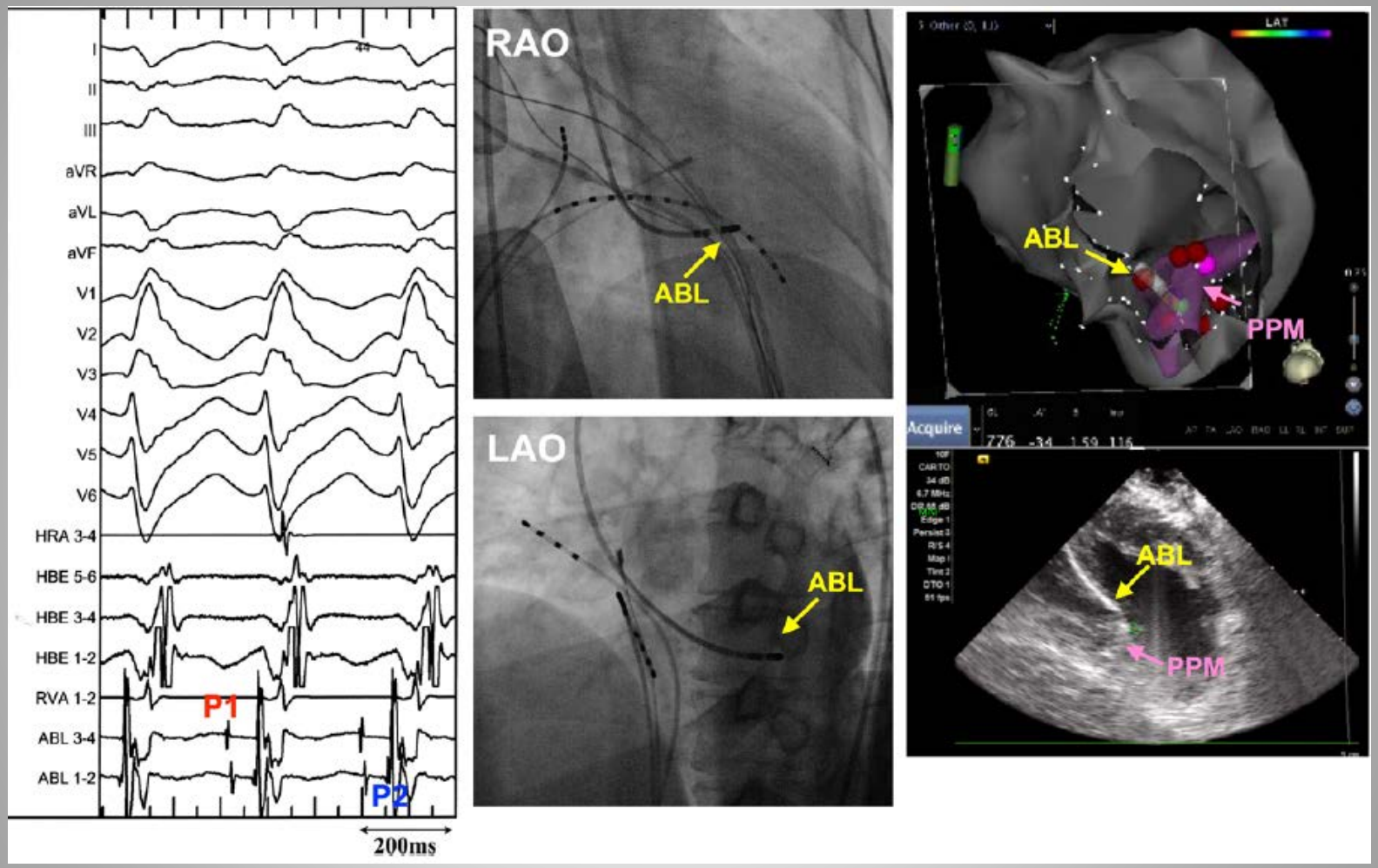
ECGs of papillary muscle - fascicular VT before ablation.



Average QRS duration with PPM-FVT was 126±8 msec. PPM-FVT exhibited RBBB and superior right axis.

All patients with PPM-FVT had a small r wave in lead III.

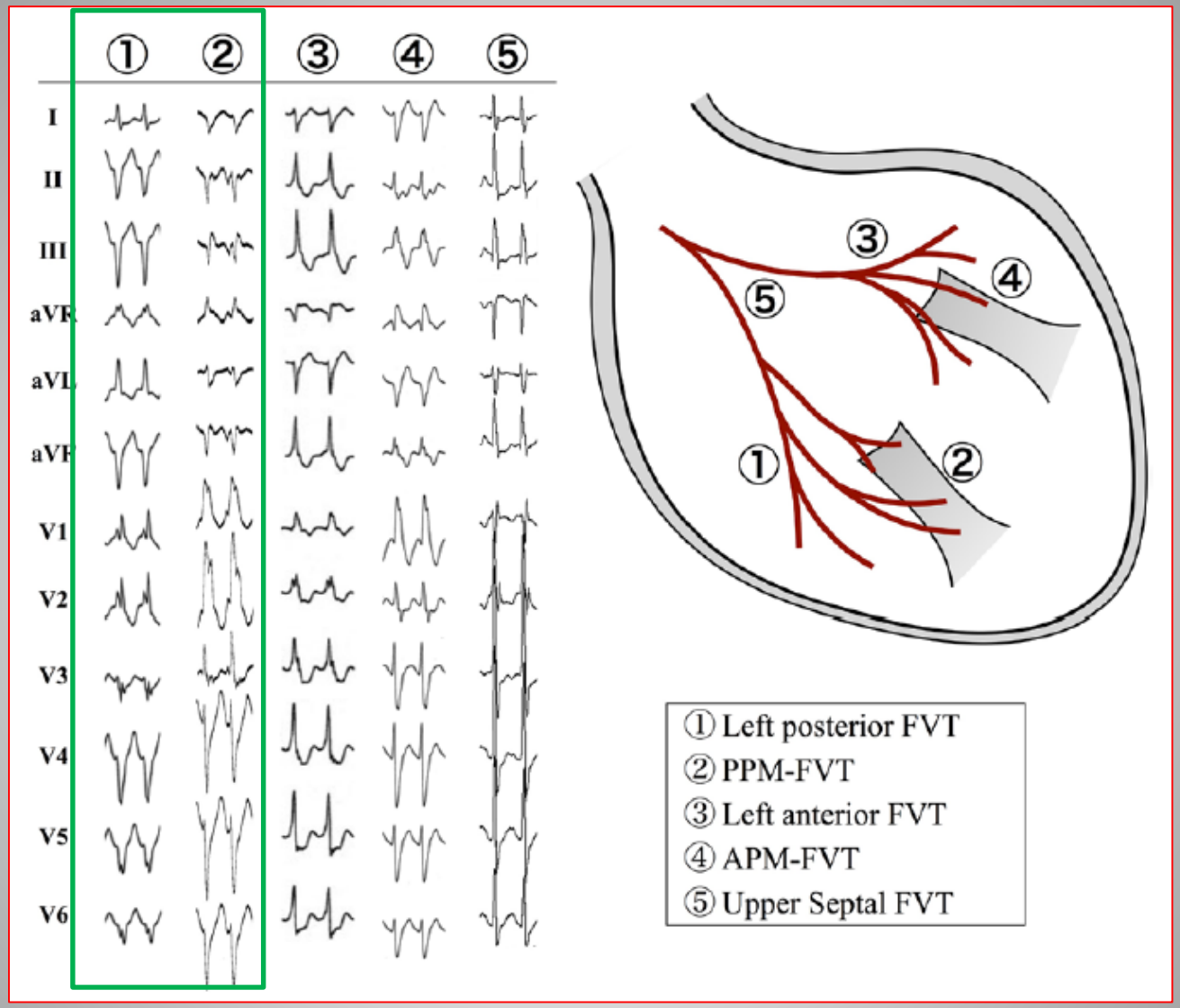
Local ventricular electrograms and intracardiac echo images at the successful ablation site



- Left panel showed the local electrogram at the successful ablation site during procedure. Both diastolic and presystolic Purkinje potentials (P1 and P2) were sequentially recorded during VT.
- Right panel showed the successful ablation site which located on the posterior papillary muscles by real-time intracardiac ultrasound image

Komatsu Y et al. Circ Arrhythm Electrophysiol 2016; 10: e004549.

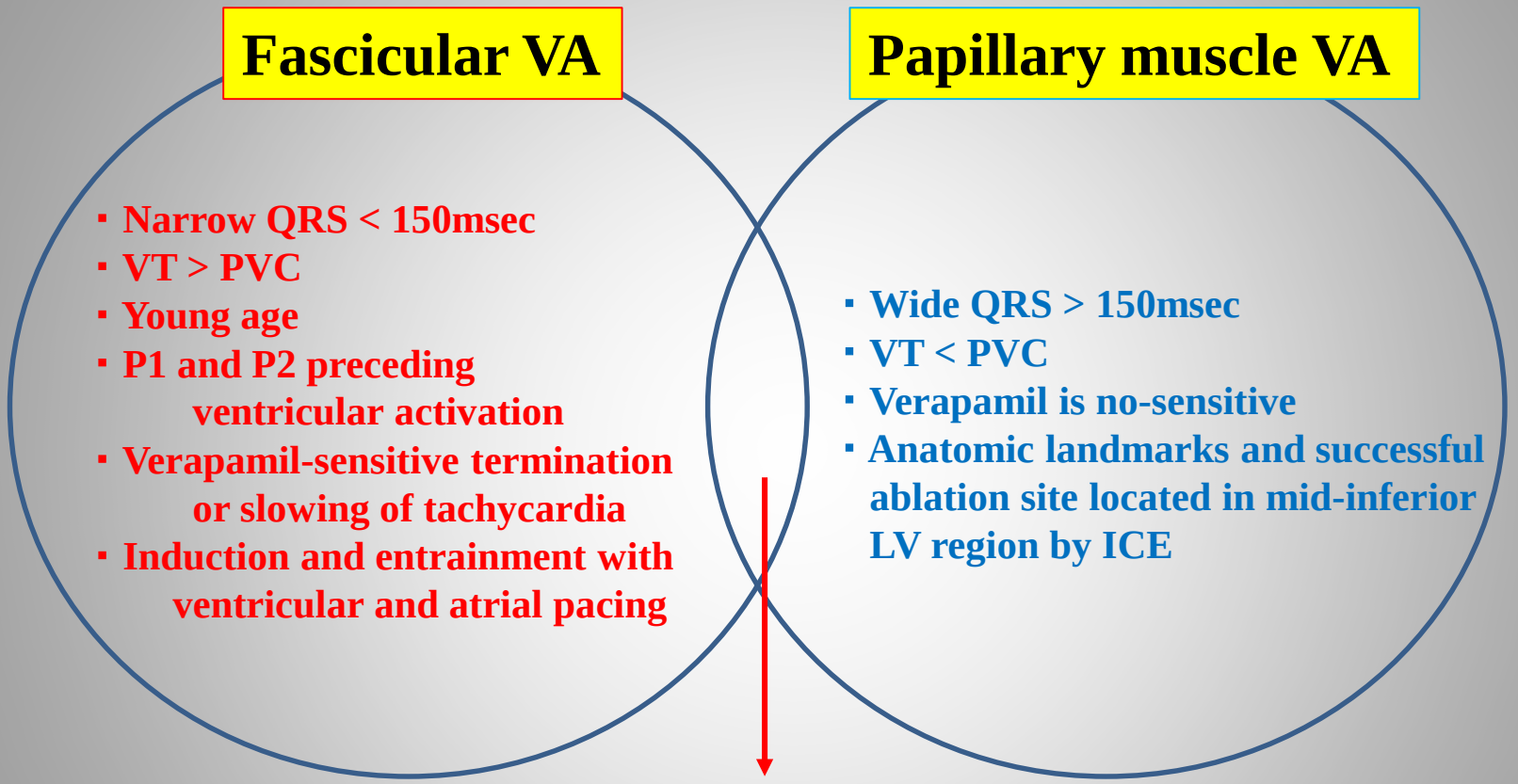
Origins of verapamil-sensitive left fascicular VT



Posterior FVT is the most common type and has RBBB and left axis deviation.

This study investigates another distinct subtype of verapamil-sensitive FVT originating from the Purkinje network around the papillary muscles.

Comparison of Fascicular VA and Papillary muscle VA



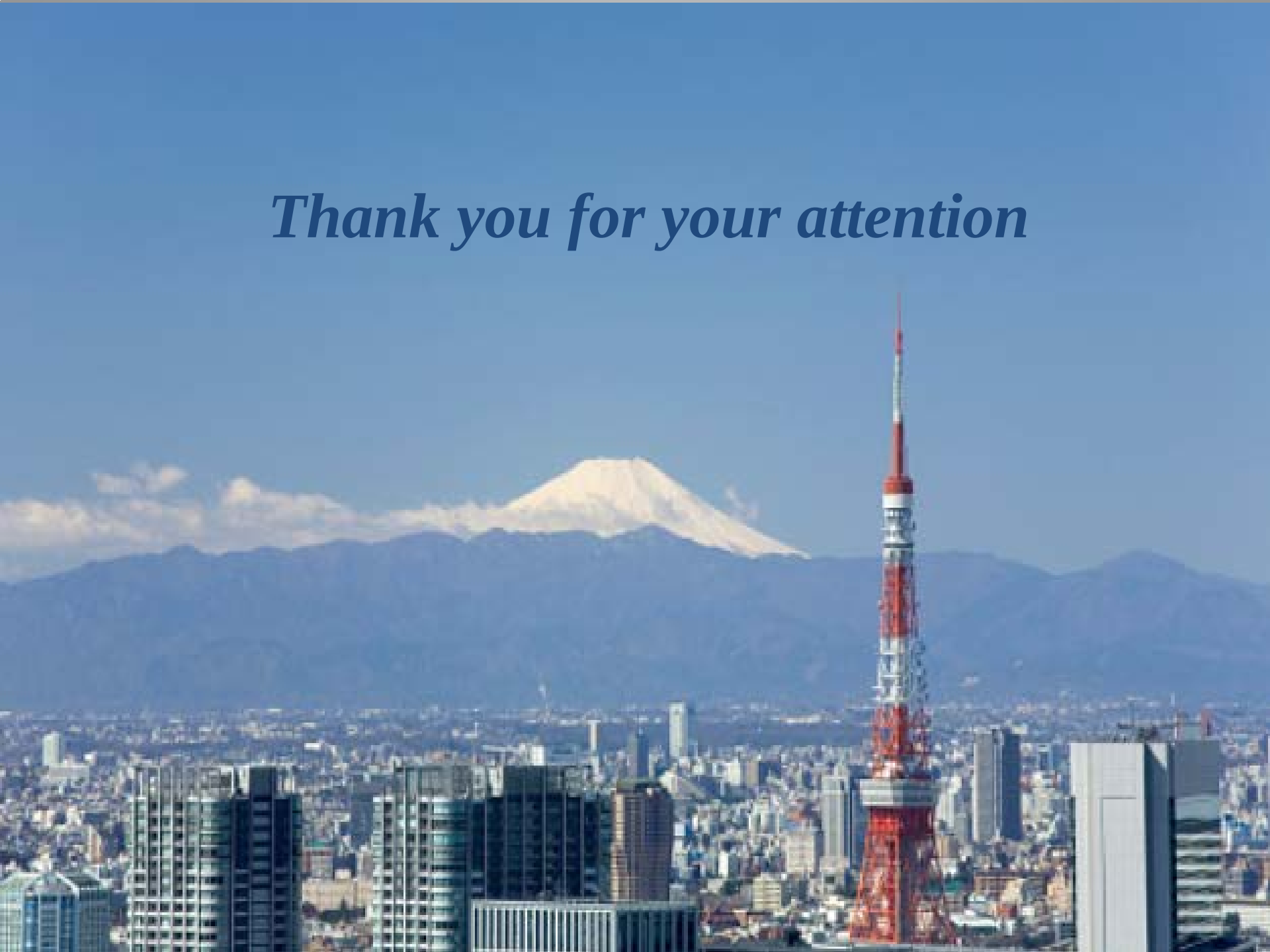
Diastolic Purkinje potential is recorded at the papillary muscle during VT.
Ablation of the diastolic potentials is highly effective for suppressing this arrhythmia.
Although PM-FVT is sensitive to verapamil administration,
it is not as highly sensitive as the common type of left FVT.

< Summary >

1) **Clinical and electrophysiological characteristics are important for fascicular VA.**
   Patients with FVT are younger as compared to those with other VAs.
   FVT is narrower with QRS duration as compared to those with other VAs.
   Purkinje potentials (P2) and diastolic potentials (P1) are preceding ventricular activation during VT.

2) **Anatomic landmark by intracardiac echocardiography is important for papillary muscle-VAs. QRS duration with PPM-VAs are wider as compared to those with fascicular VT.**
   In PPM-VA, PVC is more frequently than VT.

3) **It is challenging to distinguish from PPM-VA and LPF-VA due to overlap of successful ablation point.**
   The use of CartoSound allows real-time integration of the ICE views into the mapping system anatomic display.
   Therefore, we need to judge these VAs comprehensively.


Thank you for your attention